Rarities in phonetics and phonology

Structural, typological, evolutionary, and social dimensions

Edited by

Natalia Kuznetsova

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Shelece Easterday

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Part I

Introduction

Chapter 1

Rarities in phonetics and phonology: Exploring rarities

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This chapter introduces theoretical controversies around studies on rare phonetic and phonological phenomena, and affirms the importance of rarities for the development of phonological theory. We highlight the attempt of our volume to chart a middle ground between two extremes in existing approaches to rarities: radical exoticisation (emphasising the uniqueness of rare patterns to the point of undermining efforts to compare them) and radical normalisation (explaining away rare patterns without accounting for their peculiarity). We favour the de-exoticisation of rare phenomena and attempts to refine existing typologies to better account for them, as this can help to expand and improve phonological theory and typology. The chapter goes on to outline the main themes explored in the volume and to explore how the 17 individual chapters contribute to our better understanding of sound patterns in human language.

1 Introduction

The patterns of sounds of the world’s languages are many and varied. Although the human articulatory, auditory, and perceptual apparatus limits and shapes the ways in which spoken languages harness sound to convey meaning, considerable

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diversity can be observed in phonological systems cross-linguistically. The current volume gathers chapters exploring various facets of this diversity, with a focus on its extreme cases.

During the reviewing process for this volume, we learned of the sad death of Bob Blust. This volume is dedicated to his memory, as he was one of the most insightful researchers of phonetic and phonological rarities. Blust was a prolific linguist, authoring nearly 300 publications in his 52-year career (Lobel et al. 2022). He had an enormous impact on the field of linguistics at large through his descriptive and reconstructional work in the Formosan, Philippine, Bornean, and Central and Eastern Malayo-Polynesian subgroups of the Austronesian family. Yet even as he worked through big-picture historical problems in Austronesian, he frequently noted and puzzled over rarities present in individual languages, including rare sources of geminates in Berawan (Blust 1995), the typologically anomalous distribution of nasal and oral vowels in Seimat (Blust 1998), putative vowelless words in Selau (Blust 2003), and velar nasal intrusion in Palauan (Blust 2009). His chapter in this volume on a rare sound change in Berawan appears largely as he submitted it to us.

This introductory chapter presents the topic of rarities in phonetics and phonology as we understand it. In Section 2, we explain why we think the study of rarities is important and topical, and frame this study within current linguistic research. In Section 3, we give some background to the genesis of this book (Section 3.1) and elaborate on its conceptual foundations (Section 3.2). In Section 4, we lay out the general organisation of the volume (Section 4.1) and introduce individual chapters (Section 4.2).

2 Why rarities?

Rare phenomena play a key role in forming and challenging linguistic theory. In formal approaches, the identification of rare phenomena has long been one of the primary means of expanding and modifying the theoretical acquis. Within linguistic typology, while much research involves large cross-linguistic samples, a focus on rare phenomena has emerged since the beginning of this millennium, see *Das Grammatische Raritätenkabinett* (Plank 2000) and the proceedings of several conferences on the topic (Wohlgemuth & Cysouw 2010a,b, Simon & Wiese 2011, Golovko et al. 2015).

Two types of rarities have been distinguished in that work: absolute rarities and phenomena that are rare worldwide but frequent in certain genetic groupings (Wohlgemuth & Cysouw 2010b: 1–2). Three ways of approaching those rarities which pose challenges for general linguistic theory have been outlined. Rarities can be ignored by linguistic theory, re-analysed as regular, or incorporated by changing the theory (Simon & Wiese 2011: 9–14).

Originally, rarities were seen only as something unnatural with respect to so-called "natural" language laws. However, with the rise of research on the evolutionary aspects of both universals and rarities, a trend towards "de-exoticising" rarities by expanding existing theories has been observed. Importantly, studies in this vein start from the premise that rarities are valid patterns which theoretical frameworks must grow to accommodate. As rarities are comprehensively described and studied, the limitations and weaknesses of current synchronic and diachronic models of language structure and change are revealed. Confronted with a growing expectation that they should be able to account for patterns on the extremes, theories are challenged to widen their scope and explanatory power. This approach has resulted in progressively more linguistic, cognitive, biological, cultural, and other factors being acknowledged as critical in the emergence and functioning of linguistic rarities.

Within phonology, the number of thematic works taking the approach described above has been constantly growing. Older examples include studies on nasalised laryngeals (Blust 1998), non-modal vowels (Gordon 1998), and inhibited sound change (Blevins & Wedel 2009). More recent studies of the same kind include the analysis of vertical vowel systems (Anderson 2016), voiceless sonorants (Blevins 2018) and voiced word-final obstruents (Blevins et al. 2020), uncanonical word prosody (Kuznetsova 2018), metathesis and "un-metathesis" (Edwards 2020), highly complex syllable structure (Easterday 2019), ternary stress (Golston 2021), and ternary quantity (Kuznetsova 2025).

This work appears in the context of an expansion of research into the evolutionary aspects of both universals and rarities, with attempts to explain typical pathways of the emergence, maintenance, and disappearance of linguistic phenomena (Blevins 2004: 192–214; Simon & Wiese 2011: 15–20; Round 2019). This research follows the foundational work of Joseph Greenberg, who developed the systematic typological study of evolutionary aspects of linguistic phenomena. In outlining a probabilistic approach to diachronic change, Greenberg (1978) made an important distinction between two dimensions along which linguistic features can be classified: (a) frequency of emergence and (b) stability. The synchronic rarity of a pattern does not necessarily imply that it arises infrequently and is unstable once it arises. Just as patterns which arise frequently may be diachronically unstable (e.g. nasal vowels), patterns which arise rarely may be diachronically rather stable (e.g. clicks and ejectives). In the evolutionary sense, we can consider the latter patterns to be different in important ways from those which arise rarely and are unstable (e.g. velar implosives). Greenberg's approach shows that properties of both emergence and stability must be considered in order to fully understand the diachrony of rarities.

This "evolutionary" trend, which has appeared within functional and typological research on phonology, is currently at odds with formal phonological analyses based on the concept of markedness. Certain phenomena, like word-final obstruent voicing as discussed by Schwartz and Ulfsbjorninn (Chapter 6), are considered rare but possible in Evolutionary Phonology, where the possibility for sound change is limited only by physiological biases related to language acquisition and use (Blevins 2006a,b, Blevins et al. 2020). On the contrary, such phenomena are seen as impossible in the "amphichronic" Universal Grammar, which considers language change, and resulting synchronic distributions, to be consequences of markedness constraints (Kiparsky 2006, 2008). The constant search for and challenging of such rare pivotal cases constitutes an important line of debate in the field of phonological rarities.

The trend of de-exoticising rarities is directly linked to the growing degree of description, documentation, and inclusion of various world languages in scientific research. It has been noted that rarities, including those in phonetics and phonology, are often concentrated in lesser-studied languages (Mithun 2007, Whalen & McDonough 2019, Tucker & Wright 2020, Zellou et al. 2022). Suggested reasons for this include a sociolinguistic distance observed between those varieties and "big" languages (Mansfield & Stanford 2017), differences in input on performance, which affect language users' knowledge base, processing manner, and expectations (Lev-Ari 2016), and an especially strong motivation on the part of speakers of smaller and under-resourced languages to be different (Bird & Kell 2017). Statistically, fewer contexts for language use might also increase the probability for preserving the quirks of random language drift (Bird 2008, Jäger 2024). The prevalence and acceleration of language obsolescence itself might also be a factor behind the concentration of rare features in endangered languages. For example, some rarities happen to be documented in the middle of an unfinished sound change. These stages may exist for just a brief period in the life of a big vital language. However, if a vanishing variety is documented at one of these stages, the rarity will enter into the cross-linguistic typology and remain forever unchanged in that state (Kuznetsova 2021: 164; Kuznetsova & Markus 2022).

Some important aspects of rarities may only come to light in the context of comprehensive global surveys which include many under-represented languages. A phenomenon which appears rare as a firmly established primary contrastive phonological feature might nevertheless be quite common as a purely phonetic phenomenon or process, or as a secondary cue relevant only in certain contexts.

However, we can only arrive at this conclusion after thorough cross-linguistic investigation. A good example is preaspiration, discussed in detail in this volume (see especially Iosad's and Hejná's contributions). Such cross-linguistic findings raise the key question of why certain relatively frequent phonetic phenomena phonologise so rarely.

On the other hand, certain features might also seem rare and "unnatural" only from the perspective of the best-studied languages, while in fact they are more frequent than commonly thought. The initial database of the World Atlas of Language Structures (WALS; Dryer et al. 2005), for example, showed that at least part of Europe (more specifically, English, German, Dutch, Frisian, and French) is actually one of the geographical areas with a "high level of rarity" (Cysouw 2011: 424; see also Dahl 1990). Therefore, it is probable that many features, including phonetic and phonological ones, which seem exotic from the perspective of Standard Average European (Whorf 1941: 78; Haspelmath 2001, van der Auwera 2011) or LOL (Literate, Official, Lots of users; Dahl 2015) languages can be actually common worldwide. A parallel observation has been also made in psychology (Henrich et al. 2010, Henrich 2021). Experimental subjects coming from WEIRD (Western, Educated, Industrialised, Rich, Democratic) countries showed many unusual psychological and behavioural features, as compared to the rest of human species. The problem here, as Henrich argues, is that such subjects constitute 96% of all experimental participants in psychology, so these often quite unusual results are typically extrapolated and considered universal for all human beings.

In sum, a greater inclusion and finer investigation of lesser-studied languages and cultures will likely progressively challenge our understanding of what is rare or typical, possible or impossible.

A further factor contributing to the de-exoticisisation of rarities is a spread of parametric methods in typology and a shift from languages as the minimal units of analysis to the features of languages, and further to the parameters of these features. Multidimensional approaches include Canonical Typology (Corbett 2007, Hyman 2014, Round & Corbett 2020) and Multivariate (or Distributional) Typology (Bickel 2015, Tallman 2020), cf. Forker (2016) for a comparison of the two. In these approaches, marginal cases are interpreted as possible but rare combinations of universal parameters rather than as logically impossible cases. The reasons for the rarity of certain combinations, however, still have to be explained and accounted for within those frameworks.

The general approach we take in the present book to two other common treatments of rarities – radical exoticisation and radical normalisation – is returned to in Section 3.2.

3 History and conceptual basis of this volume

3.1 History of the volume

After founding the series *Topics in Phonological Diversity* at Language Science Press in 2021 (https://langsci-press.org/catalog/series/tpd), we conceived of a book on phonological rarities as one way of launching the series. The three of us had been conducting typologically oriented research of various rarities in phonetics and phonology for some time, including in our doctoral studies (see references in Section 2), and shared an interest in the topic. To gauge whether there would be sufficient interest from the community to fill a volume on rarities in phonetics and phonology, we organised a thematic session at the Poznań Linguistic Meeting in 2021 (http://wa.amu.edu.pl/plm_old/2020/PLM2021_Programme).

The session invited submissions for papers including individual studies or thematic surveys of specific sounds, features, systems, structures, or phenomena. We declared the workshop open to a wide range of topics and frameworks addressing phonological and phonetic rarities, unusual phenomena in phonological typology, explanatory factors for rare phenomena (structural, acoustic, articulatory, perceptual, cognitive, statistical, sociolinguistic, etc.), the evolution and the social aspects of rarities.

The call attracted considerable interest, and fourteen papers were accepted to the thematic session, six of which are represented in this book. Following on from this success, we made an open call for chapter proposals, to which we received over thirty-five responses. In the end, seventeen chapters appear in this volume.

In reviewing proposals for both the workshop and the book, we considered contributions focusing on synchronic rarities in individual languages, especially lesser-studied ones, and on studies with a broader typological or evolutionary perspective. Over the course of this process, we formulated our general approach to the study of linguistic rarities, outlined in the next section.

3.2 Conceptual basis of the volume

When considering submissions to this volume, we identified two major pitfalls that linguists often fall into when studying languages which seem to differ from the cross-linguistic norm (in addition to just ignoring such phenomena).

On the one hand, there is the danger of (radical) NORMALISATION, whereby the researcher attempts to explain away an apparently unusual linguistic phenomenon by forcing it to fit into an existing framework, often through some creative reinterpretation of the pattern. This is usually carried out in defence of the theoretical acquis, to protect the universality of an existing generalisation and dependent theories or typologies.

On the other hand, there is the peril of (radical) EXOTICISATION, whereby the researcher insists on the peculiarities of a given phenomenon in a particular language, to the point of underplaying or even denying the extent to which it can be validly compared to similar phenomena in other languages. Very often, this is done in the defence of linguistic diversity, to protect the unique status of a given language variety in the linguistic (and sometimes broader) discourse. In other cases, a researcher resorts to radical exoticisation simply because current theoretical devices and conventional definitions, especially when narrowly formulated and interpreted, leave little to no room for the pattern observed.

In accepting manuscripts for this volume, we preferred studies that attempted to chart a path between these extremes, examining ways in which rare phenomena are both similar to and different from those found in more familiar languages. This can be done, for example, by decomposing rare phenomena and the paths of their emergence into many single parameters, as in Canonical or Multivariate Typology, or in Evolutionary Phonology (cf. Section 2), by observing at which exact point the rarity occurs.

What many such approaches have in common is that they do not attempt to remove the rarity, but try to move its locus. This may be, for example, a shift from phonological units to their organisation (e.g. Brandão De Carvalho 2006, Dresher et al. 2018, Wolff 2025 [this volume]) or from one level of description to another (Kiparsky 2018; see also Wolff 2025 [this volume]). Some contributions to this volume illustrate this shift of locus also with the relationship of phonetics and phonology. Sometimes a rarity turns out to be an unusual phonetic manifestation: word-final devoicing in Lakota (Schwartz & Shanti Ulfsbjorninn 2025 [this volume]), a word prosody contrast manifested by a laryngeal feature (Dobui 2025 [this volume]), fricative and uvularised vowels (van Hugte et al. 2025 [this volume] and Guan 2025 [this volume] respectively). An extreme example of uncommon phonetic realisation is presented in silently realised sonorants (Watson et al. 2025 [this volume]). This is quite a unique phenomenon in that there is an articulatory gesture, but no or little acoustic output. The gestures, observed through instrumentation, are different for each type of sonorant, and they are apparently transmitted between generations. Such phenomena seem especially challenging for most phonetic and phonological theories and might open exciting new paths for theoretical advancement in various fields.

However, rarity can also be due to an uncommon type of phonologisation (such as preaspiration addressed in Part VI, or the contrastive palatalisation of rhotics in Kavitskaya & Wandl 2025 [this volume]), or because of the unusual place of a segment in a phonemic system (ejective fricatives as analysed by in Puderbaugh 2025 [this volume]), or due to an atypical dialectal variability (consonantal epenthesis in Culhane & Edwards 2025 [this volume]). At times, the parameters may appear fairly regular in themselves, but their combination, for certain reasons, is rare, as the evolutionary approach, represented in the chapter by Blevins, claims for a series of Austronesian sound changes. In a similar vein, palatalised rhotics (Kavitskaya & Wandl 2025 [this volume]) and word-initial voiceless sonorant geminates (Shinohara et al. 2025 [this volume]) represent atypical combinations of relatively common synchronic features. The phenomenon of tone-driven vowel epenthesis (Rolle 2025 [this volume]) may also be included here.

It is also entirely valid to re-evaluate the status of a rarity when new data come to light or by bringing a wider range of factors to bear on analysis of the phenomenon at hand (as in chapters by Iosad 2025 [this volume], Puderbaugh 2025 [this volume], and Schwartz & Shanti Ulfsbjorninn 2025 [this volume]). We accept the usefulness, even the necessity, of doing this, but by the same token also wish to learn more about what exactly is genuinely rare in phonetics and phonology, not just about what is not.

At the other extreme from normalisation, as mentioned above, is radical exoticisation, where the researcher focuses on the distinctiveness of a given phenomenon in a particular language to a degree that does not admit placement in broader typologies or dialogue with general phonological theories. To varying degrees, we support the maxim that languages should be described in their own terms, but we are also interested in the wider picture afforded by cross-linguistic study. When assessing submissions, we repeatedly insisted that authors make an effort to firmly establish the rarity of the phenomenon at hand, but also to actively seek out and discuss comparanda in other languages.

Such exoticisation is perhaps most frequently encountered when it comes to rare segments. Several proposals to the volume described exquisite sound patterns, often but not always in understudied languages. We accepted such proposals only when they made an effort to contextualise these segments in terms of what other attested sound patterns might serve as comparanda and what we know about these types of sound in general. We considered the language-specific description of something that is (supposedly) rare to be insufficient. The rarity had to be viewed through both a cross-linguistic and a general theoretical lens.

We also evaluated with some scepticism cases in which researchers claimed a clear constellation of different phenomena to constitute a rarity. The problem here is that it can be statistically unlikely for a number of phenomena that are not in themselves particularly uncommon to co-occur in the same language. For example, a language with uvulars, fixed initial stress, lateral obstruents, and /θ/ could be considered to have a pretty interesting phonology. Given that each of these phenomena is more or less uncommon, their statistical cooccurrence in the same language is unlikely. However, this is an expected rarity and a rather trivial one: after all, every language variety, taken holistically, is not just rare, but unique. In such cases, we are interested to look only at individual ingredients, not the whole stew.

We are aware, however, that, on the one hand, different frameworks disagree as to what is and what is not a phonological primitive and, on the other, that it may anyway be difficult to identify what individual ingredients actually are. For example, many phonologists would argue that phonemes are not single units, but rather combinations of distinctive features, which are themselves the more fundamental building blocks (viz. van 't Veer et al. 2023). Even in this view, palatalised rhotics or word-initial voiceless sonorant geminates still require explanation in terms of why certain feature combinations are more uncommon than others.

In addition to the theoretical differences over the base unit of analysis for phonology, we also find analytical disagreements over the simple or complex nature of given phenomena (cf. "criterial conflicts" in Round 2023). In some cases, these disagreements are core to the controversies over the status of certain rarities, such as the pre-aspirated or ejective consonants, or word-initial geminates discussed in this volume.

Similarly, whether or not some sound changes are actually rare depends on whether they are seen as occurring in a single step (as Blust 2025 [this volume] proposes) or consisting of an infrequent combination of multiple more common changes (as suggested in Blevins 2025 [this volume] and by Culhane & Edwards 2025 [this volume]) and/or acting upon rare initial conditions. We agree with Blust when he argues that it is unprincipled to assume that sound changes have been telescoped when there is no other evidence for any intermediate stages. It will nearly always be possible, with sufficient ingenuity, to come up with a plausible succession of sound changes that yield a certain result. On the other hand, we cannot accept a given sound correspondence as evidence of a rare sound change without examining whether evidence of a sequence of less rare sound changes may have occurred instead.

In spite of different viewpoints on the fundamental building blocks in phonology or the nature of rare sound changes, there is also likely to be considerable convergence over what is *trivially* rare more generally. In particular, we expect that all current phonological frameworks would exclude from consideration a whole language as a rarity.

In sum, while we are sympathetic to the impulses underlying the pitfalls of radical normalisation and radical exoticisation, namely, to defend generalisations valid across human languages and to affirm the individuality of each language variety, we were most inclined to accept proposals that struck a middle ground. We favoured chapters that firmly establish the empirical status of a given rarity and describe it in a way that facilitates comparison, the elaboration of a typology, and theory development.

We also encouraged authors to be explicit about the terminology and the theoretical implications they relied on, especially in cases where those might not be familiar to all readers (e.g. in some less common formal phonological accounts) or rather technical (e.g. in phonetic experiments). In such ways, we sought to make our volume accessible to as broad an audience as possible. In the same vein, we also accepted chapters which provided comprehensive up-to-date overviews of individual phenomena (rather than brand new theoretical or experimental breakthroughs). The hope here was to raise general interest towards those phenomena and to establish a new baseline for future research.

We actively solicited cross-referencing between chapters, because many of the analytical issues regarding rarities and even of the phenomena chosen for analysis by individual authors manifested considerable overlap. The particular analytical angles, however, were always slightly different, which enabled us to provide multi-faceted coverage of certain phenomena (e.g. of preaspiration or of some Austronesian sound changes).

An outline of the chapters that met the criteria discussed above appears in the next section. Almost all rarities discussed in the book are phonological rather than phonetic, with the exception of silent sonorants in Watson et al. 2025 [this volume]. All of them concern segments and word-level prosody, while post-lexical prosody is not discussed. This is unlikely to be coincidental. Reviewing some of the initial proposals concerning intonation, we recognised that it is still extremely difficult and perhaps premature to firmly establish any rare types in this highly variable and yet much understudied field.

4 Structure and content of the volume

4.1 Structure of the volume

The seventeen chapters of the volume cover diverse rare phonetic and phonological phenomena from a wide variety of geographical areas. The contributions can be roughly divided into the following main types:

(1) broad cross-linguistic analyses of certain phenomena (most notably: preaspiration and fricative vowels);

(2) descriptive case-studies, often field-based, providing a state-of-the-art comprehensive overview of particular rare phenomena (Otomanguean ballisticity, Queyu uvularised vowels, Ghomala' tone-driven vowel epenthesis, Ecuadorian Siona preaspiration);

(3) comprehensive summary chapters primarily devoted to the diachrony of rare sound changes (the rise of Chadic prosodies, Meto epenthetic consonants, Slavic rhotics);

(4) critical re-analysis of certain rarities (diachronic and synchronic) as more regular phenomena, or a rebuttal thereof (Austronesian and Lakota sound changes, Upper Necaxa Totonac ejective fricatives, partially also preaspiration in Chapter 17);

(5) experimental phonetic studies (of Mehri and Shehret silent sonorants, Ikema Miyako Ryukyuan voiceless nasal geminates, partially also of Upper Necaxa Totonac ejective fricatives).

We divided the volume into a number of thematic parts based on the main types of phonetic and phonological rarities considered in each of them. Brief descriptions of the contents of each part follow below.

Part I of the volume includes, apart from this introductory chapter, a chapter by Iosad dedicated to the analytical status of phonological rarities, with a discussion of some examples. It raises many of the same concerns as those outlined above in Section 2 and Section 3.2 about what a phonological rarity is and how it should be analysed typologically.

The remainder of the volume is organised along the general types of phonological rarities. Part II, opening with a chapter by Bob Blust, provides analyses of rare sound changes. The chapters by Blust, Blevins, and Culhane and Edwards are especially tightly interconnected, as they discuss partially overlapping rare sound changes in Austronesian languages. The chapter by Schwartz and Ulfsbjorninn re-assesses a supposedly rare word-final obstruent voicing in a Siouan language of North America and re-analyses it as a manifestation of a common type of lenition.

Part III includes rare types of word prosody and prosodic processes: word-level "prosodies" in Chadic languages (Wolff 2025 [this volume]), Otomanguean stress ballisticity (Dobui 2025 [this volume]), and tone-induced vowel epenthesis in a

Grassfields language of Cameroon (Rolle 2025 [this volume]). In all these cases, phenomena are presented as rare in themselves, but a broader comparative context and some potential alternative analyses are also provided. Wolff's chapter discusses at length the historical evolution of prosodies and minimal vowel systems in Chadic with a keen eye to typological comparanda elsewhere.

In Part IV, two rare types of vowels are described. More specifically, both chapters address vowels with properties that are phonetically more consonantal than what would be expected of a typical vowel. The chapter by van Hugte et al. (2025 [this volume]) analyses fricative vowels in Sinitic and other languages. Guan (2025 [this volume]) discusses uvularised vowels in languages of the Qiangic branch of Tibeto-Burman. Here too, the rarity of the phenomena themselves is accepted, but they are placed in a broad cross-linguistic and historical context, and an array of different interpretations of the phenomena in question is presented.

Part V is dedicated to rare types of consonants. Three of the four chapters discuss rare sonorants. Two of those provide detailed experimental phonetic data (articulatory and acoustic) on "non-sonorous" sonorants: silent sonorants in two Modern South Arabian languages (Watson et al. 2025 [this volume]) and voiceless geminate sonorants in the Ryukyuan Japonic varieties (Shinohara et al. 2025 [this volume]). The historically oriented chapter by Kavitskaya & Wandl (2025 [this volume]) explores reasons for the preservation of a rare contrast of plain and palatalised rhotics in Slavic languages. These three chapters dedicated to sonorants do not challenge the rare status of the discussed phenomena. The chapter by Puderbaugh (2025 [this volume]), on the other hand, which explores rather rare ejective fricatives in a Totonacan language of Mexico, re-analyses these as consonant clusters.

The concluding Part VI presents an array of different analyses of the rare consonantal feature of preaspiration. The chapters by Hejná (2025 [this volume]) and Craioveanu (2025 [this volume]) provide typological analyses of the phenomenon, but from divergent perspectives (see in this regard also Iosad's Chapter 2 in Part I). Both tend to de-exoticise preaspiration, but in different ways. Hejná argues that even phonological preaspiration is more common than typically thought, while phonetic preaspiration is actually frequent. Craioveanu, in turn, reanalyses preaspiration rather as a consonant cluster, using its separate syllabification from the following consonant as the main criterion. Finally, the chapter by van 't Veer et al. (2025 [this volume]) discusses the phonological status of preaspiration in a Tukanoan language of Ecuador. The sum of evidence leads the authors to maintain the status of preaspiration as a consonantal property in this particular case.

The following section provides more in-depth overviews of findings across individual chapters.

4.2 Outlines of individual chapters

Chapter 2 by Pavel Iosad (University of Edinburgh) “Why the search for rarities must take phonology seriously” takes issue with the general notion of a phonological rarity as a unit of cross-linguistic comparison. Iosad calls for an explicit definition of a “phonological phenomenon” and an explicit threshold for “rarity”, in order to ensure the commensurability of compared phenomena. The first plea is illustrated with a case study of final devoicing, where similar surface phonetic effects might reflect very different phonological systems, some of which can be rare. The second plea is discussed as applied to preaspiration, which is phonetically frequent but phonologically much less so. The definition of a “phonological phenomenon” also requires a necessary engagement of phonological typology with theoretically informed phonology. Iosad, much like Hyman & Plank (2018), notes an uneasy relationship between these two fields and explicates the need for their mutually fruitful collaboration. This is also in line with a call by Kiparsky (2018: 97) that “the search for better linguistic descriptions, more illuminating typologies, and stronger cross-linguistic generalisations and universals should go hand in hand”. Following the typological advances in areas other than phonology (cf. Section 2), Iosad also proposes to explicitly include historical and areal dimensions into both phonological typology and phonological theory, including those concerning rarities.

Chapter 3 “ **b* > *-k-*: A Berawan sound change for the ages” by the late Robert Blust (University of Hawai‘i, Mānoa) is a scrupulous analysis of all the attempts by previous authors to normalise this idiosyncratic sound change, i.e. to re-analyse it as one or several more “natural” (phonetically or phonologically motivated) changes. The conclusion is that each of these analyses is problematic, especially because they are too speculative and do not adhere enough to the principle of Occam’s razor (simplicity of explanation). Blust also tentatively suggests that such a bizarre sound change could have even been introduced by speakers consciously, for certain sociolinguistic reasons (cf. also Culhane & Edwards 2025 [this volume] below).

Juliette Blevins (The Graduate Center, CUNY) in Chapter 4 “Linguistically motivated sound change: Revisiting some of the world’s rarest wonders” takes an opposing stance regarding the aforementioned Berawan change and nine other rare Austronesian sound changes analysed by Bob Blust throughout his career.

She sees all of them as ultimately phonetically motivated, i.e. as "natural". In particular, Blevins interprets the Berawan **b* > *-k-* change as resulting from several regular processes of lenition and fortition (more specifically, glide strengthening). She nevertheless acknowledges the importance of Blust's plea for the maximal simplicity of analysis (Occam's razor). Additionally, in line with the general spirit of this volume, her analysis is multi-parametric, as it is informed by research in phonetics, phonological typology, historical linguistics, and contact phonology from the past several decades – and Blevins calls for more such analyses.

The processes of glide insertion and fortition in Austronesian are discussed also in Chapter 5 "Consonant epenthesis in Meto: Typologically rare but diachronically explicable" by Kirsten Culhane (University of Canterbury) and Owen Edwards (University of Cologne; Language and Culture Unit (UBB), Kupang). In line with Blevins, they see rare types of epenthetic consonants in Meto, an Austronesian language of Western Timor, through the lens of these phonetically "natural" emergence processes. Like Blust, the authors also propose taking potential sociolinguistic factors into account when analysing consonant epenthesis in Meto. Different epenthesis patterns seem to serve as group identity exemplifications cited by Meto speakers themselves in support of their inter-dialectal differences. This desire to be different (cf. Bird & Kell 2017 cited in Section 2) might be an additional factor in the phonologisation and entrenchment of diverse rare types of epenthetic consonants across Meto varieties. The chapter contains a supplement with a small comparative database abundantly illustrating various types of epenthesis in Meto.

Chapter 6 "Reconciling the debate about final obstruent voicing: The phonology of Lakota obstruent lenition" by Geoffrey Schwartz (Adam Mickiewicz University in Poznań) and Shanti Ulfsbjorninn (Memorial University of Newfoundland) takes an amphichronic stance, opposing the evolutionary one, in the conceptual debate on word-final obstruent voicing (see Section 2). This subject is at the very core of the principal disagreement between the two equally influential theoretical paradigms. Such a process is considered impossible in the amphichronic programme. The authors, therefore, re-analyse the newest case of this sort attested by Blevins et al. (2020) in Lakota (Siouan) as consonant lenition, which is a cross-linguistically common process. In this case, lenition is claimed to be manifested as sonorisation of stops and devoicing of fricatives. Importantly, word-final obstruent voicing is considered within a broader picture of the Lakota phonological system.

H. Ekkehard Wolff (Leipzig University) opens the word-prosodic part of the book with his foundational Chapter 7 "Typology and evolution of minimal vowel systems in Central Chadic (Afroasiatic)". The author has been studying the topic for several decades, and the chapter is a comprehensive summary of this life-long work. Proto-Central Chadic is reconstructed with a rare minimal system of just two vowels *a and *ə, where the latter is actually a non-phonemic intrusive vowel. Modern Chadic languages, however, have extremely variable vowel systems, presented in a range from just one vowel /a/ to 17 different vowels. Wolff describes the development between these two stages as the de-segmentalisation and prosodification of the consonantal features of palatalisation, labialisation, nasalisation, and laryngealisation. These features become associated with the whole stem and "colour" not only all stem vowels, but also many stem consonants. Later, this "colouring" phonologises in the stem's vowels and consonants in different ways and to different degrees across Central Chadic varieties.

In Chapter 8 "A model of non-modal phonation: Ballisticity in Otomanguean languages", Bien Dobui (Université de Picardie Jules Verne) discusses a non-canonical phonetic cue engaged in a word-prosodic (syllable level) contrast. This contrast is observed in some Otomanguean languages and is commonly referred to as "ballistic stress" vs. "controlled stress". The feature is analysed in the chapter as a contrast of spread vs. constricted glottis. It is independent of contrasts in tone, nasalisation, and vowel length. An application of a multi-dimensional approach to word prosody proposed by Hyman (2006, 2014) within Canonical Typology leads the author to conclude that "ballisticity" does not correspond either to canonical stress or to canonical tone, while it is still a lexicalised prosodic feature. This conclusion is very similar to that made for other rare laryngeal-based or quantity-based features in Danish, Estonian, and Udihe by Kuznetsova (2018, 2022). Such features challenge the established dichotomy of stress and tone as the only word-prosodic types, because they are "neither stress, nor tone" but still highly word-prosodic.

Chapter 9 by Nicholas Rolle (Princeton University; Leibniz-ZAS) "A tonological rarity: Tone-driven epenthesis in Ghomala'" stands out with respect to the other prosodic chapters, because it considers a rare prosodic process rather than a phenomenon. What is rare in this case, is a motivation for final vowel epenthesis. According to the author, epenthesis can usually be accounted for by segmental or syllabic well-formedness. However, in Ghomala', a Bamileke Grassfields language, the motivation is rather to avoid a contour tone on a single vowel. Unlike most other chapters, this chapter also discusses post-lexical prosody in its typological overview. The author draws parallels between tone-driven and intonation-driven vowel epenthesis. The latter is likewise rare but still appears to be significantly more frequent than the former.

Thom van Hugte (Leipzig University), Yiya Chen (Leiden University), and Li Guo (Shanghai International Studies University) open the vocalic part of the book with their Chapter 10 “The contradictory nature of fricative vowels in Chinese and beyond”. This is a comprehensive typological overview of fricative vowels. These segments are at a crossroad between vowels (according to their phonological functions and history) and consonants (according to their phonetics). A multiparametric approach, which includes the analysis of many phonetic and phonological dimensions, synchronic and diachronic factors, and the cross-linguistic diversity observed for these segments, allows one to see a fuller and much more nuanced picture than just a simple binary labelling of a segment as a vowel or consonant.

Chapter 11 “Uvularization in Queyu phonology” by Xuan Guan (University of Oregon) is dedicated to another type of less vowel-like vowels. This is more of a case study, because uvularised vowels are discussed for several varieties of the Qiangic language Queyu (Tibeto-Burman). The approach is also multidimensional: Queyu uvularised vowels are described from the phonetic (articulatory and acoustic), phonological, morphophonological (vowel harmony), and historical points of view. They are placed within other similar cross-linguistic phenomena (uvularised, velarised, and pharyngealised vowels). The origin of uvularised vowels appears to be quite different from that of fricative vowels (van Hugte et al. 2025 [this volume]). The latter are the result either of an assimilation by manner of articulation with preceding consonants, or of vowel raising. Uvularised vowels rather represent a merger of a vowel and a preceding or following velar or uvular consonant. Some fricative vowels outside Sinitic (in Lakes Plain, Papuan), however, might also originate from a vowel and a following obstruent, as argued by van Hugte et al. (2025 [this volume]).

The consonantal part of the book opens with Chapter 12 “Silent sonorant articulations in Mehri and Shehret” by Janet C. E. Watson (Sultan Qaboos University, Muscat; University of St. Andrews), Barry Heselwood, Gisela Tomé Lourido (University of Leeds), Amer al-Kathiri (University of Technology and Applied Sciences, Salalah), and Abdullah al-Mahri (Dhofar). This chapter is outstanding in several respects. It discusses word-final sonorant realisations with no or very little acoustic output. The authors argue that such sonorants nevertheless contrast in manner of articulation and laryngeal specifications (plain vs. breathy). The analysis is backed up with the experimental results of several articulatory studies. An ELG study shows that phonetic realisations of preceding vowels contain some acoustic cues at least to the laryngeal contrast of silent sonorants. The authors discuss such silent realisations within the typology of consonantal lenition, arguing that these pronunciations constitute an unusual case. They have neither become more sonorous, nor has their articulation shown signs of decrease in the degree of articulatory constriction, as observed in a EPG study. This study raises important theoretical questions on the precise mechanisms of perception by speakers, transmission, preservation, and overall stability of such contrasts, as well as it contributes to the typology of lenition.

Chapter 13 "Aerodynamic and acoustic correlates of word-initial voiceless nasal geminates of Ikema Miyako Ryukyuan" by Shigeko Shinohara (Laboratoire de Phonétique et Phonologie, CNRS/Sorbonne Nouvelle), Qandeel Hussain (Universität Bamberg; University of Toronto; North Carolina State University), and Angélique Amelot (Laboratoire de Phonétique et Phonologie, CNRS/Sorbonne Nouvelle) is the other chapter in the volume which presents new experimental phonetic data. Experiments studied duration, voice quality features, and oral and nasal airflow for rare word-initial voiceless geminate sonorants in the Ikema dialect of Miyako Ryukyuan (Japonic). These sounds do not contrast with singleton voiceless sonorants in the system. They originate from combinations of high vowels (plain or fricative) and preceding obstruents or obstruent and fricative clusters (cf. Chapter 10). In addition to phonetic data, the authors provide phonological, historical, and typological analyses of voiceless geminate obstruents. A question can be raised here whether these sounds are best analysed as single geminate phonemes (as the authors propose) or as sequences of voiceless and voiced sounds. Only their initial portion (~1/3) is voiceless, and their overall duration is significantly longer than that of voiced sonorant geminates.

Chapter 14 "Preservation and loss of a rare contrast: Palatalization of rhotics in Slavic" by Darya Kavitskaya (UC Berkeley) and Florian Wandl (University of Zurich) is quite different from the two previous chapters in Part V. It discusses the history of a rare contrast between plain and palatalised rhotics observed in several Slavic languages. The contrast was lost or transformed into a different contrast in some other Slavic varieties. The authors explicate potentially conflicting articulatory or aerodynamic demands on palatalisation and rhotic trills as a possible underlying source for the rarity of the emergence of this phonological contrast. They argue then that this contrast has been preserved in those Slavic languages where its functional load was especially high, including a very broad range of its phonological contexts of occurrence and great extent of contrastive palatalisation in the system in general.

Rebekka Puderbaugh (University of Edinburgh) in Chapter 15 "Ejective fricatives in Upper Necaxa Totonac: Complex segments or consonant clusters?" discusses the synchronic phonological status of these units on the basis of several different parameters. The very path of their emergence from fricative plus stop clusters through a series of sound changes was quite unremarkable. What is rare is that those processes did not apply to other sounds, so only fricatives have ejective counterparts in the synchronic system. A multi-parametric analysis based on the distributional properties of ejective fricatives in comparison with other Upper Necaxa Totonac consonants, and on their phonetic properties leads the author to conclude that it is still best to treat these rare sounds as clusters rather than as single complex segments.

A comprehensive Chapter 16 "On the rarity of pre-aspirated consonants" by Michaela Hejná (Aarhus University) opens the last part of the book. The text is accompanied by an extensive supplement, listing all languages for which phonetic or phonological preaspiration or similar phenomena have been claimed, with references. This chapter discusses the questions of how to define and quantify preaspiration and whether it is actually rare. In this, it echoes Chapter 2 by Iosad, which considers the analytical challenges of cross-linguistic comparison of rarities in general. Hejná aims at a maximally broad cross-linguistic survey of preaspiration based on its very lax definition (including also pre-affrication, prespirantisation, sonorant and vowel devoicing, /s/ debuccalisation, /hC/ clusters, vowel aspiration, and glottalisation). The result is that phonological preaspiration taken very broadly is still rare, although phonetically it is a much more frequent phenomenon. In many cases, it serves as a secondary phonetic cue for fortis/lenis and similar contrasts. A firmly established phonological contrast between pre-aspiration and post-aspiration has not been attested in any language. However, the author argues that the two phenomena are still phonetically very distinct, so such a contrast is not impossible in principle. Hejná further discusses potential evolutionary reasons for this rarity, as well as possible analytical biases present in the very description of data containing preaspiration.

Chapter 17 "Weighing preaspiration" by Radu Craioveanu (University of Toronto) is yet another typologically instructed view on consonantal preaspiration. The author analyses in reasonable detail a subset of 12 genetically diverse languages, mostly of Europe and North America, and mentions a few additional languages. The general conclusion is that preaspiration in these languages is always syllabified separately from the following consonant. The author also argues that preaspiration associated with the coda of the preceding syllable always bears prosodic weight (a mora). One typological question which arises here is whether the mora is a necessary or at least useful concept for all the languages for which preaspiration has been ever claimed. Also, are syllable boundaries always uncontroversially identified for all these languages? Another concern is whether just one criterion (in this case, of syllabification) enables one to say anything about the phonological status of preaspiration as a consonantal feature or as a separate consonant /h/. The chapter clearly sets up this and other theoretical questions regarding the formal phonological status of preaspiration across individual languages, forming a basis for future research in this direction.

Chapter 18 "Pre-aspiration in Ecuadorian Siona" by Marijn van 't Veer (University of Amsterdam), Martine Bruil, and Oleksandra Damonte-Matveienko (Leiden University) concludes the volume by discussing preaspiration in a Western Tukanoan language and considering a diverse range of evidence. The authors discuss the distributional and phonetic properties of Siona preaspiration, as well as its emergence, proposed to be through the gemination of voiceless consonants. Preaspiration is also seen in the context of other laryngeal features of the language (in particular, the status of the glottal fricative and stop), word prosody (stress and moraic structure), and nasal harmony. This multi-parametric approach leads the authors to conclude that Siona preaspiration is best seen as a consonantal feature.

Author contributions

The draft text of this chapter was written by CA (Sections 1 and 3) and NK (Sections 2 and 4) and subsequently read and revised by all authors. Both CA and NK are the first authors of the chapter.

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Chapter 2

Why the search for rarities must take phonology seriously

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What is a phonological rarity? Answering this question requires both a clear understanding of what counts as "a phonological phenomenon", and a determination of baseline frequencies for "common" or "rare" phenomena. I argue that addressing both of these issues requires us to take seriously current views on the division of labour in phonological theory, particularly within an "amphichronic" view (Kiparsky 2006, Bermúdez-Otero 2015). Since the study of rarities is ultimately a typological enterprise, I focus on examining how typological enquiry should take into account the precise analytical status of the phenomena in question. To do so, I offer two case studies on the phonological typology of laryngeal contrast: the relationship between phonemic analysis and phonetic implementation, with a focus on the relatively rare systems that lack laryngeal contrast in obstruents, and the unusual status of preaspiration. In both cases, I argue that a theoretically informed approach significantly enriches our understanding of the typological variation. In conclusion, I outline a programmatic case for a phonological typology that is both theoretically grounded and explicitly diachronically oriented, in line with developments in morphosyntactic typology. I suggest that this approach is necessary to give us a clearer view of what is most appropriately treated as a rarity. More generally, a theoretically informed approach to cross-linguistic variation may assist us in incorporating the very significant recent advances in distributional and diachronic typology into explanatory models of phonology.

1 Phonological rarities and typology

Phonological theory has historically been closely involved with questions of frequency asymmetries. Whether a phenomenon is typologically common or rare is

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often taken as informative for theoretical analysis, very often under the rubric of "markedness" (Hume 2011). Analytic frameworks such as Evolutionary Phonology (Blevins 2004) take commonality *resp.* rarity to be fundamental *explananda* for phonological theory. And yet, while typologists have engaged in some theoretical and methodological reflection on the problem of rarities (cf. Cysouw & Wohlgemuth 2010), phonologists have not often considered issues that have traditionally preoccupied typological research (cf. Plank 2018). As a result, much progress in phonological typology has in recent years come via approaches first developed in the typological study of other domains, first and foremost morphosyntax. Morphosyntactic typology has often had a somewhat uneasy relationship with "formal" linguistic theory, preferring instead to look for frameworks that avoid overly specific theoretical commitments (e. g. Dryer 2008, Haspelmath 2010). In this chapter, I explore some consequences of transferring this approach into the realm of phonological typology, with particular reference to the issue of phonological rarities.

Of course, typology is not a unified field, with numerous directions and areas of emphasis. In recent years, typology has increasingly reoriented from the task of *classifying* languages as showing traits associated with more or less idealized "types" towards a more historically and spatially embedded approach that focuses on questions of "what's where why" (Bickel 2015), a turn that has both necessitated and been facilitated by the construction of sophisticated, large-scale datasets amenable to quantitative analysis.

Under this view, typology is primarily a historical enterprise, which aims to uncover not just what is possible or frequent in human language, but also how the present-day situation came to be. Its task lies in disentangling the multifarious forces – biological, cognitive, cultural, and sociohistorical – that have shaped the observed picture. Thus, I take typology to be, in a very broad sense, a branch of historical linguistics.[1] As such, the central question of typology is also the central question of historical linguistics, namely "what happened?" (Campbell 2006).

In this chapter, I approach the issue of phonological rarities from this ultimately diachronic perspective, which seeks to understand various factors that determine the distribution of linguistic phenomena by way of influencing their development over time. In the particular case of phonology, I argue that the study of rarities should be framed within approaches developed in historical phonology, incorporating insights from synchronic phonological theory alongside other

[1]This framing is, of course, in no way new: see, for instance, Morpurgo Davies (1975), Campbell & Poser (2008) on the relationship between typology, historical-comparative linguistics, and language classification.

domains of enquiry (Salmons 2021). In Section 2, I describe some tensions between such a theoretically informed approach to phonology and typological enquiry. I then present two case studies showing why theory is indispensable to further progress. In Section 3, I discuss the interface between the study of phonemic inventories (perhaps the most developed area of distributional phonological typology) and current approaches to phonological representations, with specific reference to laryngeal contrast. I further develop this case study in Section 4, where I consider how phonological theory can contribute to the typological study of preaspiration, a phenomenon often considered a typological rarity. Finally, in Section 5 I sketch one possible method for bringing advances in theoretical phonology to bear on typological enquiry, inevitably including the problem of rarities.

2 Typology and phonology: an uneasy relationship?

The relationship between linguistic typology and phonological theory (or, perhaps more appropriately, theoretically informed phonology) is a key concern of the present chapter (and indeed the present volume).[2] There is no a priori reason for it to be especially uneasy: after all, phonological data of *some* nature is easily available, and indeed abundant, in almost any linguistic description. On the other hand, it is difficult to credibly accuse phonologists of an excessive focus on English: for example, the index to Trubetzkoy (1939), one of the foundational texts of present-day phonological theory, contains entries for almost 200 languages (admittedly, the list has a very strong bias towards Eurasia, although this is at least in part due to the state of descriptive linguistics at the time). More recently, argumentation from typological distributions (in the guise of so-called "factorial typology") has played a key part in the development of Optimality Theory.

Nevertheless, as Plank (2018) discusses, the cross-fertilization between the two fields has historically been limited. As he puts it – with a degree of exaggeration, of course – typologists are "phonologically challenged", in that they rarely engage with the kinds of questions that are central to specialists in phonology. Phonologists, in turn, are "do-it-yourself typologists", who work freely across a wide range of languages, but remain isolated from developments in typology as it is currently constituted.

A brief illustration might be in order. Let us consider the following statement:

[2]Here, I take a rather broad view of what counts as phonological theory. In particular, I have little to say about the merits or demerits of changing views about the nature of phonological derivations or the role of rules and constraints (Anderson 2021, Dresher & van der Hulst 2022).

(1) Final devoicing is typologically unremarkable.

I do not have hard data on this point, but it is likely that most working linguists, to the extent they have ever given this point any thought, would probably regard it as almost entirely unobjectionable (Blevins 2004: 94). But is it *true*?

The answer turns out to be surprisingly tricky. First, what does "final devoicing" actually refer to? Prototypically, it is a merger of two sets of segments distinguished by a laryngeal feature, in some kind of word-final position, with a voiceless outcome. Examples are readily found in languages like Polish ([poli1250], Indo-European > Slavic) or Friulian ([friu1240], Indo-European > Romance):

(2)	[ˈalte]	*alt-e*	'tall-F.SG'	(Friulian, Roseano & Finco 2022: 638)
(3)	[ˈalt]	*alt*	'tall.M.SG'	
(4)	[ˈcalde]	*cjald-e*	'hot-F.SG'	
(5)	[ˈcalt]	*cjalt*	'hot.M.SG'	

From a phonologist's perspective, however, this merger can come about in any number of ways. Granting a typical two-level architecture distinguishing between underlying and surface representation, we can describe the process shown in these examples as mapping underlying /d/ (and other featurally similar obstruents) to surface [t] in word-final position. However, as we shall discuss in more detail in Section 3 below, the precise nature of that mapping depends on the assumed featural structure of the segments involved. Iverson & Salmons (2011), building on Vaux & Samuels (2005), elaborate this point in a theoretical context, and conclude that the process traditionally labelled as "final devoicing" is in fact just one possible facet of a more general phenomenon of *final laryngeal neutralization*, which encompasses a range of different, if superficially similar, phonological processes.

A typologist, on the other hand, might reasonably ask just how widespread this phenomenon is. Here, Iverson & Salmons (2011) offer what they describe a "typological overview" of this process, but in fact their discussion focuses on pinpointing whether particular varieties of final laryngeal realization are attested in the record, without too much attention to frequency or spatial and genealogical asymmetries. Valuable as such an overview is, it is a far cry from the state of the art in linguistic typology, as described in Section 1.

One well-known database giving an insight into the typology of phonological phenomena is P-base (Mielke 2008, Brohan & Mielke 2018). Figure 1 shows the spatial distribution of 68 instances of phenomena identifiable as final devoicing, including both rules and static distributions, plotted using geographical coordinates from the Glottolog database (Hammarström et al. 2022).[3]

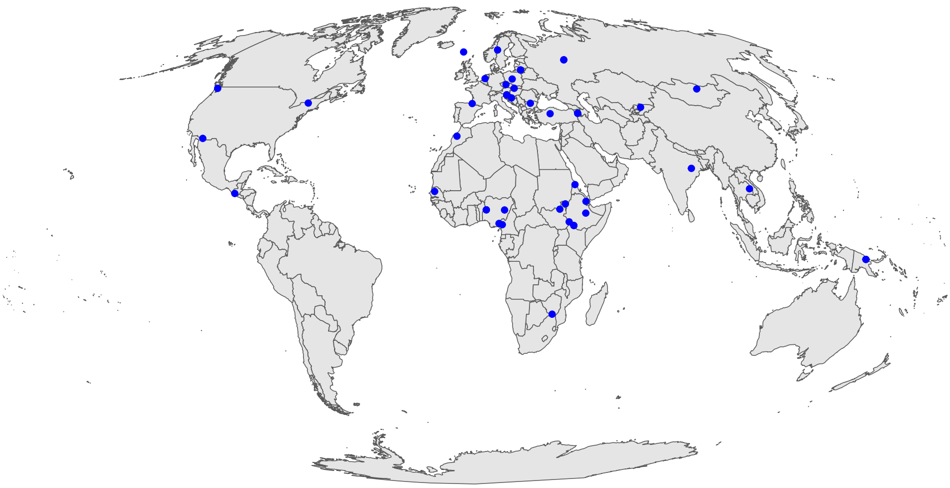

Figure 1: The distribution of final devoicing in P-base

The picture shown in Figure 1 is, perhaps, rather surprising. Some version of final devoicing is found on most continents, but no examples are identified in Australia or South America: final devoicing is not rare, but neither is it ubiquitous. Perhaps even more surprisingly, in this presentation we see a rather pronounced areal signal: instances of this process appear to cluster especially strongly in Europe and in Ethiopia. Admittedly, both of these zones have been discussed as potential linguistic areas: cf. König & Haspelmath (1999) on Europe and Ferguson (1976) on Ethiopia (but see the contrary view in Tosco 2000). Even so, final devoicing is, to my knowledge, rarely pinpointed as potentially contributing to the definition of linguistic areas. For example, it is absent in Ferguson's (1976) list of possible phonetic traits of the Ethiopian area, whilst Ternes (2010) provides a discussion of final devoicing in Europe but does not claim it as a "Europeme" (a feature that is exclusive to Europe or highly characteristic of it).

Of course, we should not take these findings too seriously. For one thing, given its methods and aims, P-base is not even intended to present either a comprehensive view of phonological processes or a representative database addressing classical typological concerns of sampling bias (Mielke 2008: 47–48). Even a cursory glance at Figure 1 shows that, for instance, the Turkic languages, a genus where final devoicing is ubiquitous (Johanson 2021: 27–28), are underrepresented in the

[3]Specifically, the query involved a change from [+voiced] to [−voiced] in word-final position.

data; the same applies to Austronesian, a phylum where final obstruent devoicing is rare as an alternation, but frequent as a sound change and (consequently?) a phonotactic restriction (Blust 2013: pp. 220–222, 246–247). There is, of course, also an overall documentation bias: the kind of detailed data necessary to make inferences about phonological patterns is simply more available for some languages compared to others, leading to underrepresentation of minoritized and indigenous languages. Furthermore, simple counting of attestations of a contextually restricted process such as final devoicing can never give a correct picture without controlling for phonotactic patterns or the presence of other phonological processes. Thus, no inference can be drawn from the absence of final devoicing in languages that do not permit any coda consonants at all, or where final consonants are subject to other processes (such as the neutralization of all word-final stops to [ʔ], which is common, for instance, in Austronesian languages; Blust 2013: 246–247).

Nevertheless, this result should also give us pause. In particular, is the common intuition that final devoicing is frequent too reliant on the fact that it is (unusually?) common in familiar European languages? A salutary reminder here comes from Ladd (2022), who observes that phonological theories developed in Central and Western Europe, including Prague School structuralism, were very concerned with the question of neutralization, with the final devoicing of German, Russian, or Czech taking centre stage. Conversely, North America was dominated by "post-Bloomfieldian" structuralism, whose *lingua franca* was English, a language with very few neutralizing alternations of a similar kind – with the result that neutralization did not play an especially important role in the theory.

The central question of this chapter is how we can make progress towards a phonological typology that allows us to address the question of whether a particular phenomenon is rare (or, indeed, common) with the degree of rigour expected in modern typological enquiry. At first glance, phonology and phonetics should be amenable to the creation of empirically rich databases. Indeed, a priori we might expect this domain to be particularly well suited to the enterprise: relevant data is found in abundance both in broader typological databases such as WALS and in an increasing number of dedicated sources, with different sampling methods, coverage, and inclusion criteria, such as UPSID/LAPSyD (Maddieson 1984, Maddieson & Precoda 1989, Maddieson et al. 2013), P-base (Mielke 2008), or PHOIBLE (Moran & McCloy 2019), to name just a few, in addition to domain-specific databases such as BDPROTO (Moran et al. 2020).

What kind of data do we find in these sources, and what kinds of research questions do they allow us to answer? First and foremost, they have tended to concentrate on phonemic inventories. In more senses than one, this is low-hanging fruit. The data is often easily available: most grammatical descriptions will include at least a phoneme chart, even if there is no other detailed phonological information. Second, phonemic inventories might seem particularly suitable for cross-linguistic comparison. After all, criteria for phonemic status appear to be widely agreed, uncontroversial, and applicable without much difficulty to most, if not all, languages across genealogical groupings and time periods and even modalities (see, however, Kiparsky 2018).

Indeed, we can point to some very real results and advances in a spatially and temporally embedded phonological typology, such as the demonstration of subtle and interesting areal signals in the distribution of affricates within Eurasia by Nikolaev & Grossman (2018) or the nuanced study of areal phonetics and phonology in the Caucasus by Grawunder (2017). The distributional typology of phonological inventories in segmental and suprasegmental domains has also informed other kinds of (often historically oriented) enquiry (e. g. Atkinson 2011, Everett 2013, Everett et al. 2015, Urban & Moran 2021).

As with other areas of typology, further advances are on the horizon. For instance, Nikolaev (2019) offers the beginnings of a general theory of how language contact and areality can be reflected in distributional typology; Macklin-Cordes et al. (2021) demonstrate how quantitative methods in the modelling of phonotactics can make further contributions to answering "what's where why" questions, while Napoleão de Souza & Sinnemäki (2023) extend typological methods to the domain of suprasegmental phonology; and Round et al. (2022) offer a quantitative approach to the long-standing hypothesis that pathways of phonological change relate to the functional load of phonemic contrasts. Without wishing in any way to underplay the importance and significance of work already carried out on applying typological and/or phylogenetic methods to phonological systems, in this chapter I would like to address some key areas where "modern" phonological typology and considerations rooted in earlier approaches are in danger of becoming disconnected in ways that hinder further progress. In particular, I am concerned with the question of how much distributional typology can afford to abstract away from phonological theory. To put it another way: are the kinds of things phonologists are preoccupied with of any use to those working in typology? And if not, is it because phonologists have simply neglected something they should (also) work on, or are there issues that typologists need to engage with in order to reach a better understanding of the key questions of "what, where, when, and why"?

Like the problem of final devoicing, the case studies I use as a lens for addressing these issues are related to the phonology and phonetics of laryngeal contrast. In the next section, I discuss the typology of apparently simple, two-way systems of laryngeal contrast and how it can be investigated using data on phonemic inventories.

3 Levels of representation in phonological typology

In the earlier discussion of final devoicing in Friulian in Section 2 I referred to segments usually transcribed with symbols such as <d> as “voiced”, and those usually written as <t> as “voiceless”. However, we also noted that languages differ in the phonological content – the featural specification – of these labels, and consequently in the nature of final laryngeal neutralization (Vaux & Samuels 2005, Iverson & Salmons 2011). Equally, it is also well known that languages differ in the precise phonetic realization of the two categories (see, for instance Petrova et al. 2006, Chodroff et al. 2019).

Natvig (2019), building on Purnell & Raimy (2015), offers a useful handle on understanding this variability. His discussion is focused on contact-induced change, but the architecture is widely applicable. He distinguishes three levels of representation:

phonological: inhabited by abstract categories implementing lexical contrasts;

phonetic-phonological: where phonological categories are fleshed out in coarse phonetic detail, for example by specifying what kind of gestures (or more precisely “dimensions”, following Avery & Idsardi 2001) are involved;

phonetic: having to do with the language-specific implementation of the phonetic-phonological representations, such as the specific timing of the gestures.

It can be shown that these levels are autonomous because we can identify cross-linguistic variation in each of them. Natvig (2019) shows this with respect to how laryngeal phonology is affected in different contact settings, but this can also be demonstrated in more focused synchronic analyses: see, for instance, Honeybone (2005) on phonological variation, Avery & Idsardi (2001) on phonetic-phonological architecture, and any number of detailed studies of finely grained phonetic variation (on English laryngeal systems, see, for example Docherty 1992, Scobbie 2006, Jacewicz et al. 2009, Docherty et al. 2014, Sonderegger et al. 2020).

In this chapter, I will use this framework in concert with the *amphichronic* approach, as developed by Bermúdez-Otero (2007, 2015), Bermúdez-Otero & Trousdale (2012). It assumes a view of phonological architecture that also distinguishes between the phonological grammar (a set of rules manipulating discrete representations) and the wider phonetic-phonological system of the language that also comprises a set of "phonetic rules" regulating how phonological representations are implemented. The former maps neatly to the phonological level, whilst the latter broadly corresponds to the phonetic-phonological and phonetic levels. A crucial notion is the *life cycle of phonological processes*. Under this view, sound patterns arise out of the pool of acoustic and articulatory variation that exists primarily by virtue of non-cognitive factors. First, they undergo the process of *phonologization*, in which they become language-specific phonetic rules, and later *stabilization* as they enter the phonological grammar. Table 1 shows the mapping between the levels and notions related to the life cycle.

Table 1: Levels of representation and the life cycle

<table>
<tr><th>Level</th><th>Representations</th><th>Status of pattern</th><th>Life cycle stage</th></tr>
<tr><td></td><td>Acoustic events</td><td>Not under cognitive control</td><td>Pre-life cycle</td></tr>
<tr><td>Phonetic</td><td>Gestural scores…</td><td rowspan="2">Phonetic rule</td><td rowspan="2">Phonologization</td></tr>
<tr><td>Phonetic-phonological</td><td>Dimensions…</td></tr>
<tr><td>Phonological</td><td>Segments, features, metrical structure…</td><td>Phonological rule</td><td>Stabilization</td></tr>
</table>

This raises both conceptual and empirical questions. Conceptually, which, if any, of these levels is the right one for typological enquiry? The empirical question is perhaps more pressing: what data do the existing sources actually contain?

The most obvious answer is that this is the phonological level, which distinguishes a very limited number of "phonemic" series, such as voiceless /p, t, k/ and voiced /b, d, g/ in most languages of Western Europe. But what is the exact content of the units at this level, and how do we compare them across languages?

3.1 Laryngeal specification and phonological contrast

We can start approaching this issue by considering inventories with only a single laryngeal series of obstruents. The typological import of such systems is discussed by Hyman (2008). That paper, in offering detailed consideration of phonological typology from a more traditional perspective focused on language universals, raises precisely the question of the extent of analytic input into the construction of phonological "facts". As Hyman (2008) discusses, "all languages have [phonemic] voiceless stops" is a candidate for an absolute phonological universal, but its status hinges on the exact content of the label "voiceless". He considers the status of languages such as Yidiɲ ([yidi1250], Pama-Nyungan > Yimidhirr-Yalanji-Yidinic), which have a single series of stops that are realized with some degree of voicing. Do they falsify the universal? If we take the definition of "voiceless" to embrace phonetic detail, then Yidiɲ is clearly a counterexample. On the other hand, it is also possible to say, as Hyman (2008) does, that such a language has a single voiceless series, if we take the observed phonetic voicing to be redundant, and irrelevant for our view of the phonological system. In this section, I expand on Hyman's (2008) point that typological generalizations in phonology can be difficult to even formulate, let alone verify, without reference to some theory of featural structure; see also Vaux (2009), Dresher et al. (2018), Youssef (2021) for recent restatements of the importance of attention to features in phonological typology.

Such theoretical questions are difficult enough to answer even *a priori*, without turning our attention to the quality of the underlying descriptions, and the role of variation in phonological analysis. How does the potentially "redundant" voicing in Yidiɲ stops compare with voicing in systems with a contrastive voiced series? More generally, how much variation can we allow: if we treat all languages without a laryngeal contrast as having a single voiceless series, how much leeway can we give the phonetic component?

Kakadelis (2018) offers some progress via a careful phonetic study of three such languages: Bardi ([bard1255], Nyulnyulan), Arapaho ([arap1274], Algic > Algonquian), and Sierra Norte de Puebla Nahuatl ([high1278], Uto-Aztecan > Aztec). She shows that despite the similarities in their phonology – they seem to have the same structure of laryngeal contrast – such systems implement the contrast very differently, in terms of timing, phonation, manner, and no doubt other properties. Kakadelis suggests that these findings "do not lend themselves to an analysis where [the languages] share the same underlying laryngeal representation" (p. 290), implicitly rejecting analyses such as Hyman's (2008). However, this conclusion only follows under certain theoretical premises, namely that the lack of laryngeal contrast *within* the set of obstruents necessarily implies the lack of a phonological specification for laryngeal features. Kakadelis (2018) suggests an analysis where privative features are assigned without regard to contrast, preserving the link between lack of phonological specification and increased range of phonetic variation, but at the cost of denying that contrast is important for featural structure.

However, depending on one's theoretical commitments this difficulty is not insurmountable. The key issue here is the definition of "redundancy". A key insight in phonology, going back all the way back to the Prague School, is that languages can differ in how "the same" phonetic substance is reified in terms of phonological contrast. This view is reiterated, for instance, by Lass (1984), Simpson (1999), Vaux (2009).[4] A prominent modern formalization of this approach is Modified Contrastive Specification (Dresher 2009). In this framework, it is perfectly possible to assign different featural specifications to superficially similar sets of segments without abandoning the commitment to avoiding redundancy in featural structure. Crucially, this approach makes specific predictions relating the place of laryngeal features within the contrastive hierarchy and patterns of phonetic underspecification and variation, which we can test against the observed systems.[5]

Let us first consider a system like Bardi (Bowern et al. 2012, Kakadelis 2018), an indigenous Australian language not dissimilar to Yidiɲ. Here, "stops" show extensive variation in terms of both voicing and manner. Within the consonant inventory, the "stops" – the label is something of a misnomer, given the ubiquity of a lenition process that often results in continuant articulations – contrast with nasals, laterals, rhotics, and glides. By contrast, all the sonorants are described as "phonetically and phonologically stable segments" by Bowern et al. (2012: 339). We can analyse the inventory of Bardi with wide scope for the manner features corresponding to nasality, laterality, and rhotic status, as sketched in Figure 2.[6] The lack of obstruent specification (and *a fortiori* laryngeal specification) accounts for the unstable behaviour of the segments in question.

In Sierra Norte de Puebla Nahuatl, the stops /p, t, k, k^w/ are generally voiceless, albeit with a significant proportion of closure voicing in contexts where phonation (modal voicing) typically perseveres from the preceding context (intervocalically and especially after a nasal). Unlike Bardi, they are not especially prone to lenition, with the exception of the velars, which are often realized with voicing

[4]See Trubetzkoy (1931) for an early statement of this approach to the cross-linguistic comparison of phonological systems within a phoneme-based framework.

[5]For extended concrete applications of the approach linking contrastive feature scope and phonetic variation, see recently Dresher et al. (2018), Natvig (2018), Purnell et al. (2019).

[6]For concreteness, I use an abstract "cover" feature for "rhotic manner". I also use binary features here, but a privative system is, if anything, more suited to capturing the kind of underspecification insights the analysis seeks to capture. See Hall (2007), Iosad (2017), Sandstedt (2018) for approaches combining privative features with Modified Contrastive Specification.

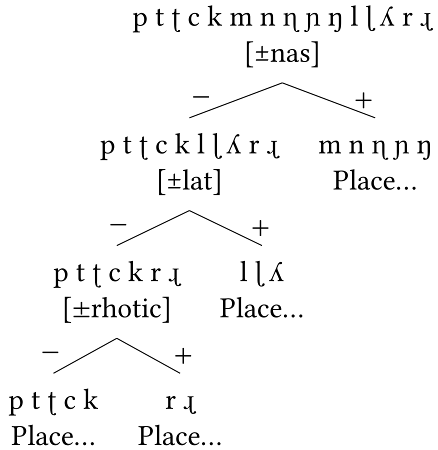

Figure 2: An outline contrastive hierarchy for Bardi

and/or as continuants. This may have led to the appearance of a phonemic /ɣ/, which is nevertheless highly marginal. This system can be accommodated if velars are specified for neither voicing nor continuancy, whilst the other stops are contrastively noncontinuant, but still underspecified for voicing. One contrastive hierarchy that meets this requirement is shown in Figure 3. Here, the place feature for velars takes scope over the manner features that come into play for other stops, rendering them redundant in the velar subinvenory. This results in a high degree of underspecification similar to what we saw in Bardi. The other stops do enter a manner contrast with fricatives: this motivates a categorical specification as noncontinuants, accounting for their resistance to lenition. However, there is no need to set up a voice contrast for these segments, which leaves some leeway for variation in this dimension.

Finally, in Arapaho the apparently voiceless stops also fall into two classes. The non-labial stops are relatively stable in terms of both manner and phonation-related properties such as VOT. Like in Sierra Norte de Puebla Nahuatl, stops at non-labial places of articulation contrast with a series of fricatives, which contributes to the lack of variation in manner. In this language, it is the labial stop that both lacks a fricative counterpart and is significantly more prone to both manner lenition and voicing. The difference, however, is that these stops also resist closure voicing, suggesting they are contrastively voiceless. An analysis reflecting these specifications is sketched in Figure 4.

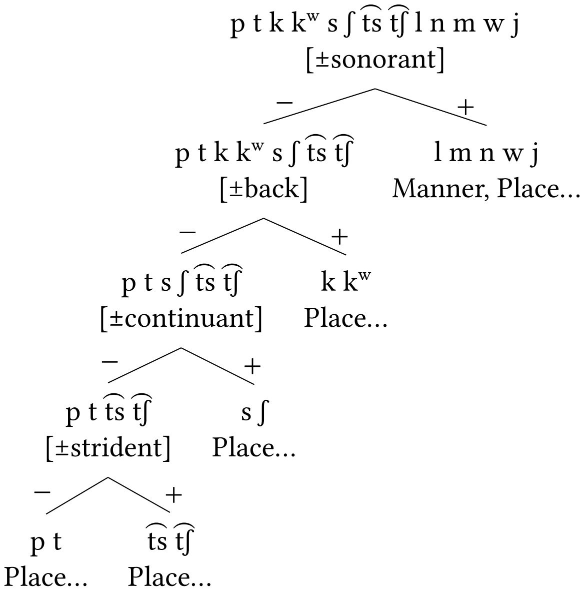

Figure 3: An outline contrastive hierarchy for Sierra Norte de Puebla Nahuatl

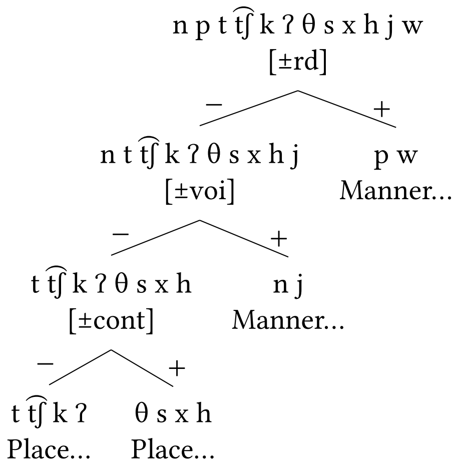

Figure 4: An outline contrastive hierarchy for Arapaho

3.2 Laryngeal contrast and phonetic-phonological variation

The discussion in Section 3.1 aimed to demonstrate the existence of a non-trivial space of possibilities available to encode sparse phonological representations that lack a lot of the phonetic detail in the construction of typological datasets. The challenges become even more acute if more descriptive phonetic detail is admitted into the typology. Consider a simple two-term system distinguishing a voiceless and a voiced series. There is an extensive literature claiming that such a pattern of phonological contrast can be implemented in multiple ways (cf. Beckman et al. 2013, Salmons 2020). Generally, voiceless stops can be realized with short-lag voice onset time ("voiceless unaspirated") or with long-lag VOT ("voiceless aspirated"), whilst voiced stops run the gamut from consistently prevoiced (VOT lead) in all positions to consistently voiceless (unaspirated), with many languages showing extensive surface variability.

To probe this variation, Table 2 lists some languages for which this issue has been addressed in the phonetic literature, grouped into four broad "types", and compares the results to the listing in PHOIBLE (Moran & McCloy 2019). Where PHOIBLE includes more than one entry for a particular language, or records synchronic variation, I use the ~ symbol to record the variants. (To save space, I do not distinguish between the two possibilities.) The "types" are, broadly, "voicing" languages with no aspiration in the voiceless series and consistent prevoicing of voiced stops; "aspirating" languages contrasting aspirated and variably voiced series; "voiceless" languages where both voiceless and voiced stops are realized without vocal fold vibration; and "overspecified" languages in which both aspiration and prevoicing are consistently used in the respective series.[7]

The point of this exercise is not to quibble about the quality of the PHOIBLE data: after all, it can only be as good as the available sources. Rather, it is to examine how the observed variation is encoded in a database. What Table 2 shows is that the only type for which the relationship between the phonetic findings and the PHOIBLE encoding is consistent is the "voicing" class contrasting voiceless [p, t, k] and fully voiced [b, d, g]. In other cases, there is a degree of inconsistency

[7]The sources used are as follows: Russian [rus1263] (Ringen & Kulikov 2012), French [stan1290] (Abdelli-Beruh 2004), English [stan1293] (Jansen 2007), German [stan1295] (Jessen & Ringen 2002), Turkish [anat1259] (Kallestinova 2004), Persian [west2369] (Bijankhan & Nourbakhsh 2009), Scottish Gaelic [scot1245] (Nance & Ó Maolalaigh 2021), Danish [dani1285] (Hutters 1985, Puggaard-Rode et al. 2022), Ulster Irish [done1238] (Ní Chasaide 1985), Swedish [stan1279] (Helgason & Ringen 2008), Najdi Arabic [najd1235] (Al-Gamdi et al. 2019), Mehri [mehr1241] (Watson & Heselwood 2016). None of the sources listed here appear in the bibliography for PHOIBLE, although I have not excluded the possibility that some of PHOIBLE's sources may in turn rely on these.

Table 2: Some systems of laryngeal contrast

Type	Language	Source: VOICELESS	Source: VOICED	PHOIBLE: VOICELESS	PHOIBLE: VOICED
Voicing	Russian	p, t, k	b, d, g	p, t, k	b, d, g
	French	p, t, k	b, d, g	p, t, k	b, d, g
Aspirating	English	pʰ, tʰ, kʰ	b~b̥, d~d̥, g~g̊	pʰ, tʰ, kʰ	b, d, g
	German	pʰ, tʰ, kʰ	b~b̥, d~d̥, g~g̊	p(ʰ), t(ʰ), k(ʰ)	b, d, g
	Turkish	pʰ, tʰ, kʰ	b~b̥, d~d̥, g~g̊	p(ʰ), t(ʰ), k(ʰ)	b, d, g
	Persian	pʰ, tʰ, kʰ	b~b̥, d~d̥, g~g̊	pʰ, tʰ, kʰ	b, d, g
Voiceless	Scottish Gaelic	pʰ, tʰ, kʰ	p, t, k	pʰ, tʰ, kʰ	p, t, k
	Danish	pʰ, tʰ, kʰ	p, t, k	pʰ, t͡sʰ, kʰ ~ b̥ʰ, d̥ʰ, g̊ʰ	b̥, d̥, g̊
	Ulster Irish	pʰ, tʰ, kʰ	p, t, k*	p, t, k	b, d, g
Overspecified	Swedish	pʰ, tʰ, kʰ	b, d, g	p(ʰ), t(ʰ), k(ʰ)	b, d, g
	Najdi Arabic	tʰ, kʰ	b, d, g	t, k	b, d, g
	Mehri	tʰ, kʰ	b, d, g	tʰ, kʰ	b, d, g

* Some perseverative voicing

as to whether aspiration is represented in the database, and the reflection of variable voicing in the VOICED series appears to be a particular source of divergence.

Even allowing for the multiple representations found in the database, Table 2 significantly underplays the synchronic degree of variation observed in the languages listed. Even the sparse encoding shown here brings across some aspects of its aspects, as in the very strong affrication of the VOICELESS coronal stop [tʰ] (or /t/?) in Danish. Even a single parameter such as VOT will often show meaningful variation within a speech community, including social and geographical variation (cf. on Danish Puggaard 2021), that is not easily captured by picking one, or even several, discrete transcription symbols. Importantly for the issue of levels of representation, extensive empirical work has demonstrated how patterns that can look superficially very similar can have very different aetiologies (Pierrehumbert et al. 2000, Scobbie 2007), sometimes even within the same speech community (for examples, see Myers 2000, Przezdziecki 2005, Strycharczuk et al. 2014). In any case, VOT is only one parameter: whilst we have at least some understanding of the typological variation in this dimension (Petrova et al. 2006, Chodroff et al. 2019), other phonetic cues such as duration, F0 perturbations, or the effect on neighbouring vowels remain grossly understudied from a cross-linguistic perspective; cf. on laryngeal distinctions specifically Kirby & Ladd (2019) and on more phonetic microvariation more generally Anderson et al. (2018), Heggarty et al. (2019).

Even assuming we have the right data, however, which of the three levels of representation is a database of "phonemic inventories" meant to encode? How much variation do we include, and how do we represent it? For example, English, Danish, and Swedish, despite the different phonetics of laryngeal contrast, all show very similar patterns of morphophonological behaviour related to laryngeal features, in which the VOICELESS series behaves as relatively marked (in a formal sense) and the VOICED series is relatively unmarked.[8] Should we choose a phonetically sparse, abstract encoding reflecting the phonological level, with a VOICELESS series (perhaps /p, t, k/) and a VOICED one (/b, d, g/?), identical to the system of Russian or French? Or perhaps we accept that it is the phonetic-phonological level that is most relevant? In this case, aspiration in the VOICELESS series would have some phonological significance, leading us to postulate different phonological representations of these types of laryngeal contrast. Such an approach (cf. Salmons 2020) would allow us to reflect the phonological charac-

[8] Iverson & Salmons (1999) offer extensive discussion of this analysis, which is widely, but far from universally, accepted. For a recent exposition of the dissenting view, see Ahmed et al. (2020).

teristics of such languages whilst effacing details (like the precise phonetics of the VOICED series) that have no phonological import.

On the other hand, encoding redundant detail runs the risk of erasing differences that are not apparent from an examination of the more concrete phonetic characteristics of the pattern. For instance, as Table 2 shows, voiceless unaspirated [p, t, k] stops realize the phonological VOICELESS series in a "voicing" language like Russian but the phonological VOICED series in a language like Ulster Irish ([done1238], Indo-European > Celtic).[9] This is reflected in both their phonology and their language-specific phonetics. For instance, phonologically VOICELESS [p, t, k] stops have longer closure durations than the VOICED series (for Russian, see e. g. Ringen & Kulikov 2012), but when [p, t, k] are phonologically VOICED the relationship is reversed, as in Ulster Irish (Ní Chasaide 1985: 174). Phonologically, [p, t, k] pattern as VOICELESS in Russian, where they trigger assimilatory devoicing. In Ulster Irish, they alternate with VOICED continuants under conditions of initial mutation,[10] and coalesce with /h/ to produce the VOICELESS stops (Ó Buachalla 1985). Given these circumstances, are the phones transcribed as [p, t, k] comparable across languages? Here, Ladd (2014) provides some very pertinent criticism, focusing on the very notion of a "phone", that addresses this point, which is itself of course also familiar as a broader concern in linguistic typology.

Possibly important as these considerations are, it could be argued that they miss the point. The purpose of distributional typology, after all, is not to offer in-depth individual case studies, but to uncover patterns and regularities on a larger scale (the "wood", as it were) that are easy to miss, if at all possible to find, by an aggregation of individual analyses (the "trees"). Nevertheless, I suggest that these problems do matter, and progress in phonological typology depends on close engagement with them. In the next section, I discuss the typology of an alleged phonological rarity, namely VOICELESS stop preaspiration, in light of these issues of phonological analysis.

4 How rare is preaspiration, really? And why?

Preaspiration, which is usually seen as especially associated with VOICELESS stops, is a phenomenon frequently cited as a phonological rarum: for detailed discussion, see Silverman (2003), Hejná (2025 [this volume]), and Craioveanu (2025

[9]This comparison is not entirely exact, as Ulster Irish VOICED stops do show a degree of voicing in postvocalic position, interpreted by Ní Chasaide (1985) as passive (coarticulatory).

[10]In the same context, VOICELESS [pʰ, tʰ, kʰ] alternate with VOICELESS [f, h, x].

[this volume]). The starting point for much research in the area has been, as so often, grounded in the situation found in the languages of Europe. Preaspiration appears to act as an areal feature in northern Europe, being found in at least three genetically diverse groups: (North) Germanic, (Goidelic) Celtic, and Finno-Ugric (specifically Sámi). Early discussions of this areal feature have consistently treated this phenomenon as cross-linguistically very rare (e. g. Marstrander 1932, Wagner 1964), and although some surveys have turned up a range of parallels elsewhere (Liberman 1982, Silverman 2003), this view remains firmly established (Salmons 1992, Hansson 2001, Blevins 2017), despite some dissenting voices (Clayton 2010, Craioveanu 2025 [this volume]).

The basics of this view run as follows. Preaspiration of VOICELESS stops is narrowly defined as a period of glottal friction associated with the oral closure, often with the qualification that an interpretation of this structure as a surface [hC] cluster is not desirable or convincing. Understood in this way, it appears cross-linguistically rare. The common explanation is that such preaspiration is perceptually weak, and therefore vulnerable to change, being either lost or, conversely, "strengthened" to an oral segment (Silverman 2003). However, in Northern Europe we find it in a group of unrelated languages that have historically been in contact. Unsurprisingly, then, proposals to derive its spread from language contact date back at least to Marstrander (1932); discussions of this phenomenon specifically as an areal feature include Wagner (1964), Borgstrøm (1974), Salmons (1992), Eliasson (2000), Hansson (2001), Rießler (2008), Blevins (2017).

Since the alleged cross-linguistic rarity of the phenomenon motivates much of this research, it is important to interrogate it: is preaspiration really rare? The answer to this questions depends both on how we define preaspiration, and on what the baseline for "rarity" is.

4.1 Preaspiration and levels of representation

Here, I do not focus too much on the recent empirical findings that demonstrate how preaspiration is much more widely distributed cross-linguistically than previously appreciated; I refer to Hejná (2025 [this volume]) and Craioveanu (2025 [this volume]) for more in-depth discussion. Granting that preaspiration is not as much of a *rarissimum*, what can we say about its precise representation?

Craioveanu (2025 [this volume]) defends a maximalist approach, in which all instances of preaspiration are treated as instances of a coda [h] segment; in terms of the three levels of representation, this is clearly a fact that belongs to the phonology. I see no reason to doubt that phonological preaspiration of this nature does exist. Icelandic ([icel1247], Indo-European > Germanic) is probably by far the best-known case (see Árnason 2011: §11.2 for a review of the evidence that Icelandic preaspiration is best treated as a coda segment), but others also exist. Northern Sámi ([nort2671], Uralic > Saami) provides a pertinent example (Sammallahti 1998, 2019, Bye 2001, Aikio & Ylikoski 2022). In general, the language distinguishes two varieties of preaspirated stops (and affricates). Within the overall quantity system, they are equivalent to long and overlong varieties of other consonants (also referred to as "short geminates" vs. "long geminates"): the relationship of forms like *lahki* 'half.GEN.SG' and *lahkki* 'half.NOM.SG' is parallel to that between *guossi* 'guest.GEN.SG' (with long [sː]) and *guos'si* 'guest.NOM.SG' (with overlong [sːs]). These segments alternate with each other as part of an elaborate morphophonological pattern known as *consonant gradation*, in which both individual consonants and consonant clusters appear in one of two shapes, referred to as the "strong" and "weak" grades (for an overview, see Bakró-Nagy 2022).

The realization of the contrast between the two series differs across dialects. In many Sea Sámi varieties, such as that of Maattivuono (Ravila 1932: 17–18), the difference lies primarily in the duration of the stop closure, with the preaspiration described as very short. In Western Inland dialects, such as those of Western Finnmark or Eastern Eanodat (Enontekiö), the difference between the two lies in the duration of the preaspiration instead: short [lɑhkiː] for *lahki* 'half.GEN.SG' vs. long [lɑhːkiː] *lahkki* 'half.NOM.SG' (Sammallahti 2019: 130).[11] This, by itself, does not guarantee the segmental status of preaspiration, but the patterns of Eastern Inland dialects such as those of the Deatnu (Tana) river valley, are more probative. Here, the two kinds of stops do not differ in the duration of preaspiration, which is always short. Indeed, in certain varieties (e. g. Upper Deatnu) distinctions such as those between *rohkki* 'dead person.NOM.SG' and *rohki* 'dead person.GEN.SG' are neutralized in favour of the short preaspiration, with both being realized as [rohkiː] (Sammallahti 2019: 141). In others (e. g. Veahčat), however, the difference is maintained thanks to the fact that the preceding vowel is long before the expected short preaspiration *áhčči* 'father.NOM.SG' [æht͡ʃiː] vs. *áhči* 'father.GEN.SG' [æːht͡ʃiː] (Sammallahti 2019: 163). I suggest that this variation is best understood if we accept that the preaspiration [h] is, or in some varieties was at the earlier stage, a segment carrying distinctive quantity.

The segmental status of [h] is supported because its patterning parallels quite precisely the behaviour of the first member in a continuant-consonant cluster. In particular, consonant gradation in fricative-initial clusters like those in *niski*

[11]The exact transcriptions in the source, which uses a version of the Finno-Ugric Phonetic Transcription, are <la˙hkii> and <la˙h.ʰ.kii> respectively, where the raised dot indicates stress, and the full stops refer to "glottal pulses".

'nape', show the same patterns as that involving preaspirated stops (quantity distinction in the first consonant in Western Inland; neutralization or vowel quantity distinction in Eastern Inland). Bals Baal et al. (2006, 2012) describe and analyse the Western Inland dialect of Guovdageaidnu, where the distinction between short and long preaspiration coexists with vowel lengthening before the short version to produce pairs like [ahːt͡ʃi] 'father.nom.sg', weak grade [aːht͡ʃi] 'father.gen.sg'. They analyse this pattern via a rule of Pre-Continuant Lengthening, which applies in the "weak grade" not only before preaspiration but also before other continuants. The rule applies before short geminate consonants (*golli* 'gold.gen.sg' [koːlːi]) and consonant clusters (*niskki* 'nape.gen.sg' [niːski]); contrast with unlengthened *gol'li* 'gold.nom.sg' [kolːli], *niski* 'nape.nom.sg' [nisːki]. Crucially, the weak grade alone is not a sufficient condition for lengthening: vowels remains short before weak-grade stops (in items like *loddi* 'bird.nom.sg', weak grade *lotti*). In other words, "[h] + stop" sequences pattern with continuant geminates and continuant-initial clusters, and not with geminate unaspirated stops, strongly suggesting that [h] is a continuant segment.

Similar facts obtain in dialects like Deatnu Valley. They lack quantitative distinctions between short and long preaspiration, as well as between strong and weak grades of continuant geminates and clusters like *sk*. However, this cannot be ascribed to a general neutralization of the grade alternation, because the weak grades remain distinct in other cases, especially where the contrast is also expressed by the duration of the second consonant: *čalbmi* 'eye.nom.sg' with [lm] vs. *čalmmi* 'eye.gen.sg' with [lmː] (Sammallahti 2019: 141). Thus, also in these dialects "preaspirated stops" specifically pattern like continuant geminates and continuant-initial clusters, but not like stops.

Dialects like Upper Deatnu provide further evidence that this phenomenon cannot be due to relatively low-level phonetic timing processes related to metrical contrasts (cf. Hiovain et al. 2020), but has undergone stabilization and participates in segmental phonology. This is because some nuclei (particularly the historical opening diphthongs) show qualitative, rather than quantitative distinctions with a parallel distribution to how long and short vowels are sensitive to the status of preaspiration. In Veahčat, the qualitative distinctions may be accompanied by the maintenance of the quantitative contrast: hence [rŏ͜æ̆hkiː] *roahkki* 'hook.nom.sg' but [ru͜æhkiːh] *roahkit* 'hook.nom.pl'. In Upper Deatnu, however, the quantitative distinction is neutralized but the quality differences remain, producing the pair [rŏ͜æ̆hkiː] vs. [rŭ͜ŏhkiːh] (Sammallahti 2019: 65).[12] The segmen-

[12] Strictly speaking, Sammallahti (2019) suggests that the diphthongs also differ in the placement of stress within the diphthong, with notations like <ŭĕ˙> vs. <ŭ˙ŏ>. However, this "stress placement", whatever its precise phonetic correlates, appears to be generally predictable from the quality and length of the diphthong.

tal distinctions in the diphthongs are synchronically opaque with regard to the quantity of the following segment, including the preaspiration, which strongly suggests the latter had been stabilized as part of the life cycle. Thus, there is considerable evidence for the segmental status of preaspiration in at least some varieties of Northern Sámi.

That being said, I suggest that phonological preaspiration is *not* the only possibility. The occurrence of glottal friction before a stop closure can correspond to a phonological [h] segment, but it can also be a by-product of the fact that the stop (usually of the VOICELESS series) is associated with glottal spreading without such a segment being present in the surface phonological representation: preaspiration belongs to the phonetic-phonological level, in this case. If a language has a "phonetic rule" of preaspiration as part of how the abstract category of VOICELESS is mapped to phonetic substance, it may very well show some language-specific patterning in terms of duration or asymmetries in behaviour determined by factors such as consonant place. Such restrictions may very well be quite similar to those visible in the behaviour of preaspiration that has been stabilized (in the life cycle sense), which exists at the phonological level. However, the root cause of this is not some fundamental identity between the two, but rather their diachronic relationship: within the architecture of the life cycle of phonological patterns, phonological preaspiration rules arise from phonetic ones.

Distinguishing between the two kinds of preaspiration is not at all trivial. I refer to Iosad (2025) for more detailed discussion. The most important consideration here is the fundamental criterion we should use to draw this line. Much of the recent work in the field builds on Helgason's (2002) distinction between "normative" (obligatory, categorical) and non-normative (non-obligatory, variable) preaspiration (cf. Hansson 2001, Blevins 2017). However, like Craioveanu (2025 [this volume]) I believe this distinction does not map to an architecturally useful difference: there is certainly no guarantee that a phonological phenomenon cannot be variable (Cohn 2006, Fruehwald 2022). Instead, I suggest that the defining criterion here is *modularity* (cf. Iosad 2017). Phonological rules are categorical manipulations of discrete entities such as segments and other representations of the phonological level (for instance, pieces of autosegmental structure); phonetic rules take surface phonological representations and map them to real-valued phonetic properties (as part of the phonetic-phonological and phonetic components).

This issue, which rides on whether preaspiration is represented in the phonological grammar of the language, is in principle orthogonal to the much-discussed question of how laryngeal articulations such as aspiration and glottalization interact with segmental representations. There is a wealth of scholarship in theoretical phonology discussing the representation of laryngeally modified segments, including their possible nature as complex segments, the precise nature of any subsegmental structure necessary to represent relevant timing relationships, the rôle of factors such as sonority and metrical (syllabic) structure in the licensing and alignment of such articulations, and many others (in addition to Craioveanu 2025 [this volume], relatively recent discussions can be found in Steriade 1993, Howe & Pulleyblank 2001, Davis & Cho 2003, Kehrein & Golston 2004, Golston & Kehrein 2013). In particular, the critical issue of whether timing and alignment must be phonologically represented, as in Aperture Theory (Steriade 1993) or Q Theory (Inkelas & Shih 2017) or is up to the phonetic (or phonetic-phonological, in our terms) component (e. g. Howe & Pulleyblank 2001) is both highly sensitive to background theoretical assumptions that we cannot treat in detail here and requires careful empirical underpinning, which for many relevant cases remains a desideratum. For now, I will set it aside, and focus on the central problem of architectural affiliation.

Under this régime, identifying whether a preaspiration rule is phonological or phonetic requires detailed analysis of each particular case. This also means that cross-linguistic comparison, in and of itself, becomes much less probative. Consider the case of Faroese ([faro1244], Indo-European > Germanic), a close relative of Icelandic. The distribution of preaspiration in Faroese is also very similar to the Icelandic. However, the phonetic properties of Faroese preaspiration are quite unlike that of its Icelandic cognate: in particular, it is both shorter and more prone to coarticulation both with the preceding vowel and the following consonant (Helgason 2002, Árnason 2011). For this reason, these and other authors tend to agree that Faroese preaspiration does not have the same status, and belongs more clearly to the suite of phonetic cues realizing VOICELESS stops.[13]

Although such comparisons of sound patterns *across* languages can be enlightening, it is not clear they are always probative. When making such comparisons, we need to exclude the possibility that differences in properties such as timing or place of articulation are due not to a difference in phonological structure but to language-specific properties of how similar phonological structures are realized. In the case of Icelandic and Faroese preaspiration, the difference in phonetic variability could be a function not of the fact that the former, but not the latter, is not a coda segment: in principle, it could simply be a difference between the languages in how they realize coda segments.

Nevertheless, I submit that it is possible to justify a distinction between fully stabilized, segmental preaspiration and preaspiration created by a phonetic rule

[13]The agreement is not universal, however: for examples of analyses where Faroese preaspiration involves phonological operations, cf. Hansson (2003), Voeltzel (2022), Craioveanu (2023).

realizing some phonological representation in which preaspiration does not have a reified status. The clearest evidence is provided by cases when they coexist in the same language. Such a situation arises due to *rule scattering* (e. g. Cohn 1998, Bermúdez-Otero 2015; on preaspiration specifically see also Hejná 2019) in the course of the life cycle, when a phonetic rule stabilizes to a phonological pattern but also remains active in the phonetic-phonological grammar. I have been able to identify several such instances.

One case comes from the Northern Tärna dialect of Ume Sámi.[14] Most Sámi languages distinguish between two quantities in preaspirated stops, as in the Northern Sámi examples given earlier. In general, long preaspiration corresponds to Proto-Sámi geminate stops before an open syllable, while short preaspiration reflects a merger of original geminates before closed syllables and original singletons before open syllables. In the Northern Tärna dialect, however, this merger is incomplete. This results in an apparent three-way quantitative distinction on the surface (or rather a four-way distinction, if one counts the non-preaspirated stop as part of the paradigm). As discussed by Bye (2001), such distinctions cannot be accommodated in any but the most unrestricted versions of metrical phonology, which usually allows for at most a three-way distinction in weight. Following the proposal of Bye (2001: 132), I suggest that the paradigm in Northern Tärna Ume Sámi consists of two versions of stabilized preaspiration (i. e. a surface [hC] cluster) differing in weight[15] and of two versions of regular stops. In the case of the latter, the longer version is ultimately realized with preaspiration by a phonetic rule, but its representation is not identical to a coda [h], which also exists in the language.

Table 3 shows the relevant examples. Lule Sámi forms are given for comparison to demonstrate the usual merged outcome. The Northern Tärna forms are given in the original transcription by Moosberg (1925), as reported by Bergsland's (1973: 51–52),[16] and an IPA interpretation of these, following Bye (2001: 132). I use ⟦double brackets⟧ to emphasize that the forms are intended to represent the

[14] The data is mostly accepted in the specialist literature, but unfortunately it is impressionistic and the variety is now extinct. The ultimate source is Moosberg (1925), which remains unpublished, but the data was brought to light by Bergsland (1973) and discussed also by Sammallahti (1998, 2012), Bye (2001). Larsson (2012) provides a broader overview of the data, based on some of the same material; his description, admittedly, does not quite match the picture in the other sources.

[15] I distinguish between "short" and "long" versions of consonants by means of an additional mora, as is standard in autosegmental analyses of the Sámi languages (Bye 2001, 2005, Bals Baal et al. 2012), but nothing hinges on this.

[16] The macron indicates length and the grave half-length. The symbol <ɔ> refers to the "voiceless vowel", i. e. preaspiration.

phonetic realizations, not the surface-phonological representation. My interpretation of the latter is given in the next line.

Table 3: Phonetic and phonological preaspiration in Northern Tärna Ume Sámi

	p, t, k		*pp, tt, kk*	
	*_VC	*_V	*_VC	*_V
Proto-form	*kātōm	*kātōtēk	*kāttōn	*kāttō
Lule Sámi	*gádov*	*gáhtot*	*gáhto*	*gáhtto*
Northern Tärna	<Gāt̀uȯB> ⟦ˈka:t·u͡op⟧	<Gāɔt̀ōt> ⟦ˈka:ht·u͡ot⟧	<Gāɔ̀t̀ὼən> ⟦ˈka:h·t·u͡on⟧	<Gàɔ̄t̀ὼə> ⟦ˈka·h:t·u͡o⟧
Phonological interpretation	[ka:tu͡op]	[ka:t$_\mu$u͡ot]	[ka:htu͡on]	[ka:h$_\mu$tu͡o]
Gloss	‘be.absent:PRS.1SG’	‘be.absent:INF’	‘cat.GEN.SG’	‘cat.NOM.SG’

I am aware of at least two other possible further cases. In the Gällivare dialect of Lule Sámi described by Collinder (1938), stabilized preaspiration is generally realized as a dorsal fricative ([ma·xt:e:t] *máhttet* ‘be.able:INF’, [ma:xta·w] *máhtáv* ‘be.able:PRS.1SG’). This is likely due to a stabilized rule of oralization, applying to all instances of coda [h]. This phenomenon occurs also after the excrescent vowel which characterizes certain consonant clusters in some contexts, as in [pa·lɐxka·] *bálkká* ‘payment’. However, when the excrescent vowel is absent, oralization is also blocked ([pa·l̥ka:m] *bálkám* ‘payment.ACC.POSS.1SG’). This suggests that even though the stop does exert a devoicing influence on the preceding sonorant – commonly agreed to be a facet of preaspiration – it does not result in the creation of a [h] segment, and thus escapes oralization.[17]

A third case is found in those dialects of Scottish Gaelic ([scot1245], Indo-European > Celtic) that are generally described as having stabilized preaspiration that produces coda fricatives ([h] or [x]), such as those of Barra and Skye (Borgstrøm 1937, 1941).[18] As in other varieties of Scottish Gaelic, preaspiration is significantly shorter or even absent after long vowels compared to the position after short

[17] This situation contrasts with dialects of Scottish Gaelic that have a similar oralization rule, which *does* apply to post-sonorant stops, resulting in forms such as [ɔlˠxk] *olc* ‘evil’ (corresponding to [ɔl̥ˠk] in other dialects); see Morrison (2019) and Iosad (2020) for more details on this rule.

[18] See Bosch (2006), Ó Maolalaigh (2010) for a discussion of the range of variation in preaspiration patterning across varieties of Scottish Gaelic. I refer the reader to Iosad (2020, 2025) for details of the analysis and the criteria used to determine the segmental status of preaspiration.

vowels. As an example, consider the pattern at Elgol (Isle of Skye), point 106 in Ó Dochartaigh (1997).[19] This variety falls within the area where glottal preaspiration is generally considered to be stabilized. In line with this generalization, we find records like <kaht> for *cat* 'cat' (vol. 2, p. 316). However, after long vowels preaspiration appears to be either reduced (<b̥aː^{h}tə> *bàta* 'boat' [vol. 2, p. 162]) or absent (<aːd̥^{j}ə> *àite* 'place' [vol. 2, p. 50]).

As I discuss in Iosad (2025), this reduction can be analysed as an effect of the consonant being lenited after a long vowel. Where such lenition occurs in a system with stabilized preaspiration such as Icelandic, it can easily be analysed as deletion of a [h] segment, or some other process that inhibits the insertion of such a segment. However, this analysis is not applicable to the Elgol situation: here, preaspiration is not categorically removed in the long-vowel context, but it undergoes reduction (with deletion as a special case, cf. Hejná 2019). I suggest that this speaks in favour of an analysis where stops after short vowels have stabilized preaspiration, with a coda [h] followed by a stop ([k^{h}aht] for *cat*, from underlying /k^{h}at^{h}/), but the preaspiration segmentalization rule does not apply after a long vowel: hence [paːt^{h}ə] for *bàta* from underlying /paːt^{h}ə/. The postvocalic VOICELESS stop is realized with optional, short preaspiration by a phonetic rule, but is not preceded by a fricative segment. Notably, if preaspiration were segmental also after a long vowel, we might expect it behave like other fricatives in similar clusters (cf. the discussion of Northern Sámi above). However, we do not observe shortening and/or deletion of other coda segments in this context (<r^{ɣ}uːsɡ̊əɣ> for *rùsgadh* 'shearing' [vol. 5, p. 101]), so I suggest that the evidence is most compatible with non-segmental preaspiration.

I conclude that, *pace* Craioveanu (2025 [this volume]), we do need to distinguish between preaspiration that is visible at the phonological level (as a coda [h] segment, whether weight-bearing or not) and preaspiration that is part of the phonetic-phonological system of the language, as a phonetic rule, but not part of the phonological computation. The next step is to approach the question of whether preaspiration is rare separately for each of these types.

The detailed study of this issue remains a desideratum. However, if the life cycle model is on the right track, our very strong expectation is that stabilized preaspiration of the clear segmental ("Icelandic") type should be rarer than the phonetic variety. This is because under the life cycle model the former diachronically presupposes the latter, but not (in general) vice versa. Once a language has

[19]This work represents the published record of the Linguistic Survey of Scotland (Gaelic), which was carried out in the mid-twentieth century. When discussing the survey data, it is common practice to cite the number of the enquiry point in the published materials.

acquired phonetic preaspiration, we should not expect that it should necessarily undergo the next step of the life cycle. Even if it does, then rule scattering ensures that phonetic preaspiration does not have to disappear.[20] In other words, languages with stabilized preaspiration like Icelandic represent the outcome of a "funnel": they are a subset of those languages that acquired phonetic preaspiration, which in turn are a subset of all languages with the potential precursors for preaspiration. This means that the question of the baseline becomes acutely important: the question of whether preaspiration, and perhaps especially stabilized preaspiration, is rare to a degree that requires explanation hinges on the question of how common the precursors to it are. We turn to this issue in the next section.

4.2 The origins of preaspiration

The literature offers three principal approaches to the endogenous origin of preaspiration.[21] We can label them "contrast-based", "duration-based", and "coarticulation-based". In the first view, preaspiration of word-medial stops arises as a means to preserve some contrast which is threatened because of other sound change – usually laryngeal contrast or a quantity distinction. Examples of such accounts include Ní Chasaide (1985), Ó Murchú (1985), Goblirsch (2001). I do not focus extensively on this view: while it remains possible that top-down factors such as contrast preservation contribute to the course of sound change (for a succinct but very useful recent overview, see Salmons 2021: chap. 9), current thinking usually rejects them as the ultimate sources of diachronic developments. Instead, many current models see change as being grounded in variation attributable to articulatory and/or perceptual biases, and the latter two potential explanations for preaspiration sit firmly within this camp.

In one view, based on quantity, the key factor behind the rise of preaspiration lies in articulatory pressures related to (de)gemination. For example, Blevins & Garrett (1993) sketch out a scenario where preaspiration arises due to the mistiming of laryngeal opening in phonetically voiceless stops relative to oral closure,

[20] In principle, we can envisage a situation where the relevant phonetic rule, for whatever reason, disappears at a later stage, leaving the patterns that are further down the life cycle, in place. This would produce a language with phonological, but not phonetic versions of the pattern in the synchronic grammar. Empirically, this does not seem to be especially common; tentatively, I would suggest that we should consider rule scattering the default case, since whatever articulatory, acoustic, and perceptual biases promote the rule in the first place are likely to persist. (I thank a reviewer for discussion of this point.)

[21] I exclude spread by language contact, and some cases where preaspiration occurs as a reflex of another segment in the local context, such as a nasal or an original [h].

the chances of which are greater in geminates because of the relatively large magnitude of the glottal opening gesture; for this reason, "accidental" preaspiration, which then develops into a full-blown sound change, is hypothesized to be more probable before geminate stops.

In an alternative view, grounded in coarticulation, preaspiration is basically a by-product of the fact that phonologically VOICELESS stops are associated with relatively large glottal opening gestures (for example, because they are specified with Glottal Width on the phonetic-phonological level, in terms of Avery & Idsardi 2001, Natvig 2019). Such large-amplitude gestures are generally found where VOICELESS stops are produced with postaspiration, but in word-medial position this glottal opening can spill over into the period before the start of the oral closure. In this way, preaspiration can be considered a product of coarticulation with the apparently more common postaspiration (Hejná 2025 [this volume], Morris & Hejná 2020).

These accounts are not mutually exclusive. For example, the quantity-based approach has been commonplace within the study of the North Germanic languages, where preaspiration in many varieties is especially prominent in connection with historical geminates, since at least Marstrander (1932). Indeed, putative phonetic rationales linking North Germanic preaspiration to increased "consonant strength" are very common in this literature (e. g. Naert 1969), although the links are ultimately rather speculative. To an extent, this reflects a bias towards viewing the stabilized preaspiration of Icelandic, which is strongly associated with historically long VOICELESS stops, as somehow prototypical. Hansson (2001) and Helgason (2002) rightly emphasize that non-stabilized preaspiration is very much attested in North Germanic languages also with singletons, suggesting that coarticulation with subsequent glottal spreading can give rise to preaspiration even of non-geminate stops. This is particularly plausible if we follow Iverson & Salmons (1999), Salmons (2020) in reconstructing aspiration (more precisely, Glottal Width specification) of VOICELESS stops to Proto-Germanic.[22] If this is correct, North Germanic does not, *pace* Blevins & Garrett (1993), present a case where preaspiration arose out of gemination of plain (unaspirated) stops: instead, it is associated especially (but not exclusively) with stops that are both aspirated and long. Similar confounds apply in cases like the Gaelic languages, which have aspirated VOICELESS stops and lack distinctive consonant quantity in the present day, but used to have the latter at an earlier stage, and Welsh, where preaspiration has been well attested in geminate VOICELESS stops (Morris & Hejná 2020), but its patterning is poorly understood in singletons.

[22] Admittedly, this view is not universally accepted (Steblin-Kamenskij 1974, Goblirsch 2005).

The close connection between glottal spreading and preaspiration is further underscored by the fact that some preaspiration – at least of the (breathy) voiced variety – is reported from languages where stops in the voiced series are categorically voiceless (as discussed in Section 3.2), which likely requires a devoicing or glottal spreading gesture. Morris & Hejná (2020) report this for Northern Welsh (for voicelessness of the voiced stops in these varieties, see Bell et al. 2021), and Nance & Stuart-Smith (2013) do the same for the Scottish Gaelic of Lewis. There are also impressionistic reports of preaspiration before voiced stops in Icelandic (Einarsson 1932: 571–572).

That being said, it seems that both mechanisms may be necessary, since both appear to be attested independently. A clear case of preaspiration arising from plain geminate stops has been identified in Tuscan Italian ([ital1282], Indo-European > Romance) by Gobl & Ní Chasaide (1999), Stevens & Hajek (2007), Stevens (2011), Stevens & Reubold (2014), Coretta (2020). The Sámi languages almost certainly present a case of this as well: the proto-language had a quantity contrast in obstruents, but not a laryngeal distinction (Aikio 2022), and preaspiration arose first in geminates. Preaspiration of singleton aspirated stops is discussed in more detail by Hejná (2025 [this volume]).[23]

If this conclusion is correct, then the set of languages that offer reasonable preconditions for the appearance of preaspiration is the union of languages with contrastive (post)aspiration (as in English) and those with contrastive quantity in stops (as in Italian). We can estimate the prevalence of these conditions in the languages of the world with the help of PHOIBLE (Moran & McCloy 2019): despite the criticisms levelled at it in Section 3, it remains our most comprehensive source for understanding the range of variation in phonemic inventories. As of the time of writing, PHOIBLE contained 507 languages with either postaspirated stop (or affricate) or long stop (or affricate) phonemes, out of a total of 2,167 in the database, or just under a quarter (23.40%).[24]

Of course, this number is only a very approximate estimate of languages with preconditions for the phonologization of preaspiration. On the one hand, it is very likely that the focus on phonemic inventories leads to an undercounting

[23]Clayton (2010) calls cases of preaspiration arising from plain voiceless stops without additional factors like quantity "spontaneous". It should be pointed out that at least one case that Clayton (2010: 49) puts in this category, that of Tyneside English, is more likely due to the presence of glottal spreading: English generally shows postaspiration of voiceless stops, and preaspiration is not unknown in other varieties of this language (e. g. Jones & Llamas 2008, Hejná 2015, 2021). More discussion of the case of Tyneside is offered in Iosad (2025).

[24]The information was extracted by matching the regular expression `(?<![ǁǂǀ!ʘ])[ptʈckq][^ǁǂǀ!ʘ]?[ʰː]` to the `Phoneme` field in the PHOIBLE database at commit ID `b66d3ffe1b16ed9b426e6a3f7d32e4cc1f96290a` and counting unique Glottocodes.

of length that is phonologically relevant ("distinctive") but not necessarily contrastive on the surface (Kiparsky 2015, 2018, Iosad 2017).[25] On the other hand, of course, these two factors are not sufficient to create the right conditions, and the likelihood of the appearance of preaspiration might be inhibited. For example, while German ([stan1295], Indo-European > Germanic) has aspirated voiceless stops, it is usually claimed that the glottal opening is timed in ways that fail to produce preaspiration (in addition to Jessen 1998, cf. Helgason 2002: 231; see, however, Tronnier 2019 for a brief report to the contrary).

Nevertheless, taking this estimate as approximately correct, only a quarter of the languages of the world have clear preconditions for preaspiration. Only a subset of these will develop phonologized preaspiration: it is not clear how large this proportion is. It may very well be the case that it is relatively low, if the hypothesis that preaspiration has low perceptual salience (Bladon 1986, Silverman 2003, Blevins 2017) is correct. Even so, Clayton (2010) and Hejná (2025 [this volume]) sound some notes of caution as to how much this hypothesis can explain the attested outcomes. On the other hand, as both Hejná (2025 [this volume]) and Craioveanu (2025 [this volume]) emphasize, this kind of preaspiration is strongly under-reported in the literature, so we may very well not have a complete empirical picture at our disposal just yet. In any case, it is only in a subset of these languages that preaspiration can undergo stabilization to produce the kind of system that is often considered prototypical. We are still some way away from understanding clearly what factors drive this process (Sen 2016, Salmons 2021), but one proposal is that the stabilization of a phonetic rule can be "primed" by the prior existence of a phonological distinction for which the phonetic phenomenon in question provides a useful cue (Kiparsky 1995). With regard to preaspiration, Iosad (2025) develops the hypothesis that its stabilization is encouraged by the existence of quantitative (metrical) distinctions in stops, which are otherwise especially poorly cued.[26] This hypothesis has the corollary that "prototypical" stabilized preaspiration should be over-represented in languages possessing quan-

[25]See, for instance, Iosad (2012) for discussion of Welsh ([wels1247], Indo-European > Celtic) and Standard Latvian ([stan1325], Indo-European > Baltic). Neither appear to have phonemic quantity distinctions in (most) consonants, but both have robust phonetic and/or phonological patterns manipulating them.

[26]Note, in particular, that this approach provides a ready explanation for the asymmetry between voiceless stops and fricatives. Both are associated with glottal spreading (Vaux 1998), and both can be accompanied by phonologized preaspiration, although it is very severely under-reported (cf., however, Hejná 2015 on English, Allen 2016 on North Germanic, or Bańczerowski 1969: 139–141 on the Sámi languages). However, preaspiration before fricatives appears rarely, if ever, stabilized: one plausible reason is that quantity in fricatives, unlike stops, is saliently cued by the duration of the noise, but the matter deserves further scrutiny.

tity contrasts such as Icelandic and Northern Sámi; at the moment, unfortunately, we are not in a position to rigorously evaluate this prediction.

To sum up this discussion, a theoretically informed approach is indispensable to answering the question of whether, let alone why, preaspiration is rare in the languages of the world. Aside from the empirical difficulties due to documentation biases and insufficient reporting, the way that we reify the concept of preaspiration very strongly depends on our theoretical assumptions. In this light, I suggest that there is a serious risk of ignoring important generalizations in approaching to typological enquiry – including the analysis of rarities – by seeking to alight on a "maximum consensus" view of phonological analysis without engaging deeper theoretical commitments. In particular, I have argued that adopting a nuanced view of phonological representation and an amphichronic perspective that ties representational levels to the life cycle of phonological processes also allows us to make real progress in looking for answers to typological "what's where why" questions, and to a rigorous evaluation of the theoretical import of rare phenomena.

In this section, I have attempted in particular to relate some current ways of thinking in theoretically informed historical phonology to examining typological concerns, including those related to the study of rarities. However, in order to generalize from a case study such as that given here, it is desirable to consider what a more general methodology for integrating these two fields might look like, particularly if we are to be able to leverage the latest data-rich, quantitatively driven typological methods. In the following section, I offer one possible way of doing so.

5 A way forward?

Despite all the above objections, I do not wish to suggest that large-scale distributional phonological typology is undesirable, or even impossible. My point is, rather, that phonology presents very real obstacles to a contentful typological approach grounded in a minimum common denominator of theoretical analysis, because the data that can be extracted without avoiding theoretical commitments is not as informative as we would need. This is, of course, essentially the same conclusion that Hyman (2008) reaches in the context of a universals-focused view of typology.

How, then, can we use the toolkit of distributional typology to address "what's where why" questions in phonology? In this section, I sketch an approach that might allow us to examine the classic issue of areal influence vs. genetic inheritance in a theoretically informed context.

5.1 Areal signal in phonology

Constructing a temporally and spatially embedded framework for understanding the synchronic distribution of linguistic phenomena requires disentangling three forces that shape these distributions: vertical transfer (inheritance), horizontal transfer (language contact), and universal tendencies (of whatever aetiology). In particular, the relationship between vertical and horizontal transfer of linguistic features within coherent spatial domains is, of course, a classic problem in historical linguistics and in historical phonology specifically (cf. for some recent discussions François 2015, Jacques & List 2019). Much progress has been made in recent years in building sophisticated models that attempt to incorporate all these factors into a unified framework, albeit often with a focus on grammatical rather than phonological systems; for some recent examples, see Cathcart et al. (2018), Dedio et al. (2019), Ranacher et al. (2021).

Here, I would draw attention to two considerations that are important in exploring these approaches in a phonological context. First, we need to consider just how much universal tendencies shape the properties of phonological systems. When the aim of typological enquiry is primarily historical, aiming not only to reconstruct the course of endogenous change but also to examine vertical and horizontal transfer events, such universal tendencies will often represent noise rather than signal, a constant hum of background change that we need to penetrate in order to identify those phenomena that give us crucial information about important historical developments. It is perhaps unfortunate, then, that sound change is especially strongly guided by just such universal tendencies, whether they have to do with articulatory, perceptual, or general cognitive biases. In turn, this means that a large proportion of the attested phonological patterns can be explained by appeal to such biases. This is very widely recognized by phonologists (cf. Blevins 2004, Hansson 2008, Gordon 2016). Of course, morphosyntactic developments can also be guided by such universal considerations. Nevertheless, it seems plausible that phonology differs from morphosyntax (perhaps especially syntax), because so much phonological change is phonetically grounded in one way or another (cf. Garrett & Johnson 2013). Because of the sheer volume of changes that can be directly attributed to such factors, which are less informative with respect to vertical or horizontal relationships, the "signal-to-noise ratio" in phonological typology may well be lower than in other areas of grammar. I am not aware of work that directly attempts to explore and quantify this difference, but it seems to be an important direction for future research.

This difficulty feeds into the second consideration, which is of a more general nature. Many current typological models rely on inference from synchronic distributions to identify phylogenetic or areal signals, rather than on attempting to directly operationalize linguistic understanding of diachronic change (for an example from phonology, see Dockum 2018). Thus the fact that, say, similar phonemes do or do not occur in close geographical proximity can affect our inference, even if it is only rarely that we can firmly establish causation. Such methods are particularly effective where we can identify and quantify relatively sharp discontinuities in the typological space, which strongly suggest the presence of an additional factor such as language contact (Nikolaev 2019).

However, if I am right in suggesting that a large proportion of the changes that we observe may be relatively uninformative for identifying genetic and areal relationships between languages, then it may be appropriate to consider if other methods might also be useful in approaching these issues. This is particularly true in the case of horizontal transfer. In constructing a phylogenetic tree, even those shared features that have clear phonetic grounding are potentially informative with respect to the topology of the grouping, because of the ground assumption that the languages are related. Shared features that are not preserved from a common ancestor may be informative (if they are due to language contact) or they may be accidental, especially when they can be ascribed to widely prevailing phonetic factors. (The indeterminacy between the two is, of course, also the source of the much-discussed phenomenon of "Sapirean drift", after Sapir 1921.)

In order to approach this problem, it is worth taking a step back to consider what mechanisms create phonological areality in the first place. To what extent can we distinguish between areas emerging from "wave-like" transmission of sound change and phonological areality effects driven by contact? In particular, what would the phonological consequences of the sort of area formation that is likely to leave a distinct typological signal look like?

Following Winford (2005), the kind of long-term profound multilingual situation leading to area formation generally involves what he calls "recipient-language agentivity" (roughly mapping to "borrowing" in Thomason & Kaufman 1988). Under this régime, phonology is open to convergence just like any other linguistic subsystem, and is in fact generally seen as more amenable to it, because it is not as deeply integrated with other aspects of the grammar as, say, inflectional morphology. Moreover, this type of language contact promotes also lexical borrowing, which is widely recognized as an important vector for the introduction of items such as new phonemes. This is consistent with studies of bilingual phonological acquisition, which show that cross-linguistic transfer can indeed occur; for an overview, see Kehoe (2015), who nevertheless cautions that straightforward mutual influence is not the only possible outcome.

The literature on language contact has increasingly recognized that this type of contact situation is approached most fruitfully as a linguistic ecology of vernacular multilingualism within communities on a much smaller scale and a focus on "contact between speakers" rather than "contact between varieties": see Enfield (2005) on Mainland South-East Asia, Friedman (2011) on the Balkan *Sprachbund*, and Dombrowski (2013) for a series of phonological case studies that demonstrate the fecundity of this framework.

What kind of phonological outcomes should we expect in this situation? It should be clear that such settings in particular are conducive to the sort of effects identified by Blevins (2017) and Andersson et al. (2017), where the perceptual system, articulatory routines or even the phonological grammar of one of the languages can influence the other and lead to changes over time. I suggest that one possible diagnostic of this situation that can be observed and aggregated in a typologically interesting manner is the existence of *shared sound changes* in different lects: indeed, I would hazard it is positively *predicted* that such changes should result in these contexts.

5.2 Shared sound changes and typology

The phenomenon of shared sound change has certainly been discussed before in areal typology. Indeed, some of the very earliest work in areal linguistics already engaged with the issue. For example, the early list of Balkanisms by Seliščev (1925) points to a shared change notated as *î > *ă* in Meglenoromanian ([megl1237], Indo-European > Romance) and the immediately neighbouring Macedonian ([mace1250], Indo-European > Slavic) dialects on the present-day border between Greece and North Macedonia. Specifically, where Balkan Romance has [ɨ] arising from Latin *a before a nasal, most Meglenoromanian dialects show a back open [ɔ]: <lǫnă> [lɔnə] 'wool' < LANA (Romanian [roma1327] *lână*), whilst others have [ə], assumed to be an intermediate stage (Capidan 1925: 97). Within Macedonian, a mid central reflex of the Proto-Slavic nasal vowel *ǫ is a well-recognized, distinctive feature of precisely this dialect region, so [rəka] 'hand' < **rǫka* (Vidoeski 1999: 19–27).[27]

More examples can be adduced from the Balkans. The raising and centralization of vowels in the context of an adjacent nasal is found not just in Balkan Romance but also in Albanian [alba1267] (*mëz* 'foal' < **mandjo-*, *këngë* 'song' < Latin CANTICU) and in Macedonian dialects (with forms like *znəm* 'I know' < **zъ-namь*). Moreover, as Koneski (1983: 37) points out, when such vowels undergo

[27] See Marković (2007: 45–46) for discussion of similar outcomes in contact between Aromanian and the Macedonian dialect of the Ohrid-Struga region.

further change, their reflexes (such as [ɔ] or [ɛ]) can be similar in Albanian and Macedonian vernaculars of the same region; see further Sawicka (2000) on the "nasal schwa" as a Balkan areal feature. On a much larger scale, Vermeer (1989) has proposed that the differences in how Proto-Slavic mid vowels developed in the western Balkans map closely to isoglosses related to the outcomes of Latin mid vowels in Romance. Outwith Europe, Dockum & Gehrmann (2021) have reconstructed a Voicing Shift cutting across language families in South-East Asia to understand the development of tone in the area.

Leaving aside the merits of these specific proposals, I would argue that a systematic approach to such data can offer valuable insights into areal typology; and, conversely, a more rigorous application of the methods of distributional typology genuinely offers a way to look beyond individual hypotheses about isolated facts.

Consider, for instance, Romance varieties in the western Pyrenees such as Gascon ([gasc1240]) and Aragonese ([arag1250]). It has long been recognized that they share many sound changes with Basque ([basq1248]), a language that was historically spoken in the areas currently occupied by these Romance varieties, with vernacular bilingualism persisting in some areas until very recently (for overviews, see Jungemann 1950, Baldinger 1958, Rohlfs 1970, Haase 1997). Examples of shared sound changes include the loss of intervocalic *n* (Gascon *garia* 'chicken' < GALLINA, Basque *katea* 'chain' < Latin CATENA), post-sonorant stop voicing (Gascon *plandá* 'plant' < PLANTARE, Basque *denbora* 'time' < Latin TEMPORA[28]), and vowel prosthesis before initial *r* (Gascon *arrìu* 'stream' < RIVU, Basque *errege* 'king' < Latin REGE). Furthermore, some Romance vernaculars in this area show a *lack* of changes that are otherwise pervasive in related varieties: for example, Aragonese and Béarnais resist the lenition of Proto-Romance singleton voiceless stops in intervocalic position, as in Béarnais *pleká* 'fold' < PLĬCARE, Aragonese *saper* 'know' < SAPĒRE (Elcock 1938), just like Basque (cf. *katea* just cited). Evaluating the role of language contact in such phenomena is, of course, notoriously fraught. When considered individually, all these changes, or lack of changes, clearly do not *require* contact-based accounts: they are often phonetically unsurprising (as with post-sonorant voicing), typologically common (pre-*r* prosthesis), and/or parallelled elsewhere in the family (for example, intervocalic *n*-deletion is also a feature of Galician-Portuguese [gali1263], cf. *lua* 'moon' < LUNA). Similarly, the absence of a change can simply mean that that it has not had the time to diffuse to a variety, especially one spoken in a peripheral or remote community – compare the fact that some varieties of Aragonese also preserved distinctive consonant length until modern times (Badía Margarit 1950),

[28]This is not universal in Basque, however (Trask 1997: 132).

much longer than other surrounding Romance vernaculars, with no parallel in Basque.

To appreciate the complexity of these inferences, we can consider the example of the Greek dialects of Calabria (Bovezika; Indo-European > Greek [aspr1238]). Blevins & Garrett (1993) cite them, with reference to Falcone (1973), as an example of preaspiration as the outcome of plain stop gemination. Intriguingly, they also list the Romance vernacular of the region (Falcone 1976) as showing the same sound change. This appears to be imprecise. First, singleton voiceless stops can be aspirated in Calabria (e. g. Mele 2009), so the degemination may be less relevant than coarticulation with postaspiration here. Second, Falcone's accounts in both cases quite clearly describe the relevant geminates as postaspirated, not preaspirated; acoustic studies of both dialect and regional standard speech in Cosenza by Sorianello (1996), Stevens & Hajek (2010) confirm the existence of post-aspirated geminates in this region. Armostis (2009) provides similar acoustic proof with regard to Cypriot Greek (Newton 1972), which Blevins & Garrett (1993) also cite.

That said, Karanastasis' description of the dialect of Kos (Karanastasīs 1963/1964: 77–78), which Falcone (1973, 1976) claims is similar or identical to Bovezika in this respect, suggests that preaspiration might be at least possible: for instance, for [pː] he uses the notations <π-‘π>, <‘π>, and <πh>, of which at least second may suggest preaspiration. Furthermore, Stevens & Hajek (2010) identify the possibility of "panaspirated" realizations of voiceless geminates, that is with laryngeal noise both before and after the closure, in a wide range of Italian regional varieties. They entertain the possibility, however, that in this case postaspiration is diachronically secondary to preaspiration. They cite the well-known case of West Andalusian Spanish ([anda1279]; Indo-European > Romance) as a parallel (e. g. Torreira 2012, Ruch & Harrington 2014). An even closer comparison can be made with Aanaar Sámi ([inar1241]; Uralic > Saami), where the relevant stops, unlike the Spanish ones, are geminated; see Iosad (2022) and Iosad (2025) for more detail.

That said, even if the Calabrian vernaculars do not present an example of preaspiration, they *do* present an instance of shared sound changes, since the presence of aspiration in geminates is clearly innovative in both. The possibility that these varieties have undergone convergence of this type is further buttressed by the presence of other shared innovations, such as the change **ll* > *ḍḍ*: Calabrese *kavaḍḍu* 'horse' < caballu, Bovezika *aḍḍo* 'other' < ἄλλος (Falcone 1976: 54, 1973: 185). On the other hand, as we have seen, (post)aspiration of geminates is also found in south-eastern varieties of Greek such as the dialects of Kos and

Chios and Cypriot Greek, which may suggest that convergence with Calabrese may not provide the whole story in the case of Bovezika.

In cases such as these, the methods of distributional typology are precisely what is required to evaluate the balance of the evidence, by establishing baseline probabilities for both individual changes and their co-occurrence, with controls for spatial and genetic proximity. This issue of the baseline is, as I argued in Section 4, of key importance for the questions that this volume poses: how do we identify a phenomenon as a phonological rarity, and what can it tell us about linguistic structure and history?

Understanding the distributional typology of phonological change, of course, likely requires us to make progress in its descriptive typology. So far, this remains a desideratum: although most historical phonologists have some idea of the range of possible changes and some rough probabilistic intuitions (cf. Cser 2015), systematic descriptions that would allow us to start building distributional models (along the lines of the monumental Kümmel 2007) remain rare. Here, recent advances in computer-assisted inference of sound change (e.g. List 2019, Bodt & List 2019) promise to increase our coverage quite significantly, hopefully opening up the way to further progress.

Focusing on sound changes within smaller-scale communities may also help to address an important criticism aimed at areal linguistics by authors such as Campbell (2006). He points out, not unfairly, that areal inquiry has often suffered from an undue focus on "large", often standardized (and in any case well-described) varieties. In the context of traditional areal linguistics, this can lead to relatively sterile chasing of definitions built around the counting of shared features, often relatively marked ones, which are subject to levelling out in precisely these kinds of varieties. In distributional typology, especially prior to the age of "big data", a point would often be sampled not because it is especially informative in and of itself, but because it was hoped that it would contribute to a representative sample, which again could erase the local effects of contact.

Some work in this direction has already started. Bye (2011) showed how disaggregating present-day distributions of features into the reconstructed sequence of sound changes that led to them allows us to make much stronger inferences about the course of events compared to examining final states. More recently, Cathcart (2022) proposed a methodology for disentangling vertical and horizontal transfer in a set of closely related, neighbouring varieties that is built on representing each variety as a vector of probabilities for a set of explicitly coded (rather than inferred) sound changes, with promising results.

To conclude this section, I suggest that a focus on the actual processes that produce convergences (or divergences) takes us closer to pursuing an areal linguistics that addresses the question of "what happened?" directly, rather than obliquely, by identifying "language areas" or "contact superposition zones" (on this notion, see Koptjevskaja-Tamm & Wälchli 2001) and inferring past changes on this basis (Campbell 2006). Furthermore, operationalizing phonological phenomena in explicit phonological terms could potentially allow us to also draw on the kind of theoretically informed analysis that I have advocated in Sections 3 and 4, and hopefully provide even more information to base our inferences on. More generally, a focus on actual diachronic processes over inference from synchronic distributions in phonology appears to be an appropriate avenue to explore in light of arguments made for a similar turn in morphosyntactic typology (e.g. Maslova 2000, Bickel 2013, Cristofaro 2019).

6 Conclusion

Throughout this chapter, I have expressed both skepticism and optimism about applying the methods of modern typology to phonological data, including the search for phonological rarities. Both the skepticism and the optimism come from engagement with theory-building. On the one hand, even for apparently uncontroversial concepts like "the phoneme" or "distinctive features" it is not clear that they are sufficiently "theory-neutral" to be used in typological study without further elaboration. On the other hand, the significance of phenomena like shared sound changes is identified not merely on the basis of inferences from observed co-occurrences, but from first principles, based on our understanding of how language contact works.

Where does this leave the analysis of phonological rarities? I have argued for at least two ways in which phonological theory is indispensable to this enterprise. First, I have suggested that much insight can be gained from a theoretical framing of apparently rare phenomena, so that the precise nature and import of the rarity can be clearly delineated. Second, I have investigated the question of how we should identify the baseline against which the rarity, or otherwise, of phonological phenomena should be measured. Whilst endorsing distributional typology as an appropriate method, I have also argued that this kind of enquiry can also be enhanced with reference to specific theoretical commitments. With both Hyman (2008) and Plank (2018), I conclude that typology and phonology can, and should, work together, as long as the phonologists closely engage with state-of-the-art typological methods, and the typologists take the theory with the seriousness it deserves.

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Abbreviations

1	first person	INF	infinitive	POSS	possessive
ACC	accusative	M	masculine	PRS	present
F	feminine	NOM	nominative	SG	singular
GEN	genitive	PL	plural		

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Part II

Rare sound changes

Chapter 3

*b > *-k-*: A Berawan sound change for the ages

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Berawan, an Austronesian language spoken in northern Sarawak, Malaysian Borneo, is one of several languages in central and western Borneo that have unusually innovative phonologies. Not only are these phonologies rich in number of changes, and the effect they sometimes have on concealing cognation (e.g., Malay *bəruaŋ* and Long Terawan Berawan *kəbiŋ* 'the Malayan sun bear: *Ursus malayanus*' are cognate), but the search for theoretically-supported motivations for some changes leads nowhere. One of these changes in all dialects of Berawan is *b > *k* in intervocalic position, a change that is abundantly attested, and therefore not in question as a valid transition from an earlier to a later state of the language. A basic question is whether this was a one-step change, or a telescoping of several phonetically more 'natural' changes, and while it can be resolved into a two-step change, this hardly relieves our sense of theoretical angst, since so far as the evidence allows us to infer, these changes were *b > *g* in intervocalic position, followed by intervocalic devoicing of *g* from two historically distinct sources. Attempts so far to show that this change involved other intermediate steps have yet to be successful.

1 Introduction

Bizarre sound change is not a topic that is well-suited to congenial dinner chat. Before they know it, the conversationalists are apt to snatch up fork and knife, and face off across the table in a confrontational mood, ready for battle. The defender of theoretical orthodoxy demands: "How do you *know* that this unexpected transition was a single change, and not the telescoping of multiple smaller and (of course) more expected sound changes?", to which the other, ignoring his

Robert Blust. 2025. *b > *-k-*: A Berawan sound change for the ages. In Natalia Kuznetsova, Cormac Anderson & Shelece Easterday (eds.), *Rarities in phonetics and phonology: Structural, typological, evolutionary, and social dimensions*, 87–113. Berlin: Language Science Press. DOI: 10.5281/zenodo.15148166

eggplant, responds with equal passion: "How do *you* know that there were 16 baby steps between *x and /y/ if there is no direct evidence of them?" In the end, those who are unwary enough to be dragged into this kind of conversation are more likely to experience indigestion than enlightenment.

That is the risk I take here in introducing to the world of linguists a piece of the phonological history of Berawan, a cluster of four closely-related Austronesian languages or divergent dialects of a single language spoken in the basin of the Baram river in northern Sarawak, Malaysian Borneo. The Berawan languages (Long Teru, Long Jegan, Batu Belah and Long Terawan) belong to the North Sarawak subgroup, which comprises four primary branches:

1. Dayic (Lun Dayeh/Lun Bawang, Kelabit, Sa'ban, Tring, etc.).
2. Kenyah (many communities in central Borneo).
3. Berawan-Lower Baram (the Berawan languages and others in the lower course of the Baram river, such as Kiput, Narum, and Miri).[1]
4. Bintulu.

The Berawan group itself breaks down into two primary branches:

1. Northern Berawan (Long Terawan).
2. Southern Berawan (Long Teru, Batu Belah, Long Jegan).

Gluttons for punishment can find further details in Blust (2010).

2 Sound change and reflex

Any historical linguist worth his salt knows the difference between a sound change and a reflex. Nonetheless, when he attempts to express the mapping between the phonological shape of a language at earlier and later states in the most neutral terms possible, well-meaning critics feel little restraint in peppering him

[1] The Berawan-speaking communities are Long Terawan, on the Tutoh branch of the Baram river, Long Teru and Long Jegan, on the Tinjar branch of the Baram, and Batu Belah, on the Apoh branch of the Baram. Place names in Sarawak often are based on a reflex of *əluŋ 'confluence, place where two rivers meet' (hence 'Long Teru' is at the confluence of the small Teru river with the larger Tinjar). Batu Belah, by contrast, means 'split rock', and shows up in more than one part of the Austronesian world as a place name based on a topographical feature.

with questions of the form "Have you thought about intermediate steps x, y and z?" To some extent, this is because the term 'sound change' is often used loosely either for a single phonetic transition from one state to another, as in the title of this chapter, or for a reflex, which may encode an accumulated history of changes (but would you want to read a chapter titled '*b > *-k-*: A Berawan reflex for the ages'?).

However, more generally, this insistence on breaking down phonetically puzzling reflexes into smaller, phonetically motivated steps is due to an ideological stance that adheres consciously or unconsciously to the proposition "Most sound changes are phonetically motivated; *therefore* all sound changes are phonetically motivated." We need not comment on the groans coming out of Aristotle's grave when we dare to state something so outrageous to basic principles of logic, but it is hard not to infer this presupposition when theoretical purists insist that a change such as Proto-Polynesian *l > Rennellese /g/ ([ŋg]), or *w > Sundanese *c-, -nc- must* have involved intermediate steps (Blust 2005).

Science in all its manifestations is obviously more than a collection of observations about the real world. What organizes these observations into a network of mutually-supportive data is the framework of theoretical constructs that show *why* these observations take the form they do as observable consequences of an unobservable reality. One can think of this as triangulation: at the base of the triangle are two or more (possibly many more) observations about the world that may or may not be causally connected, and at the top is a theoretical construct that cannot be observed, but is justified by its ability to show that various superficially dissimilar observations are the expected consequences of a single underlying reality. Although we daily place our trust in its existence, no one has ever seen gravity, yet we accept it because of a wide range of sensory impressions that tell us it must exist. A proto-language is a theoretical construct that occupies the top of a theoretical triangle much like gravity does, and it is justified only to the extent that it serves to explain diverse observations about languages that follow as expected consequences of its existence. In the rest of this chapter, I will adhere to that basic principle of good science called "Occam's razor", meaning that I will assume only what is necessary to explain the primary observations that make up a scientific corpus as the expected consequences of an underlying reality that has been independently justified through prior reference to a wider range of other observations.

3 Before Berawan

As already noted, the Berawan languages form part of a Berawan-Lower Baram subgroup that itself is one of four primary branches of the North Sarawak subgroup of Austronesian languages. Suffice it to say that there are various proto-languages to which the sound changes in Berawan could refer. In the interest of citing forms that are well-known to a relatively large number of people (at least those familiar with Austronesian historical linguistics), one might refer to Proto-Malayo-Polynesian (PMP), the hypothetical ancestor of the non-Formosan Austronesian languages. However, because Proto-North Sarawak (PNS) had already undergone several important sound changes that are relevant to discussing the phonological history of Berawan, I will generally use PNS reconstructions, and only resort to higher-level (and hence more widely-known) reconstructions if this sheds additional light on the problem at hand.

Proto-North Sarawak had a simple four-vowel system (*i, *u, *a and the schwa *ə), and the consonant system shown in Table 1. Canonical shape of base morphemes was CVCVC, or less commonly CVNCVC, where N was a nasal homorganic with the following obstruent.

Table 1: The Proto-North Sarawak consonant system

	bilabial	dental/alveolar	palatal	velar	uvular	glottal
voiceless plosive	p	t		k		ʔ
voiced plosive	b	d	j	g		
voiced aspirated plosive	bʰ	dʰ	jʰ	gʰ		
voiceless sibilant	s					
nasal	m	n	ñ	ŋ		
lateral liquid	l					
flap	r					
trill					ʀ	
glides	w		y			

The voiceless obstruents require little discussion. So far as their reflexes permit us to infer, they were unaspirated. Plosives *p, *t, and *k could occur in any position, but *ʔ was contrastive only medially and finally, not morpheme-initially.

The voiced obstruents *b, *d, *g were the voiced equivalents of *p, *t, *k, except that *t was postdental, and other consonants in column 2 were alveolar. In PNS, the palatal affricate *j lacked a voiceless counterpart, which either merged with *s before PNS came into being, or merged with *s recurrently after the split-up of PNS, leaving no trace of its former presence.

As noted in a number of previous publications (Blust 1969, 1974, 1993, 2005, 2006, 2016, the segments written b^h, d^h, j^h, g^h meet Ladefoged's (1971: 9) definition of true voiced aspirates (phonologically unitary segments that begin voiced and end voiceless, with optional delayed VOT on the following vowel), although throughout his career he continued to deny this for reasons that were never clear to me personally (e.g. Ladefoged & Maddieson 1996: 80).

The only other segment that requires special comment is *R, which is reflected as /r/ or /l/ in many Austronesian languages, but as /g/ or /h/ in others (for a full discussion of the variety of reflexes of this rhotic see Blust 2013: 595–596).

Appendix A provides minimal evidence supporting this reconstructed system in intervocalic position, which is the position that most concerns us in this chapter. Insufficient evidence is available for reconstructing PNS *-ñ- and *-r-, although at least *ñ is reconstructable as a word onset. *r is more problematic throughout Austronesian, but is supported as distinct from *R in a handful of forms in Kenyah languages. These gaps have no effect on the argument to follow.

4 What happened to Berawan?

The four Berawan dialects/languages naturally share some phonological innovations apart from other North Sarawak languages, but they also each have individual peculiarities that set them apart from their subgroup-mates. The sound change I address here applies to all four Berawan speech communities, but in the interest of coherence, I will consider mainly the Batu Belah dialect (hereafter BBB), for which I recorded the largest number of relevant forms, with passing remarks on the others where I feel this might be helpful.

Since my concern is with the development of intervocalic *b in the Berawan languages, it will be well to start by observing the reflex of PNS *abu 'ash' in Appendix 1. In Kelabit this is *abuh*, the only change being the historically secondary *-h* that was added here and in a number of other forms. The Long Anap dialect of Kenyah lacks a cognate, although other Kenyah dialects have one (e.g. Long Atip *avoʔ* 'ashes, hearth'), and the Bintulu form is *avəw*. In each of these languages, we see a readily recognizable sound change in which a voiced bilabial stop has been either retained or lenited to a labiodental fricative. But what happened to Berawan? BBB *akkuh* sticks out like the proverbial sore thumb. Is it related at all? One's first guess is "probably not", but the only way to test decisions of cognation is by *recurrence*, which is, and always has been, the key to determining cognation. This is a point that is often misunderstood by scholars in sister disciplines, such as cultural anthropology, and even by some linguists who have had little experience in dealing with historical questions. So, the next question must be: "What happened to intervocalic *b in other reconstructed forms?"

Table 2 lists all other BBB reflexes of PNS forms with medial *b for which I have data.

Table 2: Reflexes of PNS *-b- in Batu Belah Berawan

PNS	BBB	
*abu	akkuh	'ash'
*babuy	bikuy	'pig; wild boar'
*bəlabaw	bəlilkiw	'rat'
*bubu	bukkuh	'conical bamboo fish/eel trap'
*bubuŋ	bukuŋ	'ridgepole of house'
*kabiŋ	kakiŋ	'left side'
*lubaŋ	lukiŋ	'hole in the ground'
*mabuk	makuk	'drunk'
*nibuŋ	nikuŋ	'nibong palm, *Oncosperma* spp.'
*Rabun	gikuŋ	'cloud'
*Ribu	gikkuh	'thousand'
*tuba	tukkih	'fish poison, *Derris elliptica*'
*ubi	ukkih	'yam'

All thirteen of these etymologies are completely straightforward: the reconstructions are well-established not only in PNS, but in higher-level proto-languages, as cognates that contain a medial voiced bilabial stop or some phonetically transparent lenition of it are found in scores or even hundreds of other languages, depending on the form. They are completely straightforward, and they are completely crazy – how does a language change *b to /k/, and undergo this change only in intervocalic position?

The next step, then, is to show that PNS *b > Berawan *-k-* was conditioned. This is already clear from the four *b-initial words in Table 2, but to show that PNS developed along fundamentally different lines in word-initial, medial and final positions, a fuller set of data is given in Table 3, leaving aside the forms already mentioned.

Although only two examples of *b > *-m* could be found in my fieldnotes, the nasalization of word-final voiced stops in Berawan is supported by more numerous examples of *d > *-n/ŋ*:

(1) PNS *alud > *aloŋ* 'boat', *kuyad > *kuyan* 'gray langur', *likud > *likoŋ* 'back (anat.)', *pusəd > *pusən* 'navel', *tumid > *tumin* 'heel', and *uləd > *ulən* 'maggot, worm', where word-final *d normally became *ŋ* after rounded vowels, and *n* elsewhere.

One other thing to show is that PNS *p did not undergo labial backing in intervocalic position, which enables us to infer that this change in the data of Table 2 must have preceded intervocalic devoicing (hereafter IVD), since otherwise PNS *p and *b would have merged as /k/ intervocalically. This should be clear from Table 4.

Table 3: Reflexes of PNS *b- and *-b in Batu Belah Berawan

PNS	BBB	
*b- > *b*		
*bahu	biʔoh	'stench, odor'
*balu	billoh	'widow(er)'
*baRa	bikkeh	'shoulder'
*baRiw	bikiw	'wind'
*batu	bittoh	'stone'
*batuk	bitok	'nape; neck'
*bawaŋ	biwaŋ	'expanse of water; lake'
*bəd^{h}uk	bəcuk	'monkey sp.'
*bəkən	bəkən	'other, different'
*bəRas	bəkiʔ	'husked rice'
*buaya	bijjih	'crocodile'
*buku	bukkuh	'node, joint'
*bulan	bulin	'moon'
*bulu	bulluh	'body hair; feather'
*-b > *m*		
*eleb	lu-ləm[a]	'knee'
	ŋ-uam	'to yawn

[a]Cf. Long Jegan, Long Teru *ləm* 'knee'. For the likely explanation of the first syllable in the BBB form, cf. Malay *lutut* and similar forms for 'knee' in other languages < PMP *qulu tuhud 'head of the knee' (= knee cap).

Table 4: Reflexes of PNS *-p- in Batu Belah Berawan

PNS	BBB	
*anipa	lippah	'snake sp.'
*apuR	apon	'lime (for betel)'
*apuy	apoy	'fire'
*kapal	kapan	'thick (as a plank)'
*lipen	dipan	'tooth'
*lupi	luppeh	'dream'
*sepaq	supa	'betel quid'
*tapan	tapan	'winnowing basket'

Several of these Batu Belah forms show irregularities in the development of a single vowel or single consonant, but all appear to be native, and together with data from other Berawan dialects they leave no question that PNS *p remained unchanged, in stark contrast to the development of intervocalic *b.

The last thing to mention in this section is that *b is not the only PNS phoneme that has undergone IVD. As noted following Table 1, PNS *R (and its predecessor in earlier proto-languages back to Proto-Austronesian (PAn)) apparently was either an alveolar trill that became uvular in many daughter languages before undergoing further change, or a uvular trill that became alveolar. Some of the best-known languages in the Austronesian family reflect it as /r/ (e.g., Malay). Others reflect it as /g/ (e.g., Tagalog). Still others reflect it as /h/ (Ngaju Dayak in southeast Borneo), zero (Javanese), /d/ (Inati/Inete), /l/ (Bunun), a voiceless lateral distinct from /l/ and /r/ (Thao), a retroflex flap (Saisiyat), /n/ (Mekeo), /s/, /x/ or /y/. Given the direction of front-back movement for trills in better-known languages, it seems likely that *R was an alveolar trill that was backed to uvular position in many daughter languages. Berawan evidently is one of the latter languages. Although it is the only language in the North Sarawak group to do so, it reflects *R as *g* in initial position. Intervocalically it is usually reflected as *k*, which is what interests us here, and word-finally it disappeared. Examples of these changes are shown in Table 5.

Comparing the reflexes of PNS *b and *R in BBB then, we see wide divergence in initial and final position, but identity (and hence merger) word-medially, as shown in Table 6.

Table 5: Reflexes of PNS *R in Batu Belah Berawan

PNS	BBB	
*R- > *g*		
*Rabun	gikuŋ	‘cloud’
*Ramut	gimok	‘root’
*Ratas	gitaʔ	‘milk’
*Ratus	gitoh	‘hundred’
*Ribu	gikkuh	‘thousand’
*Rusuk	gusok	‘chest’
*-R- > *k*		
*aRəm	akəm	‘pangolin’
*baRa	bikkeh	‘shoulder’
*baRiw	bikiw	‘wind’
*bəRas	bəkiʔ	‘husked rice’
*bəRat	pəkit	‘heavy’
*duRi	dukkih	‘thorn’
*kaRaw	kikiw	‘to scratch (an itch)’
*paRa	pakkeh	‘storage rack’
*suRat	sukit	‘wound’
*təgəRaŋ	takiŋ	‘ribs’
*təRəp	təkəp	‘k.o. breadfruit’
*uRat	ukit	‘vein; tendon’
*-R > zero		
*alaR	aka	‘vine, creeper’
*ikuR	iko	‘tail’
*ipaR	l-ipa	‘opposite bank or side’
*tuduR	turo	‘to sleep’

Table 6: Reflexes of PNS *b and *R in Batu Belah Berawan

PNS	BBB		
	initial	medial	final
*b	b	k	m
*R	g	k	∅

Since the simplest way to account for the difference between word-initial and medial reflexes of *R is to assume *R > *g* as syllable onset, followed by intervocalic devoicing, it seems clear that intervocalic devoicing also accounts for *b > -*k*- as a two-step change that began as *b > -*g*-.

5 Ockham and me

The stage has now been set: PNS (and earlier) *b did not change word-initially, became a voiceless velar stop intervocalically, and became the homorganic nasal word-finally, the latter as part of a more general process in which voiced stop codas were nasalized as an alternative to final devoicing (Blust 2018). Since PNS *p shows no change in intervocalic position, we can rule out the possibility that IVD preceded labial backing, and since PNS *R also shows IVD, the simplest way to account for this range of observations is that (1) *b backed to *g in intervocalic position, and (2) *g from both *b and *R devoiced intervocalically.

Where does this leave us as practitioners of the kind of science that is governed by Occam's razor?[2] Although I *could* begin to speculate about possible intermediate steps that would allow these puzzling observations to be seen as outcomes of natural sound change, it is unnecessary, since the two assumptions made in the previous paragraph are sufficient to account for the observations. The only thing that might prevent us from stopping here is that the explanation is inconvenient for the theoretical assumption (and it is no more than that) that because *most* sound change is phonetically motivated, *all* sound change must be phonetically motivated.

This is where we return to the dinner table, fork and knife in hand.

[2]William of Ockham is usually cited as such, but his famous "razor" is more often called "Occam's razor" (although "Ockham's razor" also appears). I let the inconsistency stand here, as it makes me consistent with (at least) tens of thousands of references in the scientific literature.

6 Inside the purist's lab

There are two major publications that have dealt with some of the oddities of Berawan historical phonology since my data was collected in 1971. The first is Burkhardt (2014), a doctoral dissertation done at Goethe University in Frankfurt, Germany, in 2014. As its title suggests, it aims at a comprehensive account of the phonology of Proto-Berawan, and its development in the modern languages through a bottom-up reconstruction. Of the two publications that I cite here, it is the more data-oriented, less theory-focused of the two. The other is Beguš (2018), a dissertation defended at Harvard University. It focuses on a wide crosslinguistic sample of problematic phonological phenomena, in each case seeking to find a solution that is phonetically "natural". One of the changes that it addresses is *b > *-k-* in Berawan. I will return to Burkhardt (2014) shortly, but for the moment let me try to summarize the approach that Beguš (2018) takes to the problem at hand.

Beguš (2018: 122–130) proposes something he calls the "Blurring chain hypothesis" (BCH), which involves the following steps in order to get from *b to *k* only in intervocalic position, entirely through phonetically-natural changes:

(2) Step 1: The voiced stops *b/d/g developed voiced fricative allophones intervocalically, hence:
-b- → *-β-*
-d- → *-ð-*
-g- → *-ɣ-*

This is considered a natural change, since intervocalic lenition of voiced stops is common in the world's languages.

(3) Step 2: The non-coronal voiced fricatives devoiced.
-β- → *-ɸ-*
-ð- → *-r-*
-ɣ- → *-x-*

This step is justified by an abundant phonetics literature which states or implies that voiced fricatives are unstable, and hence show a strong tendency to devoice.

(4) Step 3: Labial fricatives were backed to velars
-ɸ- → *-x-*
-r- → *-r-*
-x- → *-x-*

This step is based on the claim that the change from labial to velar position is more likely with fricatives than with stops.

(5) Step 4: Fricatives return to stops.
-x- → *-k-*
-r- → *-r-*
-x- → *-k-*

Beguš sums up the BCH in the following formula, which is to be interpreted as:

(1) stops become fricatives intervocalically;

(2) voiced fricatives devoice;

(3) (after backing) fricatives return to stops.

(6) D → Z / V_V
Z → S / V_V
S → T / V_V

He illustrates this with the following example (correcting errors in his reconstruction, and the phonemic representation of Berawan):

(7) *babuy > *biβuy > *biɸuy > *bixuy > *bikuy* 'pig'

By all accounts we should be happy – we now have an explanation for a truly puzzling sound change that shows it to be the outcome of a series of intermediate steps, each of which purportedly can be motivated by reference to general phonological processes in human languages as a whole. Book closed?

7 Reality strikes back

The first thing likely to trouble anyone who thinks seriously about the BCH is its violation of Occam's razor. We start with voiced stops that are visible from their reflexes in numerous languages outside the Berawan group (reflexes of PAn *qabu 'ashes', *babuy 'pig', etc.). Then, in the history of Berawan, these segments go out of sight and become fricatives, only to re-emerge as voiceless stops with different place features in the daughter languages when they are visible again (*akkuh, bikuy*, etc.). When a stop is reflected as a stop, with no direct evidence of any intermediate stage in which it was a fricative, standard scientific method would not support the claim that it became something different, and then reverted to its original state once it became possible to see it again. To scholars in many scientific disciplines, this would hardly be considered a sound scientific procedure. So, how is this claim justified?

First, to account for IVD, Beguš (2018: 127) draws attention to the phonetics literature where it is commonly accepted that "Voicing in fricatives is highly dispreferred and articulatorily difficult to maintain … Because voiced fricatives at this stage surface only intervocalically, the result is an apparent intervocalic devoicing." This provides a potential explanation for IVD, provided that an independent line of evidence supports the claim that stops became fricatives before becoming stops again. To date, no such independent line of evidence has been forthcoming.

Second, to account for the backing of labials to velars, Beguš refers to the study of consonant changes by Kümmel (2007), which focuses on Indo-European, Semitic and Uralic languages. In his sample of 294 languages, Kümmel found no cases of labial backing for stops, but he reportedly found two cases for fricatives. For reasons that many statisticians will surely find puzzling, Beguš (2018: 128) uses this observation to state that "The sound change [ɸ] > [x] or [β] > [ɣ] (if it happened prior to devoicing) is *much more common* than [p] > [k] or [b] > [g]" (italics added). In fact, two cases to none makes the backing of labial fricatives to their velar counterparts *infinitely* more common than the similar change for stops, but what can this mean in such a tiny sample?

I maintain a close watch on a language family with over 1,200 members, and I have seen *no* examples of labial fricatives backing to their velar counterparts anywhere in this family. If it happens in any language on the planet it must be very rare, and to claim that even two occurrences makes it "much more common" than the backing of labial stops to their velar counterparts is essentially meaningless. Of course, *f > *h* is a common sound change, but that is part of the universal lenition sequence *p > *f* > *h* > zero in many of the world's languages, and is irrelevant to this discussion.

To summarize, the first objection to the BCH is that it violates Occam's razor by positing hypothetical intermediate stages in a sound change that are not needed to account for the facts. Some might see this objection as more esthetic than substantive, although that is certainly debatable. More seriously, however, a central prediction of the BCH is contraindicated by the data, a fact that Beguš never mentions, and, I assume, was unaware of.

As seen above, his steps 1 and 2 introduce a voiced bilabial fricative that then devoices before backing and returning to its original state as a stop. However, as Burkhardt (2014: 166) makes clear, Proto-Berawan (PB) had a voiced bilabial

Table 7: Proto-Berawan voiced fricatives and their reflexes in the modern languages

PNS	PB	LTB	BBB	LJB	
*bəRuaŋ	*bəguβiŋ	kəbiŋ	kuβiŋ	kuβiŋ	‘Malayan sun bear’
*dua	*duβa	ləbih	duβeh	duβyəy	‘two’
*bituʔən	*təkun[a]	təkəbin	təkuβən	təkuβən	‘star’
*kuay	*kuβe	kəbe	guβi	guβiæ	‘Argus pheasant’
*puʔan	*puβan	pəban	puβan	poβan	‘squirrel’

[a]For reasons that are unclear, Burkhardt (2014: 166) has PB *kətuβən, based on a form of this shape only in BBB, as against *təkuβən* in all other Berawan languages. My own fieldnotes for BBB have *təkuβən*, showing agreement in all four dialects, hence the reconstruction given here.

fricative derived by glide fortition from automatic transitional glides, and this occurs in some very common words, as shown in Table 7 (LTB is Long Terawan Berawan; LJB is Long Jegan Berawan).

This is not a large number of forms, but it is sufficient to test the adequacy of steps 1 and 2 in the BCH. Moreover, the historical reality of automatic transitional glide fortition is further illustrated by a similar change for the palatal glide in forms such as PNS *ia, PB *jəh, LTB *jəh*, BBB *jah*, LJB *jiæ* ‘3sg., s/he’, PNS *lia, PB *ləjəh, LTB *ləjəh*, BBB *ləjeh*, LJB *ləjiæ* ‘ginger’, PNS *duRian, PB *dugəjin, LTB *kəjin*, BBB *kəjin*, LJB *kəjin* ‘durian’, etc.[3]

What matters here is that PB shows a voiced bilabial fricative identical to what Beguš posits in Step 1 of the BCH, as in PNS *lubaŋ > *lubiŋ (> hypothetical *luβiŋ > *luɸiŋ) > *lukiŋ* ‘hole in the ground’. However, unlike the hypothetical fricative in the BCH, the empirically-grounded (i.e., “real”) fricative did not 1) devoice, 2) back to a velar, or 3) revert to a stop. Since all science is ultimately observation-based, there is only one scientifically-responsible way to explain this difference, namely that the hypothetical voiced bilabial fricative in the BCH *did not exist*, since if it did, it should have remained unchanged like the examples in Table 7. It is obvious that his conclusion is fatal to the BCH – without an unobservable intermediate stage in which *-b- became a fricative before devoicing and reverting to a stop, the entire structure of Beguš’s theory collapses, and we are back to a theory that is more responsive to Occam’s razor.

[3]To avoid confusion, the reader should keep in mind that while the phonetic symbol [j] refers to a palatal glide in accordance with IPA conventions, the phonemic symbol /j/ refers to a voiced palatal affricate in accordance with conventions common to the spelling of languages throughout Indonesia and Malaysia.

This is the most serious problem with Beguš's treatment of Berawan historical phonology. However, it is not the only problem with his treatment of the history of this language.

8 Post mortem

Before I say anything else, let me make it clear that I believe Gašper Beguš is a fine scholar. His 'Blurring chain hypothesis' is an ingenious theoretical construct that required considerable skill and knowledge to propose. It has failed for one simple reason: its claims do not match the data of the real world. In many ways I feel that people like Beguš are victims of their foundational assumptions, in particular the commonly-held but rarely-expressed assumption that I have expressed earlier as: "Most sound changes are phonetically motivated; therefore *all* sound changes are phonetically motivated." What this belief commonly triggers is an argument chain that I would characterize as follows:

(8) mindset >> freewheeling treatment of data >> careless treatment of data >> erroneous conclusions

What I mean by this is that if one begins with an unshakeable mindset that all sound changes, no matter how phonetically challenging, *must* be products of the telescoping of a larger number of smaller changes that are themselves natural, the temptation becomes irresistible to force the data by any means possible to conform to theoretical expectation. This leads to a freewheeling treatment of the primary data, as with Beguš's willingness to assume that *b became a voiced bilabial fricative before undergoing further changes to emerge as /k/, hence going from STOP to FRICATIVE to STOP, with no direct evidence, or even indirect supporting evidence, that the intermediate stage ever existed as part of this sound change. The need for intervocalic fricatives rather than stops to provide a reason for labial backing is also based on the flimsiest of evidence (two cases to none). Yet, consistent with the freewheeling treatment of data, the reader is told that labial backing to velars is *much more common* with fricatives than with stops, when simple statistical tests provide no support for such hyperbole. What I mean by 'freewheeling', then, is that the argument may still be anchored in an accurate factual basis, but the leap from observation to inference begins to take on the appearance of an elaborate contrivance – there is pressure to find a way to show how an odd phonetic transition in the history of a language *must* have been the product of smaller, phonetically more natural steps, so a full arsenal of speculative proposals is brought to bear on the question.

Once this habit of "reaching" for a way to explain away theoretically non-conforming data begins to gain momentum, it is hard to stop, and may easily lead to careless treatment of the data itself – something we might call 'data-boggling'. In the case at hand, although the BCH was Beguš's own creation, and the responsbility for its failure therefore falls squarely on his shoulders, some other serious factual errors in his treatment of Berawan historical phonology are products of an over-reliance on Burkhardt (2014), when other sources going back to at least Blust (1992) were available. In short, it appears that Beguš's analysis fell victim to both of his foundational assumptions and his dependence on a primary source that itself contains serious flaws.

Let me begin with errors that are related to *b > -*k*- as a historical change, but are not fatal to the BCH, and then mention others that are separate from this issue, but which involve serious misrepresentations of the data.

Keeping in mind that he cites Burkhardt's PB *b and *g, rather than my PNS *b, *g and *R, Beguš (2018: 123) says the following with reference to the development of voiced stops in word-initial position:

> In contrast to intervocalic position, *b and *g remain unchanged in initial position. There are 46 reconstructed words with initial *b in Pre-Berawan. In all but one word the initial *b remains unchanged. A similar distribution holds for the velar voiced stop in initial position … In the one exception, devoicing occurs initially in all four dialects: *bəlippiəŋ > *pəlipiŋ* (['butterfly', RAB]). According to Burkhardt (2014: 144), this development is sporadic in a word that already exhibits another sporadic development: degemination of -*pp*-. There is only one other example in which devoicing initially occurs only in Long Terawan: *buraq > [purăh] (Burkhardt 2014).

Unfortunately, it is demonstrably not true that *b and *g "remain unchanged in initial position" with only a single exception each. Although Burkhardt (2014: 150ff) notes that *b- is sometimes reflected as *p*- if it was intervocalic as a result of prefixation, he does not point out that it is also reflected as *k*- in the same languages under the same condition (or consistently reflected as *k*- in LTB), and Beguš simply failed to see examples such as those in Table 8.

This is a minority pattern, but it is sufficiently well-attested that it should not have been overlooked, as it includes data from the basic vocabulary ('swollen', 'heavy', 'long', 'rotten'). What we would expect for the six LTB forms is *b*- for the first three, and *g*- for the last three, but instead we find *k*- for all six. As seen already, this is the normal reflex of PNS *b and *R in intervocalic position, and so is a clue that each of these bases was intervocalic when labial backing and IVD occurred.

Table 8: Anomalous reflexes of PNS *b-, *g-, and *R- in three Berawan dialects. (My field data for Long Teru is too limited to permit useful generalizations, and so is omitted from this chapter.)

(a) LTB

*b- > *k* (3 instances)	1. *bəsuR	kəco	‘full, satiated’
	2. *buat	kəbəiʔ	‘long’
	3. *buRuk	kuroʔ	‘rotten’
*g- > *k* (1 instance)	4. *gatəl	kitən	‘itch(y)’
*R- > *k* (2 instances)	5. *Raqən	kiʔən	‘light (weight)’
	6. *Raya	kijih	‘big’

(b) BBB

*b- > *k* (2 instances)	1. *baRəq	kiki	‘swollen’
	2. *buat	kuvit	‘heavy’
*b- > *p* (2 instances)	3. *beRat	pəkit	‘long’
	4. *buRuk	purok	‘rotten’
*g- > *k* (1 instance)	5. *gatəl	kitan	‘itch(y)’
*R- > *k* (2 instances)	6. *Raqən	kiʔan	‘light (weight)’
	7. *Raya	kijih	‘big’

(c) LJB

*b- > *k* (2 instances)	1. *baRəq	kikeæ	‘swollen’
	2. *buat	kuvit	‘heavy’
*b- > *p* (3 instances)	3. *bəsuR	pəco	‘full, satiated’
	4. *bəRat	pəkit	‘long’
	5. *buRuk	puriuʔ	‘rotten’
*g- > *k* (1 instance)	6. *gatəl	kætən	‘itch(y)’
*R- > *k* (1 instance)	7. *Raqən	keʔan	‘light (weight)’

The next thing to notice is that all of these words in every dialect are stative or adjectival, while this is true of none of the words in Table 2. Since PNS had an adjectival or stative verb prefix *mə- that is still common in Lun Bawang/ Lun Dayeh (cf. *mə-baraʔ* ‘swollen’, *mə-bərat* ‘heavy’, *mə-buruk* ‘rotten’, *mə-gatəl* 'itchy', *mə-raan* 'light in weight', etc.), we may assume that this prefix was still in place in the Berawan languages at the time of labial backing and intervocalic devoicing, and that after these changes took place, it was lost, leaving the bare stems with the normal reflexes of intervocalic *b, *g and *R in word-initial position. The same conclusion follows from the reflexes of trisyllabic nouns that regularly lost the first CV- after IVD had already taken place, as with the word for the 'Malayan sun bear' (PNS *bəRuaŋ, PB *bəguβiŋ) in Table 7, and the word for 'durian' (PNS *duRian, PB *dugəjin) in the paragraph immediately after it, which show parallel examples of glide fortition at bilabial and palatal places of articulation and IVD before loss of the first syllable.[4]

The situation for Batu Belah and Long Jegan is somewhat more complicated. In both of these communities, some instances of *b- are reflected as *k* and others as *p*. It is important to keep the subgrouping of the Berawan languages in mind: the first split probably separated LTB from Southern Berawan, and we can see a clear difference in the pattern of anomalous reflexes of initial *b- in Table 8, where LTB is consistent in reflecting what is now a word-initial reflex of *b- as *k,* while Batu Belah and Long Jegan show variation between *k* and *p*. The most straightforward explanation for this data appears to be that labial backing preceded IVD in LTB, but that these two changes overlapped in Southern Berawan. The ordering of relevant changes, then, evidently was as follows:

(9) Long Terawan Berawan:
  (1) labial backing/V__V;
  (2) devoicing;
  (3) loss of CV-.

(10) Batu Belah Berawan:
  (1) labial backing/V__V for items 1 and 3;
  (2) devoicing;
  (3) loss of CV-, but devoicing before labial backing for items 2 and 4 (which then could not back).

(11) Long Jegan Berawan:
  (1) labial backing/V__V for items 1 and 4, but devoicing before labial backing for items 2, 3, and 5 (which then could not back).

[4] In both cases, the high vowel that triggered glide formation in the first place was centralized to schwa in LTB – a complex sound change that is also found in other languages of coastal Sarawak. The fronting and raising of *a after a voiced obstruent is also a widespread change in northern Sarawak (Blust 2000, 2020).

What can we learn from this bit of neglected data? The firmest inference appears to be that IVD and labial backing overlapped in time. This may be of general interest, but has little relevance to the BCH, since the only ordering relation that this hypothesis requires is for *b to develop a fricative allophone intervocalically before IVD and labial backing, with the relative order of the latter two changes making no difference to the outcome of the historical derivation. However, this observation raises other questions, in particular, why does the change *-b- > *p* occur across a morpheme boundary, but never within a base morpheme? It seems that labial backing had to precede IVD within a morpheme, but could occur before or after the other change across a morpheme boundary.

The second example of data-boggling in Beguš (2018) that I will discuss concerns the history of the PNS voiced aspirates, a matter of some importance, since these were also voiced stops, although voiced stops with terminal devoicing. As noted in Blust (2006), PNS developed true voiced aspirates *b^h, *d^h, *j^h, *g^h, almost certainly from earlier geminates *bb, *dd, *jj, *gg, most of which arose after a nonmoraic schwa. As early as Blust (1969), this was taken as the defining innovation for the North Sarawak subgroup. To show that this change was complete by PB, one need only refer to nearly a dozen papers that have addressed this issue over the past half century, or to Appendix A. However, to provide a fuller account for the reader, the relevant data is summarized in Table 9.[5]

Against this backdrop of information, which shows that pre-PNS voiced geminates had *already* produced a distinctive series of true voiced aspirates in PNS, Beguš (2018: 126, fn. 66) says:

> Labial geminate stops arising after schwa and from consonant clusters do not undergo a change in place of articulation (unlike simple stops), e.g. *təbu > *təbbu > [təppu], *mə-bənnən > *mə-ppənnən > *ppənnən > [pənnən] (after the loss of *mə- and initial degemination) or *əbbis > *əppiq > [piʔ] (after the loss of initial schwa and initial degemination). Geminates arising via "h-accretion", however, do undergo a change in place of articulation: they develop to voiceless velar geminate stops.

One might respond: "Of course pre-PNS [bb] didn't undergo labial backing, as it had already become /b^h/ before the Berawan languages existed, and so was no longer a simple voiced stop, either singleton or geminate, when they began to differentiate." This was hardly a secret since, as already noted, it has been

[5]Batu Belah Berawan represents all Berawan dialects since the developments do not differ by dialect. Note also that data for *g^h is limited, and the reader is referred to Appendix A for the lone example thereof.

Table 9: Reflexes of the PNS voiced aspirates in North Sarawak Languages

(a) $*b^h$

	'head hair'	'sugarcane'
PNS	$*əb^huk$	$*təb^huh$
Bario Kelabit	$əb^huk$	$təb^huh$
Long Anap Kenyah	puk	təpu
Batu Belah Berawan	puk	təpuh
Bintulu	ɓuk	təɓəw

(b) $*d^h$

	'day'	'woman'
PNS	$*əd^haw$	$*dəd^huR$
Bario Kelabit	$əd^ho$	$dəd^hur$
Long Anap Kenyah	taw	ləto
Batu Belah Berawan	iciw	dicu
Bintulu	ɗaw	rəɗu

(c) $*j^h$

	'one'	'notched log ladder'
PNS	$*əj^ha$	$*Rəj^han$
Bario Kelabit	$əd^həh$	$əd^han$
Long Anap Kenyah	ca	can
Batu Belah Berawan	acih	acin
Bintulu	(jiʔəŋ)	k-əjan

addressed repeatedly in a literature now covering over half a century, beginning with Blust (1969).

On the other hand, Burkhardt (2014: 188) misrepresents the history of the PNS voiced aspirates in Berawan in a different way, maintaining that "PBn did not inherit the geminates *bb, *dd or *gg as they had devoiced to *pp, *tt and *kk respectively at a Pre-PBn stage." That this is false should be immediately obvious from the data in Table 9, which shows that PNS $*d^h$ and $*j^h$ merged as a new phoneme /c/ (voiceless palatal affricate) in the modern languages. In addition, the same data in Table 9, and other examples such as PNS *əb^{h}aʔ > LTB, BBB *pi*, LJB *piæ* 'fresh water' show Low Vowel Raising, which only happened after voiced obstruents, confirming that at least a three-way distinction in the voiced aspirates still existed in Proto-Berawan, namely *b^{h}, *j^{h}, *g^{h}.

These details may seem arcane, but they are critical to understanding the phonological history of the entire North Sarawak group of languages, and why both Burkhardt and Beguš would totally ignore a fairly rich literature concerned with them in favor of personal speculations that fail to account for actual observations is a mystery.

The last example of data-boggling in Beguš (2018) that I will discuss concerns the gemination of the onsets of open final syllables. As in many other AN languages of insular Southeast Asia, the schwa, which was extra-short (non-moraic) could not hold stress unless it geminated a following consonant, so allophonic gemination arose in Berawan following the reflex of an original penultimate schwa. This is of minor importance, as it remains allophonic unless one adheres to the 'once a phoneme, always a phoneme' principle, which I do not. More surprisingly, as noted in Blust (1992, 1995), the onsets of final syllables appear to have geminated if and only if they were open. At some point after this happened *-h* was added after all final vowels, possibly an areal change, as it is also found in Lower Baram languages such as Kiput, Narum, and Miri, in several dialects of Penan (Lowland Kenyah), in Sebop, Long Wat Kenyah, various Melanau dialects, several Land Dayak languages, and throughout the Dayic languages. Burkhardt (2014: 260) attempts to account for this peculiar condition as follows:

> In PWMP [Proto-Western-Malayo-Polynesian] items with an open syllable, simple consonants became PBn geminate consonants after *-h had been added at a Pre-PBn stage. The study assumes that this caused the following chain reaction: The accretion of *-h caused the vowel nucleus of the ultima, which had been phonetically long by default at the end of the word, to become phonetically short. This then caused the normal phonetic length of the penult nucleus (which was short to medium-short) to become phonetically extra-short, which then led to the gemination of the consonant that followed it (that is the onset of the ultima) to make up for the extrashortness of the penult vowel.

Beguš (2018: 124) simply accepts this hypothesis without question, but it can confidently be dismissed without elaborate argumentation. First, it is based entirely on speculation, without actual measurements of vowel length. Second, as already noted, *-h* addition is common to a number of languages of this area, and it triggered gemination nowhere else. Third, and most crucially, Burkhardt assumes that these geminates were found in PB and were added only after final /h/ accretion, yet the latter change did not affect the Long Jegan dialect, which implies that /h/ accretion *followed* the gemination of open final syllable onsets, as explained in Blust (1992), rather than triggering it, as shown in Table 10.[6]

Table 10: -/h/ Accretion in Berawan dialects

PB	LTB	BBB	LJB	
*accu	accoh	accoh	accəw	'dog'
*bullu	bulluh	bulluh	bulləw	'body hair, feather'
*dukki	dukkih	dukkih	dukkəy	'thorn'
*kuttu	kuttoh	kuttoh	kottaw	'head louse'
*matta	mattəh	mattah	matta	'eye'
*təllu	təlloh	təlloh	təllaw	'three'
*təppu	təppuh	təppuh	təppəw	'sugarcane'
*ullu	ulloh	ulloh	ollaw	'head'

9 Alternatives to "sound change"

Undoubtedly, the question foremost in the minds of phonologists who have stayed with me this long is: "O.K., if *b > -*k*- really was *b > -*g*- followed by intervocalic devoicing in Berawan, what phonological process could have motivated either of these changes?" My answer is: "None."

This leads to battle, as any phonologist worth his salt believes that sound change must involve some type of phonological process as typically understood in feature-based phonology. However, there have long been indications that this is not true. While the great majority of sound changes clearly *are* phonetically or phonologically motivated, there is no logical principle that says: "*Most* X are Y, therefore *all* X are Y". Conscious manipulation of language for social reasons is well-known in phonology, lexical semantics and morphosyntax (Conklin 1956, Li 1980, 1982, 2004, Hale 1971, Blust 1980, Thomason 2007). A particularly striking example is seen in the use of what Tagalog speakers call *baliktád*, or 'backward speech'.[7]

[6] The LJB reflex of PB *-u was recorded as -*əw* ~ -*aw* in free variation.

[7] It should be noted however that Tagalog *baliktad* means 'backwards' in general, not just of speech.

In a brief but dense description of this secret language, used mainly by teenagers at the time to disguise the content of messages from their elders, Conklin (1956) lays out the workings of a system of deliberate language manipulation that makes English 'Pig Latin' look jejune by comparison. He identifies eight types of structural rearrangement or affixation used to form *baliktád* words, including:

1. Complete reversal of the phonemic shape of the base (*salá:mat* > *tamá:las* 'thanks').

2. Partial reversal of the phonemic shape of the base (*dí:to* > *dó:ti* 'here').

3. Complete reversal of the syllable shape of the base (*pá:ŋit* > *ŋitpá* 'ugly').

4. Partial reversal of the syllable shape of the base (*ma-gandá* > *damagán* 'beautiful').

5. Insertion of the Actor Voice infix *-um-* (bolded) according to the usual pattern in productive verb morphology (*tiná:pay* > *t-**um**-iná:pay* 'bread', *na* > *n-**um**-a* 'already').

6. Infixation of a separate -VC- infix after all syllable-initial consonants (*sí:loʔ* > *s-**ig**-í:-l-**o:g**-óʔ* 'snare trap' *salá:mat póʔ* > *s-**ag**-a:l-**ag**-á:m-**ag**-át p-**og**-óʔ* 'Thank you, sir').

7. Double infixation with -VC- followed by -VCVC-, a shape that does not occur in ordinary language (*hindíʔ* > *h-**um**-ind-**imí:p**-iʔ* 'no, not', *puntá* > *p-**um**-ú:nt-**amá:p**-á* 'goes').

8. Complete reversal of the base and double infixation (*hindíʔ* > *d-**im**-í:h-**in**-ín* 'no, not', *saʔán* > *ʔ**um**-a:ns-**am**-á 'where?'*).

A similar system, called *cakap balek* (which, like *baliktád* means 'backward speech') was recorded very briefly for Malay by Evans (1923), suggesting that such systems of speech disguise may be more general in insular Southeast Asia than is commonly appreciated.

Given the purpose of *baliktád*, it is clear that it cannot remain constant over time, or its function would be lost (at least for those adults who might recall their own earlier use of the system). One can legitimately object that this type of word-play could never give rise to a permanent sound change, given both its specialized function, and its inherent lability. However, what is *does* show is that speakers are capable of creating deliberate changes in their language for special purposes, and the suggestion that conscious manipulation might lie behind a sound change like *b > -g- or intervocalic devoicing is not inherently unlikely.

10 Conclusion

It should be obvious that the issue of the obligatory naturalness of sound change is one that is going to divide the community of linguists into opposing camps, probably as much as any other issue in the field. Until studies of language change in progress are able to capture an example of a sound change that is both abrupt and phonetically "unnatural", we will have no way to determine by direct observation whether a change like *b > -g- in Berawan has actually occurred in any language. My own guess is that there have been many such changes, and my recommendation to all scholars, regardless of which side they take in this debate, is that they respect the integrity of the scientific process by adhering to Occam's razor, and limiting questionable inferences by demanding converging lines of independent evidence, rather than resorting to freewheeling speculation because they "know" in advance that their position is correct, when in fact its correctness is exactly what is at issue.

Appendix A Sample evidence supporting the PNS consonants in intervocalic position in Bario Kelabit, Long Anap Kenyah (LA Kenyah), Batu Belah Berawan (BB Berawan), and Bintulu

PNS	*apuy 'fire'	*batu 'stone'	*ikuR 'tail'	*daʔun 'leaf'
Bario Kelabit	apuy	batuh	iur	daʔun
LA Kenyah	(lutən)	batu	iko	(tuŋ kayu)
BB Berawan	apoy	bitoh	iko	dioŋ
Bintulu	(jarəʔ)	batəw	ikoy	raʔun

PNS	*abu	*ŋadan	*ujan	*təgəRaŋ
	‘ash’	‘name’	‘rain’	‘ribcage’
Bario Kelabit	abuh	ŋadan	udan	—
LA Kenyah	(lisəŋ)	ŋadan	ujan	təgaaŋ
BB Berawan	akuh	ŋaran	usin	takiŋ
Bintulu	avəw	ñaran	ujan	—

PNS	*əbʰuk	*ədʰaw	*əjʰa	*məgʰəl
	‘head hair’	‘day’	‘one’	‘sleep’
Bario Kelabit	əbʰuk	ədʰo	ədʰəh	məgʰəl[8]
LA Kenyah	puk	taw	ca	məkən[9]
BB Berawan	puk	iciw	acih	(turo)
Bintulu	ɓuk	ɗaw	(jiʔəŋ)	məgən

PNS	*kuman	*tanəʔ	*-ñ-[10]	*taŋih
	‘eat’	‘earth, soil’		‘to weep, cry’
Bario Kelabit	kuman	tanaʔ		taŋe
LA Kenyah	uman	tanaʔ		taŋe
BB Berawan	kuman	tana		taŋeʔ
Bintulu	kuman	tanəʔ		(məŋit)

PNS	*asu	*təlu	*-r-[11]	*bəRat
	‘dog’	‘three’		‘heavy’
Bario Kelabit	(ukuʔ)	təluh		bərat
LA Kenyah	asu	təlu		baat
BB Berawan	acoh	təloh		pəkit
Bintulu	asəw	ləw		vat

[8]‘stay with a small child to make him sleep’.

[9]‘to rest, to lie down’.

[10]There are no good candidates for PNS *ñ in medial position.

[11]There are no good candidates for PNS *r in medial position.

PNS	*tawa 'to laugh'	*kayu 'wood, tree'
Bario Kelabit	(riruh)	kayuh
LA Kenyah	pə-tawa	kayu
BB Berawan	tavah	kajuh
Bintulu	bə-taba	kayəw

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Chapter 4

Linguistically motivated sound change: Revisiting some of the world's rarest wonders

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Historical linguists of the last several centuries have come to widespread agreement that the majority of regular sound changes in the world's languages have clear phonetic and/or structural motivations. It is surprising then, that on the basis of ten typologically rare sound changes in Austronesian, Blust (2005) takes an opposing position: sound change is not phonetically motivated, and need not be linguistically motivated at all. In this chapter, Blust's (2005) analyses are questioned, taking into account research in phonetics, phonological typology, and contact linguistics of the past few decades. In some cases, multiple innovations are telescoped, while in others, articulatory, perceptual, aerodynamic, and structural factors, as well as language contact, are shown to play a role. The general conclusion is that sound change is indeed linguistically motivated.

1 Understanding sound change

Centuries of work in historical linguistics demonstrate that the great majority of regular sound changes in the world's languages have clear phonetic and/ or structural motivations (e.g. Yucai 1815, Osthoff & Brugman 1878, Grammont 1933, Ohala 1974, 1981, 1983, 1989, 1993, Blevins 2004, 2008b, Garrett 2015). Phonetic motivations can be articulatory, acoustic/perceptual, and/or aerodynamic. Structural factors include systems of contrast (e.g. De Chene & Anderson 1979, Blust 2004), functional load (e.g. Martinet 1952, Wedel et al. 2013); predictability (e.g. Blevins 2005a), frequency (e.g. Blust 2007), and contact (e.g. Thurgood

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1999, Blevins 2017a,b), and can all act as inhibitors of change, or as facilitators or attractors in sound pattern categorization. Nevertheless, in light of the ten typologically rare sound changes in Austronesian languages listed in Table 1, Blust (2005) argues that sound change need not be *linguistically* motivated.[1]

Table 1: Some bizarre sound changes in Austronesian languages (Blust 2005: 221)

	Sound change(s)	Language(s)
a.	*w/y > -*p*	Drehet [tlx], Levei [tlx] (Khehek varieties)
b.	*w/b > *c*-, -*nc*-	Sundanese [sun]
c.	intervocalic devoicing	Berawan [zbc], [zbe], [zbw], Kiput [kyi]
d.	*dr > k^h	Drehet
e.	*-b/d/g > -*m/n/ŋ*	Berawan, Karo Batak [btx]
f.	C > C: /__V#	Berawan
g.	*b > -*k*-	Berawan
h.	*g > *p*-, -*j*-, -*p*	Sa’ban [snv]
i.	*an/aŋ > -*ay*, *em/en/eŋ > -*aw*	Iban [iba]
j.	postnasal devoicing	Murik [mxr], Buginese [bug]

Each change in Table 1 is claimed to be regular (in the sense of Neogrammarian regularity), and each change is argued to be a single step, as opposed to a sequence of multiple changes. In later work, Blust (2018) holds fast to this position:

> In an earlier publication (Blust 2005) I drew attention to a number of surprising innovations in Austronesian languages, and concluded that few if any of them can convincingly be explained as due to previously unknown phonetic mechanisms, or to a telescoping of more typical changes over time. This has not stopped some scholars from continuing to speculate about possible phonetic conditions that apply very rarely, or about transitional steps that have never been observed… Needless to say, my purpose in discouraging arguments based on speculation is not to be anti-explanatory, but

[1]Blust (2005) concludes that social factors must trigger regular sound change in these special cases, though no particular social scenarios are put forth, and his general method is to continue to seek phonetic explanations for regular sound change, even when changes are highly unusual (Blust 2018, Lobel et al. 2021). In Table 1 and throughout, I follow Austronesianist practice: <y> represents IPA [j] and <j> represents IPA [ɟ]. However, all symbols inside square brackets are IPA symbols. In Table 1, ISO 639-3 language codes are included after each language name.

> rather to insist that explanations be empirically grounded… With enough persistence and freewheeling imagination, some contrived explanation can no doubt be found. But my point in trying to raise awareness about the importance of such ‘unnatural’ cases is that an acceptable explanation (i.e. one based on phonetic motivation) can usually be salvaged only by proposing a series of steps for which no evidence exists. Rather than ‘whitewash’ such apparent changes or hide them in a closet of silence, it seems much more in the interest of science to recognize that they challenge a widely-held assumption, namely the assumption that because *most* sound changes are phonetically motivated *all* sound changes are phonetically motivated. In short, only by incorporating deviations from expectation in a theory of sound change can we hope to gain a deeper understanding of why expected changes work the way they do. (Blust 2018: 1–2)

A similar position is echoed in Blust’s contribution to this volume.

This study, informed by research in phonetics, phonological typology, and contact phonology of the past several decades, reviews the sound changes in Table 1, questioning each step of Blust’s original argumentation. In line with Blust’s remarks above, I evaluate the extent to which these changes challenge widely held assumptions about sound change: (i) Must the change be viewed as an instance of sound change, or are there alternative analyses? (ii) Is there evidence that the change is a single-step reflex, as opposed to a cumulative product of multiple innovations? (iii) Is there really no evidence for articulatory, perceptual, aerodynamic, or structural motivation of the change? And, since significant language contact can result in otherwise unexpected sound changes that mimic internal change (Hamp 1996, Babel et al. 2013, Yao & Chang 2016, Blevins 2017a,b)[2], (iv) Has language contact played a role in any of these changes? Multiple innovations are suggested for several cases, and arguments are made for articulatory, perceptual, aerodynamic, and structural motivation, as well as influences of language contact. The general conclusion is that sound change *is* linguistically motivated, but in line with Blust’s intent, exploration of these rare deviations from common and predicted patterns allows us to gain a deeper understanding of sound change in all its complexity.

In Table 2, the sound changes listed in Table 1 are reordered and annotated to reflect the order of discussion in this study, specifics of target segments, and previous work on these recalcitrant problems (not including Blust’s subsequent

[2]Precursors to this work include Sapir (1921: 213) Hock (1975), Deshpande (1979), and Hamp (1979). Andersson et al. (2017) refer to these as “Sprachbund” effects.

Table 2: "Unmotivated" sound changes from Blust (2005)

SC#	Sound change(s)	Language(s)	Previous work	This work
SC1	*-w, *-y > *-p*	Khehek (Drehet, Levei)	Goddard (2007)	Section 2.1
SC2	*-b/-d/-g > *-m/-n/-ŋ*	Berawan, Karo Batak	Blevins (2007)	Section 2.2
SC3	*b > g / V_V	Berawan		Section 2.3
SC4	*D > T/ V_V	Berawan, Kiput	Beguš (2018, 2019)	Section 2.3
SC5	*ND > NT	Murik, Buginese	Beguš (2018, 2019)	Section 2.4
SC6	*g > *p-*, *-j-*, *-p*	Sa'ban (Kelabit)		Section 3.1
SC7	*-an/-aŋ > *-ay*, *-em/-en/-eŋ > *-aw*	Iban		Section 3.2
SC8	*C > C:/_V#	Berawan		Section 3.3
SC9	*dr- > k^h-	Drehet		Section 3.4
SC10	*w-/b- > *c-*, *-w-/-b- > *-nc-*	Sundanese		Section 3.5

publications which are cited throughout this chapter). In the first column, sound changes are numbered for easy reference throughout the chapter, and in the last column, the section of this chapter where the sound change is discussed is listed. The order of Blust's original list in Table 1, to my knowledge, had no particular rationale, and seemed to reflect the order in which he found himself working on these problems for the 2005 *Diachronica* publication. Blust's claim is that these sound changes are bizarre or unnatural, lacking clear phonetic or phonological motivation. Let us see if this is the case. Are any of these processes natural, where by natural we mean having a clear phonetic basis (Blevins 2008a)? If so, what factors obscure this naturalness?

2 Earlier replies to Blust (2005)

Since 2005, at least four of Blust's "unexplainable" one-step changes in Table 2 have been challenged, with sequences of natural phonetically motivated changes suggested instead. Under "Previous work" in Table 2 are published studies that have explored some of the sound changes further, including the extensive work of Beguš (2018, 2019, 2020) in forging a deeper understanding of unnatural phonology more generally. In reviewing the proposed sound changes in Table 2, I consider sound changes reviewed in earlier literature in Section 2 (including

SC3, which must feed SC4 in Berawan), and then, in Section 3, turn to the remaining proposed sound changes that have not received significant attention outside of Blust's own work.

2.1 *-w, *-y > p in Levei and Drehet

Goddard (2007) reviews the apparent one-step merger of Proto-Oceanic *-w and *-y (IPA *[j]) to *-p* in Drehet and Levei (SC1), repeated in (1). Drehet and Levei are two dialects of Khehek, an Oceanic language of Manus Island within the Admiralties subgroup. Data on Khehek (Drehet-Levei) includes Blust's published work and unpublished fieldnotes, the organized phonology data of Beard (1992), and an updated version of that (SIL 2004).

(1) Glide fortition in Khehek (Drehet and Levei dialects)
*-w, *-y > *-p*

Blust's central contention is that, while *w > (β > b) > *p* is arguably a natural fortition process, a parallel change of the palatal glide *-y, and, in particular, *-y > *-w*, is decidedly unnatural and unexpected. Data from Blust (2005: 230–231) supporting the sound change in (1) is shown in Table 3, including Proto-Oceanic

Table 3: Drehet and Levei data from Blust (2005: 230–231)

Proto-Oceanic	Proto-Manus	Lindrou	Levei	Drehet	Gloss
a. *boRok	*powo	bow	pup	pup	'pig'
b. *kanawe	*kanawe	kanaw	kanap		'seagull'
c. *koe	*koe	ow	op	op	2sg pronoun
d. *pakiwak	*paʔiwa	beʔew	peʔep	peʔep	'shark'
e. *pitaquR	*pitawu	besew		p^wisip	*'Calophyllum'*
f. *qayawan	*qaiwa	ew	ep	ep	'banyan'
g. *kayu	*kayu	key	kep	kep	'tree, wood'
h. *laqia[a]	*laqia	ley	lip	lip	'ginger'
i. *layaR	*palea	baley	pelep	pelep	'sail'
i. *paRi	*payi	bey	pep		'stingray'
j. *puqaya	*puaya	p^wiyey	puep	puip	'crocodile'
k. *waiwai	*weweyi	ewey	owip	owip	'mango'

[a] In Blust (1995: 231, Table 1) there are two typographical errors: Proto Oceanic *laqia and Proto Manus *laqia 'ginger' are both written as *qalia.

reconstructions (widely agreed upon) and Blust's Proto-Manus reconstructions as well (cf. Blust 2013: 659–660). Data from neighboring Lindrou [lid] illustrates continuations of inherited word-final glides, and Levei and Drehet, show *-w continued as *-p* in the top half of the table, and *-*y* continued as *-p* in the bottom half.

Goddard (2007) reviews the apparent one-step merger of Proto-Oceanic *-w and *-y to *-p* in Drehet and Levei. He suggests a sequence of two natural phonetically motivated sound changes, where each step is claimed to be natural and supported by parallel developments in other languages. First, word-final *-w, *-y merge as -*w* (2a); then *-w strengthens to *-p* (2b).

(2) Suggested glide merger and glide strengthening in Khehek (Drehet and Levei dialects)

a. *-y > *-w Glide merger

b. *-w > -p Glide fortition

However, the example of glide merger that Goddard refers to is not a word-final neutralization of *-y > *-w, but the Proto-Algonquian post-consonantal *w > *y/C_ in Proto-Arapaho-Atsina. As such, it differs from (2a) in two important ways: the target is *w, not *y; and the context is post-consonantal (syllable-initial), not word-final. Goddard (2007: 117) suggests that since the merger of labial and palatal glides is attested in one direction in one language family, there is no reason to doubt that it could have happened in the opposite direction in another.

I agree with Blust (2005, 2018) that there are reasons to doubt the naturalness of glide merger as stated in (2a). First, many sound changes, like *θ > *f*, are strongly unidirectional, so A > B should not be thought to imply B > A (Blevins 2019). Second, Blust (2018) notes that not a single case of regular context-free *y > *w* is known in Austronesian. Finally, an attempt to collect all reported cases of non-assimilatory glide mergers, summarized in Table 4, suggests that non-assimilatory *y > *w* is rare:[3] Semitic, Bodish and Algonquian show *w > *y*; Kuki-Chin suggests merger, but with no evidence of directionality. The only case with a clear non-assimilatory *y > *w* merger is East Franconian, which is questionable, since the glide may be optional or variable.

Given the rarity of non-assimilatory y > w mergers, it might be fruitful to consider distributional factors that could have played a role in a hypothesized -y > -w change in Khehek. In (3) we see generalizations holding of word-final consonants and VG sequences in Khehek *prior* to the hypothesized glide merger.

[3]Assimilatory *w > *y/_e* occurs in Tabasco Chontal (Justeson 1985), while assimilatory ?*y > *w/ u* may be found in Middle Indo-Aryan (Kümmel 2007: 243).

Table 4: Some non-assimilatory *w, *y (partial) mergers

Proto-language	Sound change	Evidenced in	source
Proto-Semitic	*w- > *y*-	Northwest Semitic	Suchard (2019)
Proto-Bodish	*w- > *y*-	Old Tibetan	Hill (2019)
Proto-Algonquian	*w > *y/C_*; *w,*y > *n* elsewhere	Arapaho-Atsina	Goddard (1974: 106–107)
Proto-Kuki-Chin	*-ay, *-aw > -*ɘ*; *-aay/*-aaw > -*e*	Monsang	Konnerth (2018)
Central German	?*y > *w/V_V*	East Franconian	Kümmel (2007: 243), Armborst (1979)

(3) Khehek word-final segments prior to *-y > -*w*
  a. Final -C
     *-h, -ŋ, -k
  b. Final -VG
     *-{i, e, u, o, a}w
     *-{i, e, a}y[4]

Apart from *h which, under most accounts, lacks specified place features, prior to the proposed glide-merger, final Cs {*ŋ, *k, *w} are all dorsal/[+back] with the exception of *-y. The high frequency of [+back] segments in final position might lead the listener to expect a final segment to be [+back]. In addition, since final *-y is only preceded by non-round (and, possibly, non-back) vowels, [5] one can understand the Khehek shift of *-y > -*w* as a dissimilatory process: perceptual

[4]There are few clear examples of directly inherited *-iy sequences. One possible example is Levei *kaalip* 'rock cod, grouper' < POC *kalika (cf. Lou *keliy*, Ere *kaliy*, Titan *kaliy*, Lindrou *kalik*) (Blust 1995: 230–231; ACD).

[5]That the central vowel /a/ is treated as [-back] in Khehek is suggested by the evolution of /ɔ/ from /a/ under backing/rounding as in: *buɔ* 'water' < *bua; *ɲuɔh* 'steam' < *ɲuah; *n'druɔ* 'possum' < *ndrua (cf. POC *k(ʷ)adroRa 'phalanger, cuscus'). These Khehek forms are from SIL (2004), where it is stated that /ɔ/ (written as <ø>) is included as a sixth vowel phoneme "because it carries a fairly heavy semantic load, with several minimal pairs." Note also the Levei form *e-tæŋ* 'to weep, cry' (ACD), written with a front low vowel /æ/. In contrast, Beard (1992) writes the Khehek low vowel as /ɑ/, and places it towards the back of his vowel chart.

hypercorrection (Ohala 1981) occurs when listeners interpret [j] as the result of fronting (4a) or unrounding (4b) of [w] in the context of a preceding non-back or unround vowel respectively. Subsequent to (4), glide fortition, as stated in (2b), occured.

(4) Khehek dissimilatory *-y-backing or *-y-rounding
  a. *-y > -*w*/ [-back]_# (assuming /a/ is [-back])
  b. *-y > -*w*/ [-round]_#

Strengthening or fortition of final *-w >(*β >)(*b >) -*p* was accepted by Blust (2005) as a natural fortition process based on similar processes in other Austronesian languages (e.g. Miri *w > *b*, Kiput *w > *f*^{w}) and parallel cases could be added in other language families, e.g. proto-Siouan *waC > *pC* in Mandan (Larson 2016: 69).[6] Since all final consonants are voiceless in Khehek, devoicing is expected. A further structural factor suggested by Blust (2005: 236) as an additional component of the shift to /p/ is a possible "pull-chain": prior to this change, /p/ was absent word-finally but present elsewhere. Hence, the shift of *-w >(β >)(b>)-p could be seen to fill a phonotactic gap. In sum, the reinterpretation of (1) as the two-step sequence of sound changes in (2), and elaborated in (5), is supported, with each change phonetically motivated, and having potential structural motivation as well.

(5) Suggested glide dissimilation and glide strengthening in Drehet and Levei
  a. i. *-y > *-w/ [-back]_#
    Glide backing (phonetic + distributional/structural factors) *or*
   ii. *-y > *-w/ [-round]_#
    Glide rounding (phonetic + distributional/structural factors)
  b. *-w > (*β >)(> *b) > -*p*
    Glide fortition (phonetic + distributional/structural factors)

The unique distribution of final consonants prior to this sound change may have played a catalytic role in (5a), with non-syllabic back segments acting as attractors in the backing of *-y, and limited *-Vy sequences resulting in reinterpretation of *-y as a fronted/unrounded *-w. The pre-existing /-p/ gap in word-final

[6] A reviewer notes word-initial *w- > *gw-* in some Admiralties languages (Ross 1988: 321) and asks whether *gw might be an intermediate stage for Khehek, given Ross's proposal of *w- > *b-* in Levei-Tulu. First, strengthening of *w- > *gw-* is limited to initial position: cf. Likum *gway* < *waiR 'water', vs. *kaano-lew* 'spider' (*lew* < PMP *lawaq 'spider'), Likum *sa:kow* 'long variety of Malay apple' < POC *sakau. In addition, Ross's proposal for Levei-Tulu appears to be mistaken, with *w- continued either as /w/ or zero in Khehek: cf. Drehet *weyi p*^{w}*ehea* 'saliva' [water mouth] (*weyi* < *waiR), and Levei, Drehet *owip* 'mango' < POC *waiwai.

position, may also have given rise to a pull-chain for *-w. Reference to these unique distributional properties of pre-Khehek may allow one to better understand why changes like (5) are typologically rare.

2.2 *-b,-d,-g > *-m,-n,-ŋ* in Berawan and Karo Batak

Just as the shift of *-y > -*w* might strike one as natural, arguably involving a shift in only one distinctive feature ([+back], [+round], or [+labial]), another sound change, SC2 in Table 2, also, at first glance, appears to be natural as well. This is a sound change where, in both Berawan, a language of northern Borneo, and in Karo Batak (aka Northern Batak) of Northern Sumatra, original word-final voiced stops become nasals: *-b,*-d,*-g > -*m*,-*n*,-*ŋ*.[7] Representative data from each language along with relevant reconstructions are provided in Table 5 from Blust (2005: 248–251), with Berawan represented by the Batu Belah variety.

Table 5: Final voiced stop to nasal in Berawan and Karo Batak (Blust 2005: 248–249)

Proto North Sarawak	Batu Bela Berawan	Gloss
*eleb	lem	'knee'
*uab	ŋ-uam	'to yawn'
*laled	dilan	'housefly'
*kuyad	kuyan	'grey macaque'
*pused	pusan	'navel'
Proto Batak	Karo Batak	Gloss
*abab	abam	'fine burning ashes'
*saŋkeb	saŋkem	'lid of clay pot'
*sahud	sahun	'take place, occur'
*sered	seren	'stinger of insect'
*talag	talaŋ	'be open, as a door'

Karo Batak is unique among Batak languages in showing this sound change. Final *-b, *-d, *-g are continued without change in Simalungun, while they are devoiced in Southern Batak dialects like Toba Batak (Adelaar 1981). Similarly, within the group of North Sarawak languages, most Dayic languages, like Lun

[7]In fact, as Blust (2005: 249, 250) notes, no examples are available in Berawan illustrating reflexes of *-g.

Dayeh, continue final *-b, *-d without change (Smith 2017: 235), while the same proto-sounds are devoiced in others, like Sa'ban. What makes these two languages stand out, both areally and genetically, is the apparent nasalization of final voiced obstruents. Blust (2005: 249–251) summarizes the problem this way:

> …why should voiced stops become nasals only in wordfinal position, where the more common development is for stops to devoice?… No obvious linguistic motivation… is apparent… it might be surmised that the change of voiced stops to nasals word-finally passed through an intermediate stage in which these stops were prenasalized… Prenasalization of both voiced and voiceless obstruents is a common phenomenon in Austronesian languages, but is almost always confined to medial position. Since prenasalized final obstruents are unknown in any of the hundreds of languages of the Philippines or western Indonesia it would be unjustified to assume a historically intermediate stage in which they were present…

In earlier work, I suggested the sequence of sound changes shown in (6), where voiced stops are pre-nasalized (6a), and subsequently, prenasalized stops simplify to plain nasals (6b) (Blevins 2007).

(6) Voiced stop pre-nasalization followed by simplification
  a. *-b, *-d, *-g > *-^{m}b, *-^{n}d, *-^{ŋ}g
    i. via nasal-spread in N(C)V_#
    ii. via hypervoicing
  b. *-^{m}b, *-^{n}d, *-^{ŋ}g > *-m, -n, -ŋ*
    non-release (or non-audible oral phase)

While the focus of that analysis was (6b), phonetic support for (6a) is twofold. First, at least half of the Karo Batak words showing final nasalization of *-b, *-d, *-g (and -*g* < *-j) have historical nasal stops in the preceding syllable, allowing one to view some cases of (6a) as instances of local syllable internal-nasal spread: *cernem* < PWMP *ce(R)ñeb 'dive, immerse'; *keneŋ* < PMP *keñej 'sink, drown'; *kuniŋ* < PMP *kunij 'tumeric'; *laŋkem* < PWMP *la(ŋ)keb 'lie face down'; *saŋkem* < PWMP *sa(ŋ)keb 'lid, cover'; *sumban* < PWMP *sumbad 'plug, stopper' (ACD).[8] Second, the intermediate pre-nasalized stage shown in (6a) may have led to interpretation of pre-nasalized voiced stops as variants of plain voiced stops as a

[8] Interestingly, there also appear to be cases in Karo Batak where nasalization spreads from the end of the word back: *ambaŋ* < *abaŋ 'ambush; block the way'; *endem* < *edem 'overcast; dull luster'; *me-linduŋ* < *liduŋ 'shelter, cover, protection'.

consequence of hypervoicing. On the basis of phonetic studies of similar sound patterns, pre-nasalization is argued to be a type of hypervoicing, with nasal airflow making it easier to maintain a voiced oral stop in word-final position (Iverson & Salmons 1996, Wetzels & Nevins 2018). After historical pre-nasalization, simple non-release in final position, or a short inaudible oral phase, could result in a percept of a plain nasal (6b). Further support for (6) as a natural process is typological. The same process of final nasalization is found in some Kayanic languages, and other languages of Borneo, including Lebo and Sagai Basap (Smith 2017: 201). In Long Nah Kayan (Smith 2017: 53, 66), *-b, *-d > -*m*, -*n*, while inherited *mb, *nd, *nj, *ŋg > *b*, *d*, *j*, *g*, supporting general simplification of ND articulations. Within Oceanic, where inherited *-b, *-d, *-g are phonetically prenasalized, a syllable-final instance of (6b) is reported for Lihir, a Western Oceanic language, and in Mwotlap, a language of Vanuatu, *ᵐb, ⁿd* vary with *m, n* word-finally, while two languages of Vanuatu (Neve'ei and Avava) and two languages of New Caledonia (Nemi and Jawe) show (6b) word-finally. What appears to make the sound change rare is not the simplification in (6b), but, rather, the rarity of finding prenasalized voiced stops in word-final position to begin with.

2.3 Intervocalic devoicing in Berawan (and Kiput) and Berawan *-b- > -*k*-

Intervocalic devoicing of voiced stops has been argued by Blust (2005), and more recently, by Beguš (2018, 2019) to be an unnatural sound change.[9] On articulatory, aerodynamic and perceptual grounds, there is a natural phonetic tendency for stops to be voiced intervocalically, and intervocalic voicing is common cross-linguistically (Beguš 2019: 21–22). Nevertheless, intervocalic devoicing appears to have occurred in at least two Austronesian languages of North Sarawak in Borneo: in Berawan (Blust 2005, 2013, Burkhardt 2014) and in Kiput (Blust 2002, 2005) (SC4). Blust (2025 [this volume]) offers a critique of Beguš's general analysis of intervocalic devoicing, and of the more specific analysis proposed for Berawan where, in addition, *-b- shifts to velar articulation (SC3). In the spirit of Blust's critique, what I offer here is a simple alternative to Beguš's Blurring Account

[9] Beguš (2019: 12–13) defines "unnatural" processes in terms of "universal phonetic tendencies" (UPT). Universal Phonetic Tendencies are "phonetic pressures motivated by articulatory or perceptual mechanisms that passively operate in speech production cross-linguistically and result in typologically common phonological processes." Unnatural processes operate against UPTs, or are not UPTs. Within this model, examples of unnatural processes include intervocalic devoicing, post-nasal devoicing (see Section 2.4), and final voicing (but cf. Blevins et al. 2020). Compare this with the definition of natural sound changes in Section 1 as those with clear phonetic bases; unnatural processes are all others (Blevins 2008a).

(Beguš 2019), with a focus on Berawan. The treatment of intervocalic devoicing extends to Kiput, and to other languages exhibiting apparent one-step intervocalic devoicing.

Pre-Berawan bilabial and velar stops *b and *g devoice intervocalically, but remain voiced word-initially. The bilabial stop *b also undergos a change of place intervocalically, becoming a velar: *b > *k* / V_V. Assuming intervocalic devoicing, one could propose intervocalic *-b- > *-g-, followed by devoicing. Table 6 provides four examples of Berawan intervocalic devoicing of *g, where *g is from Proto North Sarawak *R.[10] Gemination in the last two rows of Table 6 is a consequence of a later sound change discussed in Section 3.3.

Table 6: Berawan *R> g, *-g-> -k-, C>C:/_V# (Blust 2013: 667–668)

Proto North Sarawak	after *R> *g	Berawan	Gloss
*Rabun	*gabun	gikuŋ	‘cloud, fog’
*Ratas	*gatas	gitaʔ	‘milk’
*Ratus	*gatus	gitoʔ	‘hundred’
*Rusuk	*gusuk	gusok	‘chest’
*aRem	*agem	akem	‘pangolin’
*kaRaw	*kagaw	kikiw	‘scratch an itch’
*baRa	*baga	bikkeh < *bikeh	‘shoulder’
*duRi	*dugi	dukkih < *dukih	‘thorn’

Table 7 illustrates *-b- > *-g- > *k*- with data from Blust (2013: 667–668).[11] Blust assumes the intermediate stage *-g-, and so, Berawan presents itself, in his view, with two inexplicable instances of sound change: *-b- > *-g-; and general intervocalic obstruent devoicing. Gemination in Table 7, like that in Table 6, is a consequence of a later sound change discussed in Section 3.3.

[10]The symbol *R in historical Austronesian is usually interpreted as an alveolar or uvular trill, though there is continued debate regarding its phonetic status; see Blust (2013: Chapter 8). Velar reflexes like those in Berawan are not uncommon.

[11]For a thorough review of the data, and a critique of Beguš (2019), see Blust (2025 [this volume]).

Table 7: *-b- > *-g- and intervocalic devoicing in Berawan (Blust 2013: 667–668)

Proto North Sarawak	Berawan	Gloss
*abaŋ	akiŋ	‘ilipe nut’
*abu	akkuh	‘ashes’
*balabaw	belikiw	‘rat’
*babuy	bikuy	‘pig, boar’
*bubu	bukkuh	‘fish trap’
*bubuŋ	bukuŋ	‘ridge of roof’
*Ribu	gikkuh	‘thousand’
*Rabun	gikuŋ	‘cloud, fog’
*kabiŋ	kakiŋ	‘left side’
*lubaŋ	lukiŋ	‘hole’
*mabuk	makuk	‘drunk’
*nibuŋ	nikuŋ	‘nibong palm’
*tuba	tukkih	‘derris root’

We address general intervocalic devoicing first. While intervocalic devoicing is rare cross-linguistically, under certain conditions, it can be viewed as phonetically natural. If an intervocalic consonant is in a prosodically strong position, fortition is expected to take place. For the data in Table 6, where we hypothesize a historical [ws] iambic foot structure, the prosodically strong position is the onset of the strong syllable of the foot. Prosodically strong positions range from initial position of a stressed syllable, to initial position of a foot, to initial position of the prosodic word, and higher level units (Gordon 2016: 155). In these positions, phonetic lengthening may occur as a form of fortition.[12] In intervocalic position, the association between prosodically strong positions and devoicing is most likely

[12]For a typological survey of the range of fortition processes associated with increased stricture, see Bybee & Easterday (2019). The possible typological parallels between Berawan fortition and fortition/lenition processes in Balto-Finnic and Saamic consonant gradation are discussed in Blust (2018) with specific reference to Gordon’s (1997) proposal of historical onset fortition in Finnic. Blust considers an analysis very similar to that proposed here and in Section 3.3, but rejects it on the grounds that one is unable to explain the absence of similar fortition in the hundreds of other Austronesian languages have similar prosodic structures. As suggested by the comparison with Haroi here, and the brief discussion in Section 4, fortition may be due to contact with Mon Khmer languages with sesquisyllabic structure. In sesquisyllables or uneven weak-strong iambs, the initial syllable is severely restricted in terms of segmental and prosodic features, while the strong syllable shows all possible contrasts.

related to increased stop duration: the longer the stop closure, the higher the probability that voicing will decay (Ohala 2003). A recent corpus-based study of synchronic word-initial devoicing in five Romance languages supports an association between obstruent devoicing and prosodically strong word-initial position, and, for Portuguese, shows a clear effect in intervocalic, as well as other positions (Hutin et al. 2021).

Apart from Berawan and Kiput, historical cases of prosodically conditioned intervocalic devoicing in Austronesian might include devoicing and aspiration of proto-Chamic voiced obstruents in the main syllable onset of Hainan and Coastal Chamic languages (Thurgood 1999: 82).[13]

Table 8: Intervocalic devoicing and aspiration in Haroi, a coastal Chamic language (Thurgood 1999: 82)

Proto Chamic	Jarai [jra]	Haroi [hro]	Gloss
*ʔabih	abih	aphih	‘all; finished, done’
*ʔiduŋ	aduŋ	athuŋ	‘nose’
*babuy	bəbui	pəphui	‘wild pig’
*habow	həbau	aphɨau	‘ashes’
*hadaŋ	hədaŋ	athɨaŋ	‘charcoal’
*hubey	həbəi	aphui	‘taro; tuber; yam’
*huda:ŋ	həda:ŋ	athiaŋ	‘shrimp, lobster’
*labuh	rəbuh	ləphuh	‘fall down’
*muda	məda	məthɨa	‘young; unripe; tender’
*pagar	pəga	pəkhɨa	‘fence’

The Chamic cases are not described in terms of the intervocalic environment, because the main syllable onset is a clear prosodic position in the evolution of Chamic sequisyllables through documented contact with languages of mainland southeast Asia (Thurgood 1999); however, as the data in Table 8 illustrate, the position, is, indeed, intervocalic. Another Austronesian language with clear evidence of intervocalic devoicing is Sula, a language of north Maluku (Bloyd 2020), where stem-initial consonants have devoiced under prefixation and compounding.

[13] Outside of Austronesian, a parallel change can be found in the devoicing of proto-Samurian voiced stops in the onsets of stressed syllables in pre-Lezgian, where the same segments were geminated (Topuria 1974, Yu 2004). It is notable that in Berawan as well, as discussed in Section 3.3, intervocalic gemination occurred, albeit in a more specific prosodic context.

In short, there is evidence that intervocalic devoicing can and does occur in prosodically strong positions. For this reason, following Blust's quest for the simplest analysis (Blust 2025 [this volume]), we hypothesize the sound change in (7) for Berawan (and Kiput).

(7) Intervocalic devoicing in Berawan
*g > *k* / V_V (Hypothesis: the position is prosodically strong)

A final piece of evidence supporting the sound change in (7) as direct devoicing under phonetic lengthening in prosodically strong position is that fact that it targets velar *g, but not stops at other points of articulation. This is more evident in Kiput, where *b is continued as a bilabial stop and "intervocalic stops *b and *d generally did not devoice, but *g did" (Blust 2013: 668). The aerodynamics of stop voicing appear to be at work: velar stops are more likely to undergo devoicing than stops at more advanced positions in the oral cavity because there is less air volume behind the point of closure, and limited capacity for passive enlargement to lower supraglottal pressure (Ohala & Riordan 1980). If general, across-the-board devoicing, of the kind suggested by Beguš (2019) was at work, this pattern would be unexpected.

Let us now turn to the apparent *-b- > *-g- sound change in pre-Berawan. I suggest, based on parallel developments in other languages of Borneo, that this is not a single labial-to-velar sound change, but rather a sequence of lenition and fortition processes, as stated in (8a) and (8b). A later process of glide-insertion and strengthening (8c), illustrated in Blust (2025 [this volume]) for Proto Berawan, post-dates glide-strengthening (8b), producing a new set of bilabial glides/fricatives.

(8) Proto-Berawan *-b- > *-g- as a lenition + fortition sequence, followed by *w-insertion[14]

a.	*-b- > *w/ V_V	intervocalic lenition
b.	*w > *g/V_V	glide strengthening
c.	*ua > *uwa* (> *uβa)*	glide-insertion + glide strengthening

Similar sound changes to those in (8) have been proposed for other languages of Borneo. In Table 9, Smith's (2017) treatment of historical developments in Segai-Modang, a subgroup of Kayanic, is illustrated, involving a different timeline of the same developments suggested for Berawan in (8).

[14]A reviewer notes that Burkhardt (2014) also reconstructs *β to proto-Berawan as the outcome of intervocalic glide insertion. One can still propose *b > *w > *g* after this insertion, provided that the inserted *w in (8c) had already become /β/.

Table 9: Proposed historical developments in Segai-Modang (Smith 2017: 76–77)

	PMP		
Sound change	*abu 'ashes'	*sawa 'spouse'	*lubaŋ 'hole'
i. *uba > *uwa*	-	-	*luwaŋ
ii. *-w- > *gw[a]	-	*səgwa	*ləgwaŋ
iii. *-b- > *-w-*	awu	-	-
Modang [mxd]	əwae̯	səgua̯n	gua̯ŋ
Long Gelat [mxd]	awaː	səgün	gua̯ŋ
Gaai [sge]	awaw	sgua̯n	gua̯ŋ
Kelai [sge]	awəw		gua̯ŋ

[a]Though Smith (2017: 77) writes the sound change as *-w- > *g*, the data suggests *w > *gw.

As a consequence of these changes, there is an apparent shift of *-b- > *-g- in the *u_a environment (e.g. Modang ***g**ua̯ŋ* < *lu**b**aŋ 'hole', *tə**g**awʔ* < *tuba 'derris root') though the context, as well as the strengthening of inherited *-w- argues for earlier (contextual) weakening of *-b- to *-w- (10i), as opposed to a single-step change. Compare the developments in Table 9, with the proposed sequence of changes for Berawan in Table 10.

Table 10: Proposed developments in Berawan (from Blust 2005, except where noted)

	PNS		
Sound change	*abu 'ashes'	*lubaŋ 'hole'	*dua 'two'
i. *-b- > *-w-	*awu	*luwaŋ	
ii. *-w- > *g	*agu	*lugaŋ	
iii. *ua > *uwa	-	-	duwa
(ex. 7) *-g- > *-k-*			
Batu Belah	akkuh	lukiŋ	duβeh
Long Terawan	akkuh	luyə̯ŋ	lebih
Long Jegan		lukiŋ [AS]	duve [AS]

A brief comparison of the proposed account above with that of Beguš (2019) highlights both its simplicity and improved plausibility, in line with the desiderata of Blust (2025 [this volume]).

Beguš (2019) offers an analysis of intervocalic devoicing in Berawan and Kiput that involves a sequence of three arguably natural and well motivated sound changes in the context of what he calls the "Blurring Account". The Blurring Process is a term for a special combination of sound changes that gives rise to an unnatural sound pattern in the technical sense of footnote 9. In Table 11 we see the proposal for sound changes to account for Berawan intervocalic devoicing and labial-to-velar shift under Beguš's Blurring Account. The three definitive sound changes under the Blurring Account are I, II, III in that order, defining (rare) intervocalic devoicing patterns cross-linguistically. Note that the second of these, including ɸ > *x*, is empirically questionable, at least within Austronesian (a family of at least 1,200 languages), where Blust (2025 [this volume]) cannot think of a single case.

Table 11: Berawan intervocalic devoicing and labial-to-velar shift after Beguš (2019)

Context	#__	V_V
Pre-Berawan	*b *d *g	*b *d *g
I Intervocalic spirantization		*β *ð *ɣ
+Rhoticization *ð > r		*r
II Fricative devoicing		*ɸ *x
+Place change *ɸ > x		*x
III Fricative occlusion		*k *k
Berawan	*b- d- g-*	*-k- -r- -k-*

Compare Beguš's analysis of *g > *k* stop devoicing in Table 11, with three stages, to the account in (7), with one. In addition to this added complexity, Beguš must rely on modifications of I, II, III to restrict devoicing to *g in Kiput, while this feature follows from aerodynamic properties of velar stops under the phonetic lengthening account, as noted above. While details of (7) and (8) remain to be worked out, *gw* < *-w- in Segai-Modang provides preliminary support for glide-strengthening, as opposed to fricative occlusion. Under the proposed account, the rarity of the Berawan development is a simple consequence of the rarity of the four sound changes in (7) and (8) co-occuring in this particular sequence.

2.4 Post-nasal devoicing in Murik, Buginese and elsewhere.

Postnasal devoicing of voiced stops has been argued by Blust (2005: 258–262), and, more recently, by Beguš (2018, 2019) to be an unnatural sound change. On articulatory and aerodynamic grounds, there is a natural phonetic tendency for stops to be voiced after nasals, and post-nasal voicing is common cross-linguistically. Nevertheless, *ND > NT (D a voiced stop, T a voiceless stop) appears to have occurred as a regular sound change in Murik-Merap, Kayanic languages of Borneo (dialects include Merap, Ngorek, and Mpraa), and in Buginese in its development from Proto South Sulawesi (Mills 1975). I believe that Blust (2005: 258–262) has already offered a clear solution to the origins of post-nasal devoicing in both of these cases, and an explanation for why the process is not more common. The central observation is that prior to the *ND > NT sound change, there is no contrast between ND vs. NT in these languages (in Buginese, earlier *NT > TT). As a consequence, Blust (2005: 261–262) suggests two conceivable scenarios leading *ND to devoice. In the first, speakers assume post-nasal voicing to be automatic, and, essentially, hypercorrect by devoicing. In the second scenario, which he seems to endorse, the absence of a voicing contrast in *ND leads to natural variability in the extent to which the cluster is fully voiced, with the voiceless variant ultimately prevailing. Both of these proposals are plausible, and provide a testable hypothesis regarding true one-step sound changes of ND > NT: they will occur only where obstruent voicing is non-contrastive after nasals.

Needless to say, adopting these proposals for post-nasal voicing in these Austronesian languages does not preclude other cases that may reflect telescoped changes. The alternative in Beguš (2019), is, like the analysis of intervocalic devoicing, a three-step process: (i) voiced stops become fricatives in all environments, except after nasals; (ii) general oral stop devoicing; (iii) occlusion of voiced fricatives to stops. This may be appropriate for some languages, but it does not fit with the well studied phonological developments in either Kayanic (Smith 2017) or South Sulawesi languages (Mills 1975).

3 New cases of phonetically motivated sound change (or not).

Since the publication of Blust (2005), six of the "bizarre" changes in Table 2 have, to my knowledge, been revisited only in Blust's own work (Blust 2013, 2016, 2018). In this section, I review each of the remaining proposed sound changes in Table 2, beginning with the case of Sa'ban (SC6) where supporting data appears to be misanalysed, and then turning to Iban (SC7), where the sound change may be misstated and better viewed as a case of nasal dissimilation. Section 3 continues with discussion of Berawan gemination (SC8), Western Manus trill obstruentization (SC9), and Sundanese labial palatalization (SC10), which, it is argued, can all be seen to reflect natural phonetically motivated processes.

3.1 *g > *p*-, -*j*-, -*p* in Sa'ban

Sa'ban is a highly innovative dialect of Kelabit spoken at the headwaters of the Baram River in the phonological 'hot spot' of northern Sarawak, where several languages show extensive and unusual sound changes (Blust 2001). Among many innovations classified as "bizarre" by Blust (2005) is the Sa'ban shift of *g to *j* ([dʒ]) intervocalically and initially in some forms, but to *p* word-finally, and, in two forms, word-initially (Blust 2005: 255–257, 2018: 28–29). Forms supporting *g > *j-, -j-* are shown in Table 12, where PKLD is Proto-Kelabit-Lun Dayeh. The shift of velar to palatal place is natural from an articulatory perspective, involving advancement of the tongue body. While context-sensitive shifts are common in front-vowel contexts (see, e.g. Kümmel 2007: 215–216), recent work suggests that velar palatalization can be triggered by articulatory strengthening, where tongue-to-palate contact increases significantly in non-front vocalic environments (Recasens 2020); in a least one variety of Catalan spoken on Majorca, the standard velars /k/, /g/ are realized as palatal [c], [ɟ], except before back rounded vowels (Wheeler 2005: 10). In Sa'ban, the shift from velar to palatal may be part of a chain-shift, since Sa'ban, like other Dayic languages, has undergone a merger of PMP palatals with coronals (Smith 2017). In particular, PMP *d and *z (an alveo-palatal affricate) are continued as /d/ in Dayic.

What makes Sa'ban remarkable, in Blust's view, is the apparent sound change of *g > *p* initially in some words, and finally in others.

Let us first review the cases where Blust suggests a regular change of word-initial *g- > *p*-. The only two examples noted are shown in Table 13. Given the seemingly regular correspondence of *g- with *j*- in Table 12, it would appear that these examples do not constitute a case of regular sound change.

In the first example, Sa'ban *pelawet* 'complicated' appears to reflect a /pe-/ prefixed form of an earlier root *lawat 'cross over, go across': cf. Kayan *lawat* 'to cross over'; Gah *lawat* 'bridge' [AS]; Sawa *lawat* 'bridge' [AS]; Kelabit *gərawat* 'tangled, complicated' [BD]; *pəlawət* 'religious travellers' [BD] (i.e. 'those that go across'); Bidayuh Serian *kaawat* 'wire' [BD] < *ka-lawat (i.e. 'crossed over, tangled').[15] Sa'ban *pelawet* 'complicated' appears to derive from earlier *pe-lawet

[15]The prefix /pe-/ appears to be a productive reciprocal prefix, among other functions. Compare Kelabit *pebala* 'to tell each other' (*bala* 'news, fame, reputation'), *pebisung* 'to shove each other about' (*bisung* 'shoved, pushed'), *pebukut* 'to punch one another' (*bukut* 'a punch') [BD].

Table 12: Velar palatalization: *g > j-, -j- in Sa’ban (Blust 2018: 28–29)

PKLD	Sa’ban	Gloss
*gatəl	jatəl	‘itchy’
*gənuluh	jənləw	‘empty rice head’
*gəramih	jəlaməy	‘rice straw’
*gituʔən	jɪntoʔɔn	‘star’
*ŋ-agap	m-ajeəp	‘to startle’
*sagət	ajɪt	‘quickly’
*iguʔ	jəuʔ	‘shame’
*pəgamuŋ	pəjamuəŋ	‘tangled’
*təgəkər	təjaʔəl	‘to shiver’
*təgəraŋ	təjareəŋ	‘ribs’

Table 13: *g- > *p*- in Sa’ban from Blust (2005, 2018)

PKLD	Sa’ban	Gloss
*gərawat	pelawet	‘tangled, complicated’
*giləg	pelep	‘skittish, easily startled’

‘crossing over each other’, and be cognate with Kelabit *pəlawət* ‘religious travellers’. Blust’s PKLD reconstruction *gərawat appears to correspond with a distinct derived form with prefix *gə-. If this is the case, there is no sound correspondence between initial *g- and Sa’ban *p*- in this word pair. In the second example, Sa’ban *pelep* ‘skittish’ is compared with Kelabit *gileg* ‘feel nauseated, feel like vomiting when seeing something disgusting; squeamish about something; make a startled movement, as when someone pokes you in the ribs’[BD]. Although there is some semantic overlap, there also appears to be evidence for a root *leb/lep ‘jump, flicker’ in the languages of North Sarawak: cf. Kayan *lepseu* ‘jump’, Bidayuh Serian *leb-leb* ‘a flickering light’, *lep-lep* ‘lightning flash’, Lun Dayeh *məkələp* ‘blink’, *lep:u* ‘faint’; Ketapang *solap* ‘faint’ [AS]; Sanggau *mbilap* ‘blink’ [AS]. On this basis, Sa’ban *pelep* < *pe-lep ‘jumpy, skittish’seems just as plausible as Blust’s comparison. Neither of these comparisons, then, is convincing.

Turning to reflexes of word-final *-g, Blust (2005) provides one example of *-g > *-k:* Sa’ban *malok* ‘to trick’ < PKLD *m-alug (cf. Kelabit *malug* /em-alug/). Sa’ban *luwék* ‘chest (anat.)’ may also show the same correspondence if this form is cognate with Bidayuh Serian *adŭg, aadŭg* ‘chest’ (but cf. Kelabit *ruuk* ‘chest’). While PWMP *-g is continued as /-g/ in Kelabit (e.g. Kelabit *aag* ‘finely chopped meat or vegetables’ < PWMP *sagsag ‘to chop, to mince, as meat, fish or vegetables preparatory to cooking’; Kelabit *teteg* ‘stick used for beating a gong’ < PMP *-teg ‘hit, beat’), there are no Sa’ban cognates presented by Blust for these common roots, and examples of *-g > -p in Sa’ban are not altogether convincing. Consider Sa’ban *arep* < *areg ‘crumbs, rubbish’ (cf. Kelabit *areg* ‘crumbs’). The problem with this comparison is that there is another Kelabit word, *arep* ‘rubbish, litter’ which is also a potential cognate (cf. Malay *sarap* ‘dry rubbish’). Another comparison is Sa’ban *ppap* ‘a slap’ < PKLD *pepag (cf. Kelabit *pepag*). But here, again, there are other potential comparisons, including PWMP *epap ‘slap’, Proto-Kayan *ne-bip ‘slap’, Proto-Kenyan *tepap [AS], Bidayuh Serian *nipaap, ñipap* ‘to slap’, *tipaap* ‘slap’. Two additional comparisons appear to involve the same root: Sa’ban *eləp* ‘to separate, divorce’ < *iləg (cf. Kelabit *ileg* /e-i-leg/ ‘was stopped by’) and Sa’ban *ləp* ‘to stop, as working’ < *ələg (cf. Kelabit *eleg* ‘cessation, divorce’). In these cases, reconstructions appear to be based on the Kelabit form alone. For ‘divorce, separate; stop, finish’, compare Dusun Witu *ulep* ‘stop’, Seputan *palop* ‘finish’, Sekapan *kaʔarəp* ‘divorce’, and Pawe *pələpək* ‘finish’, all consistent with derivations from *elep ‘stop, cease’. The only comparison set which shows a clear bilabial reflex of *-g is Sa’ban *ajiəp* ‘rice sieve’ < *agag (cf. Kelabit *agag* ‘sift’).[16] In this case, a dissimilatory sound change is suggested taking *gVg* > *gVb*, followed by Blust’s other proposed regular sound changes: *agag > *agab* > *ajab* > *ajap* > *ajiep*. While this proposal may appear ad-hoc, ACD *agag is reconstructed to PWMP on the basis of Kelabit and Agutaynen alone. Of interest is that Agutaynen shows *mag-agag* ‘to sift’, but also *maŋ-agat* ‘to sift’, where final /-t/ also appears to involve place-dissimilation. Compare also the doublet PWMP *qayag, *ayak ‘sift, separate by sifting’, which may reflect an earlier dissimilation of *gVg > *yVg*. A final confusing factor are pairs where the seemingly bizarre correspondence goes in the opposite direction: Kelabit *alap* ‘to get, fetch’ (cf. Malay *alap*), but Sa’ban *alak*, where the PAN doublet *alaq, *alap ‘fetch, get, take’ may be continued, and/or the Kelabit form may be a Malay loan.

In sum, though there are many unusual features of Sa’ban historical phonology (Blust 2001), there does not appear to be a rare context-free shift of *-g > *-b*. Rather,

[16] Two other cases from Blust (2005: 256) may also be misanalyzed. In *rurug > *hrop* ‘to fall, pour out’, *rurug is based on Kelabit *rurug* ‘come out all at once, as when pouring something that you want to come out slowly’ [BD]. However, a better root comparison for Sa’ban *hrop* may be Kelabit *ru’eb*, Lun Bawang *rueb* ‘waterfall’. For *beluqug > *belʔup* ‘wasp, hornet’, where *beluqug is based on Kelabit *belu’ug* ‘wasp’s nest’, Kelabit *belubpuk* ‘wood borers, all varieties of insects etc which eat wood, bamboo, etc.’ [BD], with stem-final /b/ seems a better comparison.

*g-, *-g shifted to *j*-, -*j*-, while final *-g devoiced to -*k*, except in *gVg sequences, where sporadic dissimilation took *gVg > *gVb*, with final devoicing of *-b > -*p*.

3.2 *an/aŋ > -*ay*, *em/en/eŋ > -*aw* in Iban

Another sound change for which Blust's own reconstructions and lexical comparisons do not support his characterization of a regular sound change is the shift of final non-high vowel sequences + nasals to vowel-glide sequences in Iban, a Malayic language of southwest Sarawak. Compare Iban *jalay* 'road' with Malay *jalan* < *jalan, Iban *makay* 'eat' with Malay *makan* < *ma-kan 'eat', and Iban *diaw* 'quiet, silent' with Malay *diam* < *hidem. According to Blust (2005: 257–258), final nasals show a surprising development in weakening to glides, though he notes that the process in Iban "…has not affected all potentially available forms." This appears to be a gross understatement. In going through Iban etymologies in the ACD, there are many more exceptions than examples. Looking just at ACD entries for Iban headwords beginning with /a/ and /b/, there are 24 exceptions to the proposed change, and only two forms that conform to the generalization. The exceptions are: *acaŋ* 'pigeon' < *acaŋ; *alaŋ* 'beam' < *qalaŋ; *alaŋ-alaŋ* 'insufficient' < *alaŋ-alaŋ; *amaŋ* 'menace, threaten' < *amaŋ amaŋ; *anaŋ* 'don't' < *anaŋ; *ansaŋ* 'gills of fish' < *hasaŋ; *antam* 'strike' < *qantem; *asam* 'sour, acid' < *qalesem; *awan* 'cloud' < *hawan; *bambaŋ* 'large, broad'< *baŋbaŋ; *baraŋ* 'any, about; whatever' < *baraŋ; *bataŋ* 'tree, tree trunk' < *bataŋ; *bebaŋ* 'stop, hinder, check'< *beŋbeŋ; *belakaŋ* 'back, rear, behind, after'< *balakaŋ; *belaŋ* 'Leucoderma'< *belaŋ; *belian* 'perform a rite of shamanistic curing or exorcism' < *balian; *bentaŋ* 'rotan or cord stretched across a river with charms and offereings attached to it' < *benteŋ; *benuaŋ* 'quick growing softwood riparian tree'< *benuaŋ; *beraŋan* 'small trees yielding a small chestnut'< *baraŋan; *beruaŋ* 'Malay bear' < *baRuaŋ; *bidaŋ* 'numeral classifier for things spread out when in use' < *bidaŋ; *binuaŋ* 'quick growing softwood riparian tree'< *binuaŋ; *bulan* 'moon, month' < *bulan; *bulaŋ* 'cord with which an artificial spur is tied to a fighting cock' < *bulaŋ. From this sample of several hundred Iban words, only two appear to undergo the sound change proposed by Blust: *bembai* 'rush or reed with fragrant white flower*: Clinogyne dichotoma*, and *Donax*, *Cyperus* spp.' < *benban; and *bukai* 'other, another' < *buken. Even with a majority of words not undergoing the change, Blust (2005: 257) notes that "the change clearly is recurrent, and the probability that it is a product of analogy or some other mechanism of secondary change is virtually nil."

Smith (2017: 193–196) revisits the Iban data and describes the process as one of "diphthongization … a process where final *-a(C) became *-ay* or *-aw* in a number of lexemes". In his comparison sets, he includes cases where a glide is seemingly accreted (e.g. Iban *kitai* '1PL.INCL; we, us'; cf. Malay *kita* < *k-ita), as well as cases where the Iban glide corresponds to a coda rhotic or *-s* in a few Malay words (e.g. Iban *bəsay* 'big', cf. Malay *bəsar* 'big'; Iban *ataw* 'above', cf. Malay *atas* < *atas). Smith's view is that diphthongization shows inconsistent application in Iban, and in Ibanic languages more generally, and for this reason, he excludes it as a sound change defining possible Malayic subgroups.

However, a careful reconsideration of the data suggests that there was a regular sound change, but that it was more specific than the changes suggested by Blust or Smith. The sound change appears to have been one of nasal-dissimilation as stated in (9), where inherited word-final *-aN sequences (N a nasal) were denasalized when preceded by a nasal or nasalized segment: *N > [-nas]/N(C)a_#.

(9) Nasal dissimilation in the history of Iban
*N > [-nas]/N(C)a_# (Does not apply in *CVC-CVC reduplicated forms)

The hypothesis is that a phonetically nasalized sequence NãN was interpreted or perceived as NãG under the general theory of perceptual hypercorrection (Ohala 1981).[17] Denasalized [n], [ŋ] were realized as [j] and denasalized [m] was realized as [w]. Comparative data consistent with this sound change are shown in Table 14.

In some cases, the regular sound change formulated in (9) seems to apply to a phonetic form where the nasal trigger of dissimilation must be viewed as, itself, a consequence of allophonic (or phonetic) nasalization: in these cases a phonological nasal appears farther from the word-final nasal, for example, in word-initial position of a disyllable.[18] For example, from Malayic *ŋətam (< Pan-Borneo *getem 'harvest'), there is Seberuang *ŋətam* and Iban *ŋətaw*: the final

[17]The role of /a/ vs. other vowels in this sound change merits further study, but is consistent with what is known of vowel nasalization: low vowels may undergo spontaneous nasalization, and low vowels are typically more nasalized than non-low vowels (Ruhlen 1973: 9). On spontaneous nasalization associated with other segments, including aspirates and glides, see also Ohala (1974, 1975), Matisoff (1975), Blevins & Garrett (1993), and Johnson (2019).

[18]Omar (1969: 51) describes nasal harmony in Iban as follows: vowels "are nasalized in the environment of preceding nasals; the nasalization of a vowel continues within the word until it is checked by a following consonant which is not a semi-vowel", where, in his examples on p. 52, semi-vowels include [w], [j], and [l]. See Blust (2013: 239) for a summary of segments transparent to nasal spreading in six Western Malayo-Polynesian languages.

Table 14: Evidence for nasal dissimilation: *N > [-nas]/N(C)a_# (data from ACD except where noted otherwise)

PWMP	Iban	Other Malayic	Other Borneo	Gloss
*benban	bembay	bemban (Malay)		'herb used in making baskets'
*ka-/beŋis-an	binsai [BD]	ka-beŋis-an (Malay)		'anger, cruelty/ aggressive'
*kembaŋ	kemay	kembaŋ (Malay)		'swollen/ expansion/ swollen'
*hinzam	injaw	m-injam (Kendayan)		'borrow/ lend/borrow'
*ñaman	ñamai [BD]	ñaman (Malay)	main (Lung Bawang/ BD)	'tasty, delicious'
*deŋan	ŋaw	deŋan (Kendayan)	doŋam (Kadorih)	'with'
*tilanzaŋ	telañay	telañjaŋ (Malay)		'naked'
*qu(n)daŋ Proto-Malay	unay	undaŋ, (h)udaŋ (Malay)	hundaŋ (Ketapang)	'shrimp'

glide in Iban is not predicted by (9), unless the input to the sound change is a phonetic form like *[ŋə^{n}tãm]. Phonetic forms of this kind are found in the modern language (Blust 1997) and are also suggested by phonologization in other languages of Borneo, as in Basap *nanem* 'harvest'. A similar extension of (9) will account for Iban *makay* 'eat' from *ma-kan 'to eat' (Malay *makan*). It is even possible to consider that in words with no nasal consonants at all preceding the final nasal, phonetic nasal harmony across medial liquids or glides may give rise to triggers. Consider, for example, three reflexes of PMP *zalan 'road' in Borneo: Malayic Keninjal *jalan*; Iban *jalay*; and Mpraa *ñalãə̯* < Proto-Kayanic *jalan. The Mpraa form suggests that nasalization can spread across a medial lateral. If this is the case, it is possible to understand Iban *jalay* < *[jãl̃ãn], where the medial nasalized /l/ triggers dissimilation.[19]

A final observation with respect to what may have been a regular sound change regards a later dissimilatory change of Iban *yVy > *yVw. Two examples of this kind are: Iban *ayaw* < *ayay < *ayaŋ 'shadow' (cf. Seberuang *bayaŋ*, Keninjal *kemayaŋ* < PWMP *bayaŋ); and Iban *sayaw* < *sayay < *sayaŋ 'pity' (cf. Ngaju Dayak *ma-ñañaŋ*, PWMP *sayaŋ).

In addition to regular sound change, analogical change may have played an important role in the distribution of final glides in modern Iban. A productive source of nasal-initial stems is nasalization associated with the formation of transitive verbs, and denominal verbs. Under these derivational processes, allomorphs are /ŋe-/, zero, or nasalization of the initial consonant. By this last process /p, b/ are replaced by /m/, /t, d/ are replaced by /n/, /k, g, ʔ/ are replaced by /ŋ/, and /c, j, s/ are replaced by /ɲ/ (Omar 1969: 78, 82–85). This means that a historic form like *dataŋ 'come' (cf. Malay *dataŋ*) would often have had at least two basic forms in pre-Iban: *dataŋ and *nataŋ. Nasal harmony in the second would yield allophonic *[nã^{n}tãŋ], which then, could feed (9), resulting in /natay/, which, by analogy with other pairs (*dilat/nilat* 'to lick/licks', *dedat/nedat* 'to beat/beats', etc.) would yield *natay/datay*.[20] A similar account is possible for Iban *pulay* 'return' (cf. Malay *pulaŋ* 'return home') where Iban has also *mulay-*, as in *mulayka* 'return (tr.)'.

Another complicating factor in understanding this sound change is the influx of Malay loans into the Malayic languages of Borneo, as well as diffusion among Malayic languages of Borneo, as discussed by Smith (2017: 193–196). Consider Iban *kumaŋ* in *kumaŋ meñaruŋ* 'hermit crab', (*meñaruŋ* from *saruŋ* 'sheath, case, covering'). By the regular dissimilatory sound change (9), we expect Iban **kumay < PWMP *kumaŋ 'hermit crab', not the attested form eding in *-ŋ*. As far as I can tell, there are no other reflexes of this term for 'hermit crab' in Borneo.

[19] In some languages of Borneo, the allophonic nasalization is phonologized. Compare Bidayuh Bau *janaŋ* 'beam' with Iban *alaŋ*, Malay *alaŋ*. In at least one case Smith (2017: 195) may have misanalyzed an Iban form. He compares Indonesian *ada* 'exist' (< PWMP *wada) to Mualang *aday*, and we could add Iban *aday*. However, in addition to PWMP *wada, the ACD shows PWMP *wadai-i based on Iban and Cebuano *waray*.

[20] Lexicalization of nasal-prefixed forms of this particular stem is found elsewhere in Borneo. Compare Ambai Sembuak (Murutic) *matoŋ* 'arrive' and Bulusu *matoŋ* 'come' (< *d-um-ateŋ), both from the same stem.

However, there is a term *kumaŋ* 'beetle' in other Malayic languages of Borneo, including Kendayan, Keninjal, and Mualang. It is possible, then, that Iban *kumaŋ* was not directly inherited.[21]

In sum, this proposal supports Blust's (2005) intuition that a regular sound change underlies the word-final nasal-to-glide change in Iban: in nearly all inherited PWMP (non-reduplicated) words ending in *-N(C)aN#, a final nasal is continued as a homorganic glide.

3.3 C > C: /__V# in Berawan

The Sa'ban sound change discussed in Section 3.1 is suspect, and Iban final VN# > VG# has been reanalyzed in Section 3.2 as dissimilatory. In contrast, gemination of intervocalic consonants in inherited Berawan #(C)VCV# words is strongly supported by evidence like that in Table 15, as offered by Blust (2005, 2016, 2018). In Table 15, medial singleton consonants have undergone gemination in some instances; however, if the etymon has a final closed syllable there is no gemination.

However, Blust (2005) was not satisfied with this description and sought to determine whether a phonetic motivation for this gemination could be found. Comparing this process with widespread gemination of consonants after schwa in Austronesian, Blust came up emptyhanded: if historical lengthening in Berawan was, essentially, the same type of syllable-bulking as post-schwa gemination, he reasoned, "…we would expect to find some languages that automatically geminate consonants after unstressed vowels other than schwa", though he knew of none at the time. What continued to puzzle Blust (2005: 252) was the fundamental phonetic basis of the process: "What linguistic factor, if any, might drive consonant onsets to geminate only if they initiate an open final syllable…".

Blust's original assumption was that, because Berawan stress is consistently word-final in the modern language, it was final at the time gemination applied. However, Blust (2018), revisits Berawan gemination with a refreshing take on historical prosody. There, Blust suggests that, perhaps, the process of medial gemination was prosodically conditioned after all. Assuming a trochaic [sw] stress pattern at the time gemination took place, the initial open syllable would geminate

[21] Other Iban forms that are likely loans, and therefore fail to undergo the sound change in (9) are: *amaŋ* 'menace, threaten' (cf. Malay *amaŋ* 'defiance'); *anaŋ* 'don't' (with no known cognates in Borneo); *antam* 'strike' (cf. Malay *hantam* 'slamming, slapping, bumping against'); and *bentaŋ* 'rotan or cord stretched across a river with charms and offerings attached to it' (cf. Makassarese *bantaŋ* 'stretched thread or cord'). None of these terms have known cognates in other languages of Borneo. Other sporadic changes are in evidence as well. For example, the unexpected final glide in Iban *tuay* 'old, mature' (cf. Malay *tua* < *tuqah) is likely due to the influence of Iban *tuay* 'leader, head, chief, senior' < *tuqay 'leader in a group'.

Table 15: Berawan medial C gemination in *(C)V_V# (Blust 2005: 252, 2018: 29–30)

PMP	Long Terawan	Gloss
*asu	accoh	‘dog’
*aku	akkoh	‘1SG , I’
*bana	binneh	‘husband’
*batu	bittoh	‘stone’
*kali	kalléh	‘dig’
*kutu	kuttoh	‘head louse’
*laki	lakkéh	‘man, male’
*siku	sikkoh	‘elbow’
*batuk	bitoʔ	‘neck’
*buluq	bulu	‘bamboo’
*likud	likon	‘back’
*putiq	puté	‘white’
*qatay	atay	‘liver’
*tanaq	tana	‘earth’
*tukud	tukon	‘prop, support’
*utaq	uta	‘vomit’

in the strong position of the foot, – a case of post-tonic gemination. Fleshing out this analysis, a general word stress algorithm can be suggested for (pre-)Berawan: stress a final syllable if it is heavy (VV, GC, VC); otherwise, stress the penultimate syllable. With this stress pattern in place, allophonic gemination occurred as a consequence of the universal tendency for stressed syllables to be heavy (the “stress-to-weight” condition). The historical sequence is illustrated in (10) with a prosodic minimal pair.

(10) Tonic gemination in pre-Berawan

a.	Pre-Berawan 1	*batu ‘stone’	*batuk ‘neck’
	i. Stress rule[22]	*bátu	*batúk
	ii. Stress-to-weight	*báttu	*batúk
b.	Pre-Berawan 2		
	i. Final stress	*battú	*batúk
	ii. Other changes	*bittóh*	*bitóʔ*

[22] Stress the final syllable if heavy; otherwise, stress the penultimate.

While Blust (2018) seemed open to considering this possibility, he remained skeptical for one central reason. If such a historical process were truly natural, why did it not occur elsewhere in the language family, or in other language families? For the moment, let us consider the conditions under which tonic gemination does apply, both within Austronesian and elsewhere. Phonetic gemination in Austronesian languages is widespread in one particular context: after schwa in open syllables. Languages showing this sound change (with subsequent phonologization of geminates after vowel mergers) include: Buginese; Dupaningan Agta (Robinson 2008); Isneg; Guinaang Bontok; Kelabit; Konjo; Makasarese; Sangir; Sri Lankan Malay (Adelaar 1991); and Talaud (northern Sulawesi). However, there are also many languages where this process is simply allophonic and non-neutralizing. For example Blust (1995: 133) notes that in Long Terawan Berawan itself, "consonants are geminated after schwa in oxytone citation forms," while similar sound patterns are found far and wide, as, for example in Hawu where all consonants are geminated after stressed schwa (Walker 1982, Blust 2008, 2012). As for whether there are languages (outside Austronesian) with tonic gemination after all vowels, the answer appears to be yes. One of these is Kugu Nganhcara, a Pama-Nyungan language of Australia, as described by Smith & Johnson (2000). In this language, with consonants /p, t, t̪ , c, k, b, d, d̪ , j, g, m, n, n̪ , ɲ, ŋ, l, r, w, j/, all consonants except the tap, /r/, have geminate allophones optionally in intervocalic position following a short initial stressed syllable. Another language with predictable consonant length after stressed vowels is Karuk as described by Bright (1957), where in certain prosodic positions (e.g. after long accented vowels), consonant length (less than a true geminate) is allophonic (Blevins 2005b). Given the general view that post-tonic consonant gemination serves to make stressed syllables longer (Gordon 2002, 2004, Blevins 2005b), if this kind of lengthening is not taking place in many Austronesian languages, it is likely because tonic vowels are already long enough to give necessary weight to the syllable. In contrast, a working hypothesis is that the initial vowels of CVCV disyllables in pre-Berawan were significantly shorter than in other Austronesian languages. We return to this issue in Section 4.

3.4 *dr > k^h in Drehet

In Section 2.1, the apparent one-step merger of Proto-Oceanic *-w, *-y to *-p* in Drehet and Levei, two dialects of Khehek of Manus Island, was shown to be amenable to reanalysis as a sequence of two phonetically motivated changes. Khehek was also singled out as having a bizarre context-free change of an inherited word-initial trill. An additional sound change took the Proto Admiralties pre-nasalized alveolar trill *dr- (a continuation of the same sound in Proto Oceanic) to a "strongly aspirated" velar stop /k^h/ in Drehet, corresponding to /c/ a voiceless post-alveolar/palatal affricate in Levei.[23] Correspondences are shown in Table 16, where Drehet and Levei data is from Blust (2005: 247) and Nali forms are from the ACD. Note that Nali, a language of eastern Manus, continues the pre-nasalized trill without change.[24]

Table 16: Alveolar, velar and palatal reflexes of the Proto-Manus pre-nasalized alveolar trill (all forms but Nali from Blust 2005: 247; Nali from ACD)

POC	Proto-Manus	Nali	Drehet	Levei	Gloss
*drali	*dranV		k^haŋ	coŋ	'slitgong'
*draRaq	*dra	dray	k^ha	ca	'blood'
*na topu	*druhu	druh	k^huh	cuh	'sugarcane'
*ruRi	*drui-	drui-	k^hui-	cui-	'bone'
*ruyuŋ	*druyu		k^hu	cu	'dugong'
*tapuRi	*drapui	drah	k^hah	coh	'conch shell'
*tau-mata	*dramata		k^hamak	camok	'person, human being'
*t<in>aqi	*drine-	drina-	k^hini	cini	'intestines'
*tokon	*droko		k^ho	co	'punting pole'
*tola	*drolV	droy	k^hoŋ	coŋ	'outrigger canoe'
(*turuR)	*droV		k^hep	cep	'to sleep/sleeping mat'
*tuRu	*dru	dru	k^hu	cu	'housepost

Before exploring the phonetic basis of this change, it is important to note that Blust's "strongly aspirated" velar stop is written by Beard (1992) as /kx/ and described as a "voiceless velar affricate", written <kh> in the SIL orthography. Two other Admiralties languages have velar reflexes of Proto Manus *dr-: Seimat *k-* and Wuvulu *x-*, as in Seimat *kawa-*, Wuvulu *xawa-* 'forehead' < POC *dram^{w}a. These reflexes support [kx] as the more conservative phone in Drehet, as does comparative data from unrelated languages shown in Table 17.

[23]Blust (2005: 246) describes the Levei /c/ as "a voiceless palatal affricate", though, by this, in many of his descriptions, he seems to often mean IPA [t͡ʃ], the voiceless post-alveolar affricate (Blust 2013: 601). Since Beard (1992)/SIL transcribe the Levei /c/ as [t͡ʃ], I assume this is what Blust means.

[24]Some Proto-Admiralties *dr- continue POC *dr-, and others are innovations. Outside of the Admiralties, POC *dr- is continued as a post-alveolar affricate in Trukic languages.

Table 17: Alveolar trill to velar fricative in Sumi (Teo 2009: 52–53)

Proto-Tibeto-Burman	Khezha	Mongsen Ao	Sumi	Gloss
*rus ~ *rew	è-ru	[tə]-ɹət	à-ɣì	‘bone’
*ran	è-ri		a-ɣi	‘war’
*rey ~ *rwi	è-rü	[a]-hɹə	à-ɣìyí	‘rattan/cane’
*d-ruk	sàrü	təɹuk	tsɨɣò	‘six’
*ruk	rho		xo	‘pick (fruit)/pluck’
*s-rik	è-rhi	[a]-tshək	à-xɨ	‘head louse’

For example, in Sumi, a Tibeto-Burman language of Nagaland, the velar fricative /x/ corresponds to the voiceless alveolar trill /rh/ in related languages, while the velar fricative /ɣ/ corresponds to /r/ (Teo 2009: 52–53).

Blust is explicit in questioning the phonetic basis of this sound change, but at the same time, recognizes that parallel shifts of *dr- to palatals and velars are suggestive of naturalness:

> What kind of phonetic or phonological bridge can be built between a prenasalized alveolar trill and either a voiceless palatal affricate or a voiceless aspirated velar stop? … If there were phonetically intermediate steps in the transition from PM *dr to *c* and *kh*, they are difficult to infer. A development *dr > *c* > *kh* is perhaps favored by the fact that several other Admiralty languages, including Likum, in southwest Manus, and Nauna in the eastern Admiralties, also reflect PM *dr as *c*. However, Seimat, spoken in the Ninigo Lagoon some 270 km west of Manus, reflects *dr as *k* or *x* …This parallelism, between historically independent changes of *dr to a voiceless palatal affricate in some languages and a voiceless velar stop or fricative in others, suggests that the change paths leading from *dr to its reflexes were constrained by some type of linguistic motivation, although what this motivation might be remains completely obscure (Blust 2005: 248).

In this context, work on the acoustic and aerodynamic properties of alveolar trills has uncovered certain natural tendencies in these speech sounds which are illuminating. First, trills have a natural tendency to devoice, since aerodynamic requirements to both sustain tongue-tip trilling and vocal fold vibration fall within narrow limits (Solé 2002). Second, trills have a tendency to produce frication, or become fricatives when oropharyngeal pressure and subglottal pressure are reduced below a certain threshold (Solé 2002: 682–684). There is also evidence for perceptual similarity between trills and fricatives (Ladefoged & Maddieson 1996: 241). Finally, alveolar trills exhibit more predorsum lowering and postdorsum retraction than taps, with more retracted alveolar closure (Recasens & Pallarès 1999), and, like other rhotics, often give rise to retraction of adjacent coronal stops (Smith et al. 2019).

Given these phonetic tendencies, the context-free shift of pre-nasalized trill to palatal, alvopalatal, or velar affricate or fricative might look like the sequence of changes outlined in Table 18, where Drehet-1 is the variety described by Beard (1992), and Drehet-2 the variety described by Blust. Levei, Likum, Nauna, and Pelipowai are listed twice, as they may show variation between palatal and alveopalatal articulations.

Table 18: Trill devoicing, retraction, and frication in some Admiralties languages

	1	2	3	{4a	4b}	{5a	5b}	
*[ndr]	> [^{t}r̥]	> [t̠r̥]	> [t̠ç̠]					(Levei, Likum, Nauna, Pelipowai)
*[ndr]	> [^{t}r̥]	> [t̠r̥]	> [t̠ç̠] >	[t͡ʃ]				Levei, Likum, Nauna, Pelipowai
*[ndr]	> [^{t}r̥]	> [t̠r̥]	> [t̠ç̠] >		[k͡x]			Drehet-1
*[ndr]	> [^{t}r̥]	> [t̠r̥]	> [t̠ç̠] >		[k͡x] >	[k^{h}]		Drehet-2, Seimat
*[ndr]	> [^{t}r̥]	> [t̠r̥]	> [t̠ç̠] >		[k͡x] >		[x]	Wuvulu[a]

[a]Loss of the closure phase of the original pre-stopped trill may have occurred earlier.

In stage 1, the trill devoices with associated loss of pre-nasalization (pre-nasalization is a feature of the voiced consonant series in these languages). In stage 2, the initial stop portion undergoes retraction triggered by the trilled rhotic. In stage 3, the trill is strengthened to a fricative: while this is transcribed as a palatal fricative [ç] it could be a complex sound involving tongue tip retraction and/or tongue root retraction. The output of stage 3 is unstable, involving a sequence of tongue blade-body articulations that are expected to coarticulate, merge and/or undergo perceptual assimilation. Change 4a shows the shift of this unstable articulation to the palato-alveolar affricate, which is already a phoneme in these languages, and hence, may act as a perceptual magnet, or an articulatory basin of attraction. In contrast, step 4b shows the shift of the same unstable articulation from palatal to velar: whether this is related to the loss of initial *k- in Drehet, Seimat and Wuvulu is unclear. In stage 5a, the fricated release of the velar affricate is weakened to aspiration, while stage 5b shows simplification of the velar affricate to a velar fricative. Only by invoking a phonetic explanation for this context-free change are we able to explain how Proto-Oceanic *dr- came to be realized as [t͡ʃ] in four languages of the Admiralties, as well as in several Chuukic (Trukic) languages, as well as the three languages with velar reflexes of the same sound, keeping in mind that, within the Admiralities, Levei and Drehet are two dialects of Khehet, and that Wuvulu and Seimat are spoken on remote islands over 400 km from Manus island.

3.5 *w/b > *c-, -nc-* in Sundanese

The final rare sound change explored in this study is an apparent labial to palatal shift in Sundanese, SC10 of Table 2, repeated in (11) with separation of word-initial (11a) and word-medial (11b) contexts. Sundanese is a Malayo-Polynesian language native to western Java, spoken today by over 40 million people, and thought to be closely related to the Malayic languages. Unless noted otherwise, all Austronesian data in this section is from the ACD.

(11) Sundanese labial to palatal glide fortition
  a. *w-, *b- > *c-*
  b. *-w-, *-b- > *-nc-*

Correspondences supporting these seemingly bizarre sound changes are given in Table 19, arranged alphabetically by Sundanese lexeme, with data from Blust (2005) updated to offer every known example of the correspondence, current etymologies, additional comparanda, and a first column with schematic environments related to the discussion that follows.[25] Where data is not from Blust (2005, 2018) it is from the ACD.

Blust's most recent published notes on the observed data take a similar position to his 2005 view:

> … *w, *b and *mb are recurrently reflected as *c-*, *-nc-* ([ʧ], [nʧ]) in Sundanese, a major Austronesian language of west Java that has been studied by linguists for well over a century. To overcome the featural absurdity of such an apparent change one might speculate that this situation came about

[25] One set from Blust (2005) that is not included here is Sundanese *kenca* (Low), *kiwa* (High) 'left side' < PMP *kiwa. The ACD proto-form is *ka-wiRi 'left side or direction', with the Sundanese form relegated to the "near comparisons" section under 'left (not right)', suggesting that a reconstruction is not possible.

> through a series of innovations *b > *w > *y > *c*-, -*nc*-. However, since *y remained unchanged, and *-mb- became -nc- in at least two known cases it quickly becomes difficult to find a way to make this work. With enough persistence and freewheeling imagination, some contrived explanation can no doubt be found. But my point in trying to raise awareness about the importance of such "unnatural" cases is that an acceptable explanation (i.e. one based on phonetic motivation) can usually be salvaged only by proposing a series of steps for which no evidence exists. (Blust 2018)

The questions we address here are: (i) Is there a reasonable, non-contrived explanation for the observed sound change in precisely the environment where it is found? (ii) If a series of steps are involved, is there evidence for these intermediate steps? However, before doing this we review several aspects of the data which, to my knowledge, have not been observed earlier, and which may be important to understanding phonetic motivations behind the change.

The first noticeable feature of the reconstructed forms in Table 19 is that the target labial is always followed by *a, the low vowel. Recall from our discussion in Section 3.2 of nasal dissimilation in Iban that a similar condition occurred. In the case of Iban, it was suggested (see footnote 17) that the presence of a low vowel could be associated with enhanced nasalization.

Since spontaneous nasalization occurs intervocalically in this data as well (e.g. *sanca* < *sawa), the vocalic context may be relevant. This observation is supported by potential near-minimal pairs where palatalization has not taken place in Sundanese. For example, compare **c**ataŋ < *bataŋ, but *bilaŋ* < *bilaŋ 'count', where *b is followed by *i. The distribution and significance of *a is highlighted in Table 19 in the first column, in the schematic environment of the sound change. In addition to the low-vowel context, all proto-forms in Table 19 include a nasal segment, an aspirate (*h or *s), or a palatal vowel or glide (*y), abbreviated as N, H, and Y respectively in the schemata of the first column. These observations lead to a new question: what do nasalization, aspiration and potential palatalization have to do with the apparent rare shift of *w, *b > *c*-, -*nc*- in Sundanese? In order to address this question, let's first step back and look at labial palatalization as it occurs in other languages.

To date, the most comprehensive study of labial palatalization[30] is Bateman (2010). Typological evidence as well as detailed diachronic studies of three distinct cases of apparent labial to palatal shifts in Moldavian, Tswana (as well as related Romance and Bantu languages), and variation in modern Polish (Kochetov

[30] In this discussion, "labial palatalization" refers to a major place of articulation shift, from labial to palatal, not to secondary palatalization of labial sounds.

Table 19: *w, *b > c-, -nc- in Sundanese where N is nasal, H is an aspirate and Y is a palatal (data from Blust 2005, 2018; ACD)

Context	PMP	Sundanese	Malay	Other WMP	Gloss
_a…aH	***b**adas	**c**adas		**w**aḍas (Javanese)	‘grit, gravel’
_aHY	***w**ahir	**c**ai	air	**v**aig (Kadazan Dusun)	‘water, river’
_a..YN	***b**aliŋbiŋ	**c**aliŋciŋ	**b**elimbiŋ		‘starfruit/tree with sour fruit’
_aNY		**c**anir	**b**anir	***b**aŋil (Proto-Philippines)	‘buttress root/wedge, prop’
_aN	***b**aŋkudu	**c**aŋkudu	**b**eŋkudu	**w**aŋkuḍu (Old Javanese)	‘*Morinda* spp.’
_a..N	***b**ataŋ	**c**ataŋ	**b**ataŋ	**w**ataŋ (Old Javanese)	‘tree trunk, fallen log’
_a…YN		**c**ariŋin	**b**eriŋin[26]		‘banyan, fig tree’
		caruluk	**b**elulok[27]		‘fruit of the sugar palm’
_a…N		**c**auŋ	**b**auŋ[28]	**b**auŋk (Bidayuh Bau)	‘catfish’
	*b-in-ahi	(see below)	**b**ini		‘woman’
_a…YNaHY	***b**a-b-in-ahi	**c**a-wene		**b**awine (Sangir)	‘woman/virgin’
_aY	***b**ayaD	**c**aya	**b**ayar	**w**aer (Tontemboan)	‘pay, compensate’
_aYa	***b**ayuR	taŋkal **c**ayur	**b**ayur	**w**ajur (Manggarai)	‘ko timber tree’
_aHaH	***b**ahaq	**c**aʔah	**b**ah	**w**ah, **w**aah (Old Javanese)	‘floodwaters’
a_aH	(*ka**w**aq)	ka**nc**ah	ka**w**ah	ka**v**aʔ (Kadazan Dusun)	‘vat, cauldron’
N_a		katu**nc**ar	ketu**mb**ar		‘coriander seed (Sanskrit loan)’
a_aH	*la**w**aq	la**nc**ah		paŋga-la**f**a (Tajio)	‘spider’
_a_aN	*la**b**an	la**nc**an	la**w**an	la**w**an (Old Javanese)	‘oppose/ opponent’
N_aN		li**nc**aŋ	le**mb**aŋ[29]		‘swollen with water’
a_aH	(*ra**w**aq)	ra**nc**a	ra**w**a(h)	ɾa**w**aŋ (Kadorih)	‘swamp, morass/ lake’
Ha_a	*sa**w**a	sa**nc**a	sa**w**a	sa**b**a (Mentawai)	‘python’

a b c d

[a] Compare PWMP *biRiŋ ‘running sore’, *biRiŋ-en ‘have a running sore’, with possible reference to fig milk, and/or irritation caused by fig milk.

[b] Compare PWMP *balulaŋ ‘thick or hard skin’, with possible reference to outer hard skin of sugar palm fruit.

[c] Compare PWMP *bauk ‘chin whiskers’, with possible reference to fish with chin whiskers.

[d] Compare PWMP *la(m)baŋ ‘to beyond, go over, go past’, *labeŋ ‘abundance, surplus’.

1998), strongly support a surprising result: apparent full palatalization (and delabialization) of labials is the result of a series of sound changes that do not target the labial itself. Rather, full labial palatalization arises due to hardening of a palatal glide that followed the labial, with subsequent deletion of the labial. The general pathway of labial palatalization is illustrated in Table 20: after labial deletion, palatal approximants or fricatives phonologize as palato-alveolar fricatives or affricates, in particular when these sounds pre-exist in the language.

Table 20: Labial palatalization as glide hardening + labial deletion (Bateman 2010)

Palatalization	p >	pj	f >	fj	b >	bj	v >	vj
Voicing assimilation		pç		fç		bʝ		vʝ
Labial deletion		ç		ç		ʝ		ʝ
(Possible strengthening)		t͡ʃ		t͡ʃ		d͡ʒ		d͡ʒ

This broad outline of labial palatalization may provide a better understanding of probable phonetic developments in Sundanese. Let us begin with Blust's first hypothesis which is the suggestion that the apparent instances of *w < *b in Sundanese are due to borrowing from Javanese, where an apparent unconditioned split of *b into /b/, /w/ occurred (Blust 2005: 239).[31] If this is the case, we can rewrite the rare sound change of interest as in (12).

(12) Sundanese labial to palatal glide fortition

a. *w- > *c*-

b. *-w- > -*nc*-

Given the trajectories of labial palatalization in Table 20, we suggest that pre-Sundanese *w (from Javanese borrowings) was nasalized and aspirated to *w̥̃,

[31]Blust (2005: 239) discards this hypothesis on the basis of the Sundanese cognates with -*nc*-, saying: "The major obstacle … is the two examples which Nothofer gives of Malay forms with -*mb*- corresponding to apparent Sundanese cognates with -*nc*-. Since the change *b > *w* following a nasal is unattested in Austronesian languages it appears necessary to assume that in at least these two forms the cluster *-mb- changed directly to -*nc*-." However, one form is a Sanskrit loan, Sundanese *katuncar* (Malay *ketumbar*) 'coriander seed', from an Indic form (cf. Prakrit *kutthuṁbharī*) with an *anusvara* nasal (syllable-final nasal glide), involving nasalization of the preceding vowel preceding the labial stop, while the other, Sundanese *lincaŋ* (Malay *lembaŋ*) 'swollen with water', appears to derive from a stem with a doublet *labeŋ 'abundance, surplus' (cf. Kayan *laveŋ,* Maranao *labeŋ*), allowing for the possibility of a -nc- < *w here as well. In all other cases, -*nc*- in Sundanese corresponds to Old Javanese /w/ < *b, as hypothesized.

and subsequently strengthened to a palatalized labial fricative, with subsequent labial deletion, as shown in Table 21.

Table 21: Labial palatalization of *w in Sundanese

Stage	Process	Context			
				V__V	#__
1	Nasalization/aspiration	*w	>	*w̥̃	*w̥̃
2	Glide strengthening-I	*w̥̃	>	*ʰ̃fʲ	*fʲ
3	Glide strengthening-II	*ʰ̃fʲ	>	*ʰ̃fɕ	*fɕ
4	Labial Deletion	*ʰ̃fɕ	>	*ʰ̃ɕ	*ɕ
5	Affrication	*ʰ̃ɕ	>	*ʰ̃t͡ʃ	t͡ʃ
6	Nasal strengthening	*ʰ̃t͡ʃ	>	nt͡ʃ	

In stage 1, nasalization and aspiration are induced by ambient nasalization (from nasal consonants) or from spontaneous nasalization associated with low vowels and/or aspirates and glides (see footnote 17). This voiceless nasalized segment is then strengthened to a fricative in stage 2: since frication and nasalization are generally incompatible (Warner et al. 2015), the initial labial fricative loses nasalization, while nasalization is maintained in pre-aspiration of the medial fricative. Stage 2 also shows a decoupling or linearization of the labial and high tongue body gestures of the labial glide: labialization is realized during the fricative stricture phase, while high tongue body is realized at release in the form of a voiceless palatal offglide.[32] Subsequent changes follow the widely attested trajectories documented by Bateman (2010): strengthening of the off-glide in stage 3; labial deletion in stage 4; and affrication in stage 5. Nasal strengthening in stage 6 is of special interest: recall from footnote 31 that it occurs not only in inherited forms, but in at least one clear Indic borrowing, where an *anusvara* nasal, is realized as a nasal stop.

Labial palatalization is relatively uncommon, since palatalized labials often persist as sequences of independent articulatory gestures (Bateman 2010), and

[32] An alternative way of conceptualizing this is in terms of (mis)perception, as opposed to articulation, - a case of *chance* in Evolutionary Phonology (Blevins 2004: 32). The height feature is associated with [j], the labial feature with [f], and spread glottis with the entire (complex) segment. A potential phonological parallel is the widespread palatalization of labials before /w/ in Southern Bantu languages as recently summarized in Bennett & Braver (2020: 2–4), where the labialization of /w/ is attributed by the listener to the preceding labial. Within the typology of Ohala (1993), all of these could be treated as cases of hypercorrection.

since glide strengthening (as opposed to weakening), is relatively less common (Bybee & Easterday 2019). Spontaneous nasalization is also uncommon, and the apparent combination of inherent nasal, aspirate, low-vowel, and glide-induced effects in the history of Sundanese is especially notable. Finally, the influx of Indic terms with *anusvara* nasals may have played a role as well, with ambient vowel nasalization phonologized in loans as pre-nasalized stops. In sum, the unique status of the Sundanese sound change in (12) can be understood as a rare confluence of all of these factors.

4 Rare sound change and language contact

Of the ten sound changes in Table 2 classified as "bizarre", most, as argued above, can be seen as phonetically natural: Sundanese labial palatalization (SC10); intervocalic devoicing in Berawan and Kiput (SC4); *dr > k^x in Drehet (SC9); *-b/d/g > ^{m}*b*/^{n}*d*/^{ŋ}*g* > *-m/n/ŋ* in Berawan and Karo Batak (SC2); tonic gemination in Berawan (SC8); Berawan *-b- > *-g-, (SC3) which telescopes weakening of *b > *w*, and fortition of *w > *g*; and the Iban shift of final nasals to glides (SC7), reinterpreted as nasal dissimilation (9). The neutralzation of Khehek *-y > *-w (SC1), and the development of post-nasal devoicing in Murik and Buginese (SC5) appear to involve non-phonetic factors: in the first case, pre-Khehek final consonant distribution appears to play a role in both glide-backing, and, later, in filling the /p/ gap; in the development of post-nasal devoicing, the absence of NT clusters may have allowed ND to vary in pronunciation, giving rise to voiceless variants which dominated over time. Finally, one of the bizarre changes listed, Sa'ban *g > *p*-, *-p* (SC6), does not appear to be a true sound change (or sequence of sound changes) at all.

In the cases of rare developments, where multiple sound changes are involved, rarity may reflect the low frequency of the individual changes that co-occur.[33]

It is also possible that some of these developments are not as rare as they might seem. For example, if intervocalic devoicing in Berawan and Kiput are analyzable as phonetically natural instances of lengthening in a strong prosodic position as suggested in Section 2.3, these sound changes are unremarkable. The same is true of Berawan gemination: if the analysis in Section 3.3 of gemination as weight-to-stress is correct, it aligns with many similar cases of tonic lengthening and/or gemination in the world's languages. Blust's (2005, 2018) concern in both of these cases was the rarity of the sound pattern within Austronesian: if such

[33]See Beguš (2020) on estimating the probability of natural and unnatural sound change.

sound changes were possible, why were they restricted to just two languages of over 500 Austronesian languages having both open and closed syllables?[34]

Five languages in this study are spoken in Borneo: Berawan, Iban, Kiput, Sa'ban, and Murik. Within the Austronesian language family, the languages of Borneo are widely recognized as being phonologically and lexically divergent, with a range of properties that are uncommon elsewhere within the family. In the realm of segmental contrasts, contrastive palatal consonants are found, final nasals may be pre-ploded, medial nasals may be post-ploded, and rare laryngeal series, like the voiced aspirates described for several dialects of Kelabit (Blust 2006), the voiceless sonorants described for the Sa'ban dialect of Kelabit, and the implosives of Bintulu are attested (Blust 2013:67, 182, 184–185). Even more remarkable are the word-level properties which make some languages of Borneo almost unrecognizable as Austronesian stock. These include variability and neutralization of vowel quality in nonfinal syllables, and bulking of final syllables, with a shift towards iambic or even monosyllabic words. These word-level properties can be illustrated with some of the Borneo continuations of PAN *asu 'dog' shown in Table 22.

While the final syllable remains light in the majority of Austronesian languages (cf. Bunun *asu*, Siraya *asu*; Ilokano *áso*; Malaweg *asú*; Toba Batak *asu*; Kambera *ahu*), the languages of Borneo are clearly different, with a range of distinct changes yielding a light-heavy or monosyllabic heavy syllable pattern. In this way, the languages of Borneo are similar to Chamic languages, where parallel shifts towards iambic and monosyllabic word types have been documented in detail by Thurgood (1999) and attributed, in large part, to intense contact with Mon-Khmer languages in mainland Southeast Asia. For PAN *asu 'dog', compare the Borneo continuations in Table 22 with Jarai *asəu*, W. Cham *saw*, and Wr. Cham *asuŋ, suw*, all from proto Chamic *ʔasɔw (Thurgood 1999: 281).

While all of these features of the Austronesian languages of Borneo suggest contact with Mon Khmer speaking populations, language contact is not considered in the major works on the historical phonology of Borneo, including the extensive work of Blust cited here, and the recent work of Smith (2017). This is due to the absence of clear evidence for these populations being present in Borneo at or after the arrival of the Austronesians.[35] Future studies may lend further support to the view that some of the many unusual sound changes in the languages of Borneo are due to contact with Mon-Khmer, and, more specifically,

[34] Many Austronesian languages lack closed syllables. In languages without closed syllables, both post-tonic gemination and weight-to-stress will be absent by definition.

[35] On linguistic evidence for a Mon-Khmer presence in Borneo at the time of Austronesian settlement, see Adelaar (1995), Blench (2010) and Blevins & Kaufman (2023).

Table 22: Some Borneo reflexes of PAN *asu 'dog' illustrating shift toward iambic word

Subgroup	Language	*asu 'dog'	Bulking of second syllable	Reduction/ loss of first syllable
Kayanic	Busang	asoʔ	C-epenthesis	–
	Kelai	asaw	V_2-breaking	–
	Data Dian	asoːʔ	C-epenthesis, V_2-lengthening	–
	Mpraa	hawʔ	C-epenthesis, V_2-breaking	V_1-loss
	Modang	saə̯	V_2-breaking	V_1-loss
	Long Gelat	saː	V_2-lengthening	V_1-loss
	Bahau	hoːʔ	C-epenthesis, V_2-lengthening	V_1-loss
Punan	Punan Tuvu'	auh	Metathesis	Metathesis
Land Dayak		*kasu		
	Benyadu	kasuʔ	C-epenthesis	–
	Sungkung	kasokŋ	C-epenthesis	–
	Hliboi Bidayuh	kisúə̯kŋ	C-epenthesis, V_2-breaking	V_1-reduction
	Sanggau	kiuʔ	C-epenthesis, C-lenition	V_1-reduction
Kenyah	E. Penan	asəwʔ	C-epenthesis, V_2-breaking	–

to the prosodic and segmental impact of sequisyllables and complex laryngeal contrasts on canonical western Austronesian forms.

In the meantime, whether phonetic or structural, internal or external, completely transparent, or clouded by diffusion and confusion, the big picture remains one of regular linguistically motivated sound change. As summarized in Table 23, Blust's recalcitrant cases of regular sound change in Austronesian can, for the most part, be viewed as natural phonetically motivated changes, or sequences of these changes. At the same time, recognition of phonotactic regularities, phonotactic gaps, absence of contrasts, prosodic factors, contact-induced

Table 23: . Motivated Sound Changes adapted from Blust (2005)

SC#	Sound change(s)	Language(s)	Phonetic motivation	Other factors
SC1	*-y > *-w, *-w > *-b > -*p*	Khehek (Drehet, Levei)	hypercorrection in glide dissimilation; fortition	VG distributions; final *-p gap
SC2	*-D > *-ND, *-ND > -N	Berawan, Karo Batak	nasal spread; hyper-voicing; non-release	analogical extension
SC3	*b > *w* > *gw* > *g* / V_V	Berawan	lenition + fortition	
SC4	*D > T/ V_V	Berawan, Kiput	post-tonic fortition	iamb/sesquisyllable via contact?
SC5	*ND > NT	Murik, Buginese	variable voicing	lack of contrast
SC6	*g > -*j*-	Sa’ban (Kelabit)	articulatory	
SC7	*N > G/N(C)*a*_#	Iban	hypercorrection in nasal dissimilation	exceptions in Malay loans
SC8	*C > C:/_V#	Berawan	syllable bulking by weight-to-stress	iamb/sesquisyllable via contact?
SC9	*dr- > *tʃ*- > k^x > k^h-	Drehet	articulatory	
SC10	*w- …> *c*-, *-w- …> -*nc*-	Sundanese	perceptual confusion; rhinoglottophilia; labial palatalization	pre-Sundanese *w from Javanese loans

change, and exceptions in loan vocabulary, may be necessary in order to make sense of the rarity of these sound patterns within the Austronesian language family, and, for some patterns, more widely.

At the same time, there are theoretical implications. While Beguš's approach to unnatural sound change (2018, 2019) treats intervocalic devoicing as decidedly unnatural, we argue that direct devoicing under phonetic lengthening in prosodically strong positions is a natural process. Apart from cross-linguistic phonetic evidence for this kind of lengthening additional arguments support this approach: first Beguš's analysis fails to make the right predictions regarding intermediate stages of change; second, devoicing appears to target sounds in order of their aerodynamic phonetic tendency to devoice, suggestive of direct stop devoicing, as opposed to indirect devoicing under the Blurring Account, where devoicing targets a critical intermediate fricative stage (for all points of articulation.)

There is clearly more work to be done in understanding fine details of many of the historical developments discussed here. The role of contact cannot be underestimated, nor can structural properties of phonological systems, nor the phonetic dimensions of speech that we have yet to fully understand. Taking all of these factors into account, with Blust's contributions to inspire and enlighten, new aspects of sound change are bound to be discovered, and with them, explanations for changes that puzzle us today.

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Abbreviations

1	first person
ACD	Austronesian Comparative Dictionary (Blust & Trussel 2020)
AS	Smith (2017)
C	consonant or glide
D	voiced stop
BD	Borneo Dictionary
G	glide
H	aspirate
INCL	inclusive
N	nasal stop
PAN	Proto Austronesian
PL	plural
PMP	Proto Malayo-Polynesian
POC	Proto Oceanic
PWMP	Proto Western Malayo-Polynesian
T	voiceless stop
V	vowel
Y	palatal vowel or glide
WMP	Western Malayo-Polynesian
*	reconstructed form
**	expected but unattested form

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Chapter 5

Consonant epenthesis in Meto: Typologically rare but diachronically explicable

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In this chapter, we examine a process of consonant epenthesis in Meto (Austronesian, Timor) which productively occurs to resolve hiatus across a prosodic foot boundary. Several consonants are inserted in different varieties of Meto including voiced obstruents /gʷ/ /dʒ/ /b/, liquids /r/ /l/, and glides /w/ /j/. Some of these are typologically rare epenthetic consonants. In addition, the diversity of consonants encountered across different varieties of Meto poses challenges to synchronic accounts of epenthesis. A diachronic perspective allows us to gain a more cohesive and unified explanation, as the consonants inserted are due to an accumulation of sound changes applying to an earlier "natural" system of glide epenthesis.

1 Introduction

This chapter examines consonant epenthesis in Meto, a language/dialect cluster of western Timor. In this process various consonants are regularly inserted after vowel-final words when they are followed by a vowel-initial enclitic. Examples from three varieties of Meto are given in Table 1, alongside a consonant-final stem after which no epenthesis occurs.

Consonant epenthesis is synchronically productive in Meto and occurs to resolve vowel hiatus across a prosodic foot boundary. This foot boundary occurs at the juncture of the root and the enclitic, and consonant insertion provides the enclitic with an onset consonant. Which consonant is inserted is predictable based on the final vowel of the host, discussed in more detail in Section 3.1.

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Table 1: Consonant epenthesis before enclitics in Meto

stem		'one, a'		Amanuban	Amfo'an	Timaus	
ai	+	*=ees*	→	*ai**j**ees*	*ai**dʒ**ees*	*aa**r**ees*	'a fire'
noe	+	*=ees*	→	*noe**j**ees*	*noe**l**ees*	*noe**l**ees*	'a river'
meo	+	*=ees*	→	*meo**w**ees*	*meo**g**ʷees*	*mee**g**ʷees*	'a cat'
hau	+	*=ees*	→	*hau**w**ees*	*hau**g**ʷees*	*haa**dʒ**ees*	'a tree'
kuan	+	*=ees*	→	*kuanees*	*kuanees*	*kuanees*	'a village'

While consonant epenthesis is a common process of hiatus resolution cross-linguistically (e.g. Casali 2011) the particular consonants inserted in some varieties of Meto are typologically unusual, including consonants which are previously unattested as a productive means of hiatus resolution; namely /gʷ/, /dʒ/, and /b/. Such consonants are difficult to account for in terms of phonetic naturalness or perceptual "minimality", which is often appealed to in order to account for consonants inserted in hiatus contexts cross-linguistically (Morley 2012). Epenthetic consonants such as /gʷ/, /dʒ/, and /b/ also pose some challenges to synchronic accounts of epenthesis because they are not minimally "marked"; and in many cases, they are not transparently analysable as sharing the features of surrounding vowels, which are the two main ways epenthetic consonants are accounted for in the literature (e.g. Lombardi 2002, de Lacy 2006, Staroverov 2014). Indeed, from certain theoretical perspectives (e.g. Optimality Theory) labial and dorsal consonants have have been argued to be impossible epenthetic segments because of their "markedness" (de Lacy 2006).

This chapter conducts a survey of consonant epenthesis in six varieties of Meto and examines the diachronic origins of these patterns. It also offers some preliminary observations on sociolinguistic factors. It shows that typologically unusual patterns of consonant epenthesis like those in Meto can develop from more typologically usual patterns through the accumulation of regular sound changes. Consonant epenthesis in Meto adheres to the prediction of Blevins (2008a) that "unnatural" patterns result from multiple changes. While the kinds of epenthetic consonants in Meto may not be attested elsewhere, the sound changes we propose are.

Initial conversations with speakers indicate that consonant epenthesis is one of a range of phonological and morphological processes in Meto which index group identity. Thus, sociolinguistic factors may have played a role in reinforcing these typologically unusual patterns. Consonant epenthesis in Meto highlights the importance of diachronic perspectives when examining typologically uncommon phonological phenomena, as well as the role of potential sociolinguistic factors.

This chapter proceeds as follows. Section 2 provides relevant background on the Meto language/dialect cluster. Section 3 provides an overview of consonant epenthesis in six varieties of Meto. Section 4 situates the Meto data within its theoretical and typological context, while Section 5 outlines how the data can be analysed synchronically. The diachronic origins of the epenthetic consonants are then discussed in Section 6 and the role of potential sociolinguistic factors is examined in Section 7. We conclude the chapter in Section 8 with a summary of our main findings and discuss the implications of the Meto data for phonological typology and theory.

2 Language background

Meto (a.k.a. Uab Meto, Dawan[ese], Timorese or Atoni, Glottocode: uabm1238) is a cluster of closely related Austronesian languages and/or dialects. It is located on the western part of the island of Timor, in the the Indonesian province of Nusa Tenggara Timur and the East Timorese enclave of Oecusse. The Ethnologue (Eberhard et al. 2022) estimates the number of speakers of Meto at 850,000, although this is based on 2009 figures. While Meto speakers consider their speech a single language, they also recognise more than a dozen distinct varieties, which themselves have named dialects. Further differences are found between different villages of speakers sharing a single dialect. A map showing the self-identified varieties of Meto is given in Figure 1. Meto data in this chapter comes from the varieties listed in (1), which also gives the sources of data. These corpora, which are archived at PARADISEC, contain data from a range of both male and female speakers from a variety of ages.

(1) Sources of Meto data in this chapter:
   a. Roi'is Amarasi, Buraen village, Suit hamlet – 101 minute corpus of recorded texts (Edwards 2014);
   b. Kotos Amarasi, Nekmese' village, Koro'oto hamlet – 180 minute corpus of recorded texts (Edwards 2009);
   c. Amanuban, Niki-niki village – elicitation, supplemented by draft Bible translation;[1]

[1]The (draft) Bible translations into varieties of Meto have been carried out by native speakers and are completely natural and idiomatic. Nonetheless, no analyses or facts presented in this chapter are based only on examples found in Bible translations.

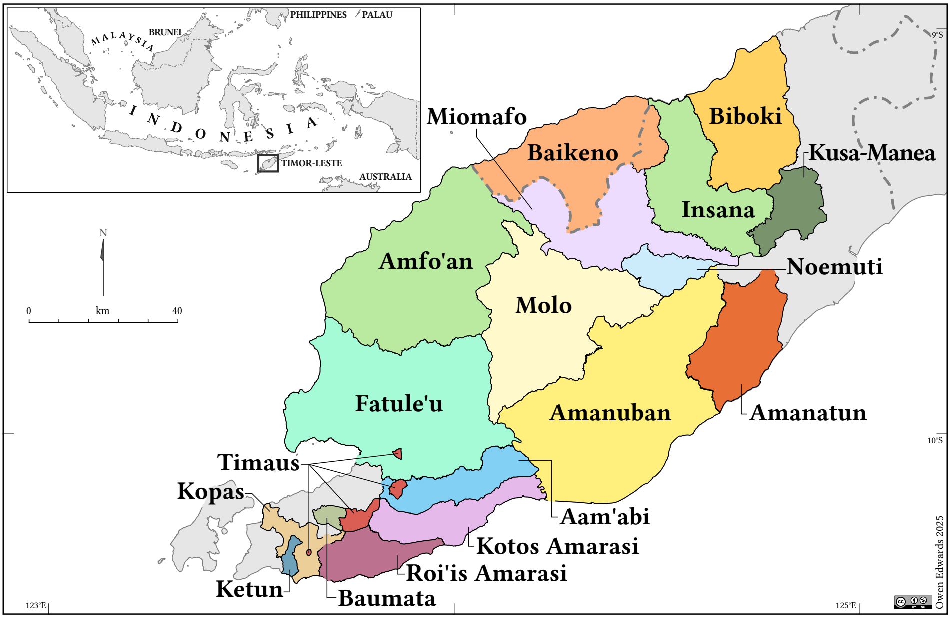

Figure 1: Self-identified varieties of Meto

d. Amfo'an, Lelogama village – 153 minute corpus of recorded texts (Culhane 2017), supplemented by Grimes et al. (2021), and draft Bible translation;

e. Timaus, Bokong village, Sanenu hamlet – 99 minute corpus of recorded texts (Edwards 2016);

f. Baikeno (multiple villages) – data collected primarily by Charles E. Grimes,[2] supplemented by translation of the Gospel of Mark.

Meto varieties have five vowels /i, e, a, o, u/. Mid vowels phonetically vary between mid-low [ɛ ɔ] and mid-high [e o]. Meto does not have segmental diphthongs. Sequences of two vowels can be realised as either vowel-vowel or vowel-glide; e.g. *ai* ⟶ [ˈʔa.i] ~ [ʔaj] ‘fire’. Every phonological and morphological process of the language treats phonetically long vowels identically to vowel sequences, and they are thus analysed as sequences of identical vowels; e.g. ***bifee*** ⟶ [bɪˈfɛː] ‘woman’. See Edwards (2020: 96–98) and Edwards (2018: 31–32) for further discussion and justification of this analysis.

[2]Additional Baikeno data comes from a language documentation workshop run by the Endangered Language Alliance in Kupang in July 2012 during which Edwards was an instructor.

All (known) Meto varieties have 11 core consonants /p, t, k, ʔ, b, f, s, h, m, n/, as well as either /r/ or /l/ which correspond to one another; e.g. Kotos, Roi'is, and Kusa-Manea *koro*, other Meto *kolo* 'bird'. Timaus has both /l/ and /r/ with /l/ corresponding to other Meto /l/ or /r/ and /r/ due to *dʒ > *r* (Section 6.4.1). In addition to these consonants, most varieties of Meto also have a voiced palatal obstruent /dʒ/ [dʒ] ~ [ʒ] and a voiced velar obstruent, either /g^{w}/ or /g/, though some varieties lack the voiced velar obstruent. These obstruents have a restricted distribution and mainly (though not exclusively) arise due to the consonant epenthesis which is the focus of this chapter. Amanuban does not have these obstruents, but has glides /w/ and /j/ in comparable environments. The labio-velar obstruent /g^{w}/ is realised as [ɡw] ~ [ɣw], a voiced velar plosive or fricative followed by a labio-velar glide, or as [ɡ] ~ [ɣ], without a following labio-velar glide. In this chapter we make a distinction in our transcription between <*g^{w}*> = [ɡw] ~ [ɣw] and <*g*> = [ɡ] ~ [ɣ].

Meto roots have a highly constrained segmental structure based around a disyllabic foot.[3] Roots must minimally comprise a foot, and contain a maximum of two feet. Consonant clusters only occur at the juncture of a foot and/or word-initially. Vowel sequences do not occur across a foot boundary, and all feet must have an onset consonant. When a word or foot has no onset, a consonant is automatically inserted (see Section 3.4). An overview of permitted root structures in Meto with examples from Amfo'an is given in Table 2. Words which have more than two syllables are nearly all historically morphologically complex or are loans.

Meto demonstrates acoustic evidence for stress – specifically from vowel quality, spectral tilt and pitch rise/fall ratios – on the penultimate syllable of the word (Culhane 2024). Syllable weight is not relevant for any aspect of Meto phonology. The only roots which do not comprise at least a foot – i.e. are monosyllabic – are a small number of functors, or function morphemes (morphemes with a non-lexical, grammatical meaning).

Meto has a productive process of final CV ⟶ VC metathesis; e.g. *hitu* ⟶ *hiut* 'seven'.[4] The forms and functions of metathesis have been thoroughly described

[3]Note that we define the foot as a phonological domain intermediate between the syllable and the prosodic word (Culhane 2023). In addition to various phonotactic phenomena, evidence for the foot domain in Meto comes from consonant epenthesis and partial reduplication (see Culhane 2024). We do not assume a relationship between the foot and stress, which is not typologically supported (Culhane 2023), and analyse stress in Meto as assigned to the penultimate syllable of the word. There is no need to appeal to foot structure to account for the distribution of stress in Meto. See Culhane (2024) for further discussion.

[4]The productivity of metathesis is demonstrated by loans undergoing the process, such as Malay *kepala* ⟶ *kepaal* 'head, chief' (see Edwards 2020: 273 ff.).

Table 2: Amfo'an root structures

Structure		Other material	Foot	Root	Translation
$_{\omega}[_{\text{Ft}}[\sigma\sigma]]$	=		(C)V(C)V(C)	*nima*	'five'
				lalan	'path, way'
				oef	'soup'
$_{\omega}[\text{C}_{\text{Ft}}[\sigma\sigma]]$	=	C	CV(C)V(C)	*snaen*	'sand'
				kninoʔ	'clean, holy'
				ʔbaʔu	'bat'
$_{\omega}[\sigma_{\text{Ft}}[\sigma\sigma]]$	=	(C)V(C)	CV(C)V(C)	*maʔfenaʔ*	'heavy'
				maslaal	'coarse'
				ansao-n	'chest'
$_{\omega}[_{\text{Ft}}[\sigma\sigma]_{\text{Ft}}[\sigma\sigma]]$	=	(C)V(C)V(C)	CV(C)V(C)	*likusaen*	'python'
				ataʔlaʔe	'praying mantis'
				aidʒiak	'jackfruit'

for Kotos Amarasi by Edwards (2020), who shows that in this variety of Meto metathesis has two morphological functions (modification in the NP and resolution in the discourse) and is also phonologically conditioned before vowel-initial enclitics. Most varieties of Meto have assimilation of final /a/ after metathesis, e.g. *nima* ⟶ *niim* 'five', though Kusa-Manea preserves forms without assimilation, e.g. *niam* 'five'.

3 Overview of the data

In this section we provide an overview of consonant epenthesis in Meto. We begin in Section 3.1 with an overview of the basic facts: when epenthesis occurs and what consonants are inserted. This is followed in Section 3.2 with justification for analysing this process as epenthesis, not deletion. In Section 3.3 we provide evidence that consonant epenthesis is a productive process. In many cases, due to restrictions of space, we cannot fully illustrate the patterns we discuss here. Wherever insufficient data is provided to establish that a particular pattern is regular, supporting data can be found in Appendix A.

3.1 Basic facts

Consonant epenthesis – that is, insertion of consonants which are not present in the phonological representation (see Section 4 below) – occurs in Meto at the juncture of a vowel-final word and a vowel-initial enclitic. For example, Amfo'an *hau* 'tree, wood + *=ees* 'one, a' ⟶ *haug^{w}ees* 'a tree'. The different consonants inserted in this environment amongst the varieties of Meto we examine are summarised in Table 3 according to whether they attach to a host with final vowel sequence (e.g. *hau* 'wood, tree') or a host with final CV (e.g. *fatu* 'stone').

An example of each epenthetic consonant is given in Table 4 and Table 5. CV-final hosts also undergo metathesis followed by final vowel assimilation to various extents in different varieties of Meto, such as Kotos ***mone*** + *=ees* ⟶

Table 3: Summary of epenthetic consonants in Meto

	VV-final hosts					CV-final hosts				
	i	e	a	o	u	i	e	a	o	u
Amanuban	j	j	j	w	w	j~∅	j~∅	∅	w~∅	w~∅
Kotos	dʒ	dʒ	g^w	g^w	g^w	dʒ	dʒ	∅	g^w	g^w
Roi'is (Buraen)	dʒ	dʒ	?†	b	b	dʒ	dʒ	∅	b	b
Baikeno	dʒ	l	b	b	b	dʒ	dʒ	∅	b	b
Amfo'an	dʒ	l	g^w	g^w	g^w	dʒ	l	∅	g^w	g^w
Timaus	r	l	g^w	g^w	dʒ	r	l	∅	g^w	dʒ

† Data is lacking for hosts with final /Va/ for Roi'is from the village of Buraen.

Table 4: Consonant epenthesis with vowel-initial enclitics /VV_

	'a fire' ai=ees	'a water' oe=ees	'two already' nua=een†	'a cat' meo=ees	'a tree' hau=ees
Amanuban	*ai**j**ees*	*oe**j**ees*	*nua**j**een*	*meo**w**ees*	*hau**w**ees*
Kotos	*aa**dʒ**ees*	*oo**dʒ**ees*	*nua**g^w**een*	*mee**g^w**ees*	*haa**g^w**ees*
Buraen Roi'is	*aa**dʒ**ees*	*oo**dʒ**ees*	?	*mee**b**oes*	*haa**b**oes*
Baikeno	*ai**dʒ**ees*	*oe**l**ees*	*nua**b**een*	*meo**b**ees*	*hau**b**ees*
Amfo'an	*ai**dʒ**ees*	*oe**l**ees*	*haa**g^w**een*†	*meo**g^w**ees*	*hau**g^w**ees*
Timaus	*aa**r**ees*	*oe**l**ees*	*nua**g^w**een*	*mee**g^w**ees*	*haa**dʒ**ees*

† Amfo'an *haag^{w}een* is 'four already' from *haa* 'four'. Amfo'an *nuga* 'two' is CV-final.

Table 5: Consonant epenthesis with vowel-initial enclitics /CV_

	‘a pig’ fafi=ees	‘a husband’ mone=ees	‘gets it’ n-ana=ee	‘a day’ neno=ees	‘a stone’ fatu=ees
Amanuban	*fafi**j**ees*	*mone**j**ees*	*naanee*	*neno**w**ees*	*fatu**w**ees*
Amanuban	*faafies*	*moonees*		*neenoes*	*faatues*
Kotos	*faaf**dʒ**ees*	*moon**dʒ**ees*	*naanee*	*neen**g**ʷees*	*faat**g**ʷees*
Buraen Roi'is	*faaf**dʒ**ees*	*moon**dʒ**ees*	*naanee*	*neen**b**oes*	*faat**b**oes*
Baikeno	*faaf**dʒ**ees*	*moon**dʒ**ees*	*naanee*	*neem**b**ees*	*faat**b**ees*
Amfo'an	*fafi**dʒ**ees*	*mone**l**ees*	*naanee*	*neno**g**ʷees*	*fatu**g**ʷees*
Amfo'an	*faaf**dʒ**ees*	*moon**l**ees*		*neen**g**ʷees*	*faat**g**ʷees*
Timaus	*faaf**r**ees*	*mona**l**ees*†	*naanee*	*neen**g**ʷees*	*faatdʒees*

† Sanenu Timaus has *e > *a* /C_(C)#.

*mo**on**dʒees* ‘a husband’ and ***fatu*** + *=ees* ⟶ *faa**tg**ʷees* ‘a stone’. In Amanuban consonant insertion does not universally occur after CV-final hosts. Instead, the host can just undergo metathesis and vowel assimilation, and the first vowel of the enclitic can assimilate to the original final vowel of the host, e.g. *fa**fi*** + *=**e**es* ⟶ *fa**afi**es* ‘a pig’.

Whether metathesis and vowel assimilation occur with CV-final hosts is dependent on a combination of factors including: the variety of Meto, the phonotactic shape of the host, and the segments in the final syllable of the host. There also appear to be speaker and/or dialect differences in some Meto varieties. The patterns are complex and not yet fully understood for all varieties of Meto.

The vowel-initial enclitics which trigger consonant epenthesis are listed in Table 6. Each of these enclitics can be analysed as a disyllabic foot (see below), with consonant insertion occurring at the clitic boundary which is the juncture of two feet.

Evidence that these enclitics are disyllabic comes from two sources. Firstly, four of these enclitics have unambiguously disyllabic unmetathesised forms: *=ana* ‘2DET’, *=esa* ‘one’, *=ena* ‘PERF’, and *=aha* ‘just’. Consistent with all /a/-final stems (e.g. *nima* ⟶ *niim* ‘five’), final /a/ undergoes assimilation after metathesis for *=esa* ⟶ *=ees* ‘one’ and *=ena* ⟶ *=een* ‘PERF’ in most varieties of Meto (Section 2), although assimilation of final /a/ does not occur in Kusa-Manea, e.g. *eas* ‘one’.

Secondly, in some varieties of Meto there is a process whereby the initial vowel of a vowel-initial enclitic undergoes partial assimilation to the quality of the

Table 6: Meto vowel-initial enclitics

Form	Gloss	Meaning
=ii	‘1DET’	definite referent near/relevant to speaker
=ana/=aan	‘2DET’	definite referent near/relevant to addressee
=ee	‘3DET’	definite referent near/relevant to a third person
	‘3SG.ACC’	third person P argument (object) of verb
=aa	‘0DET’	definite referent near/relevant to no one (≈obviative)
=esa/=ees	‘one, a’	the numeral one (1); indefinite singular
=ena/=ee(n)[†]	‘PERF’	perfect, already
=aha/=aah	‘just’	restrictive
=oo-n	‘REFL’	reflexive

[†] The perfect enclitic is usually *=ee* in Amfo'an, though sporadic instances of *=ena/=een* are also found. Similarly, Baikeno has variation between *=ena* and *=ee*. Roi'is Amarasi has consonant-initial *=hena/=heen*.

final vowel of the host.[5] Examples from Roi'is include *nif**u*** ‘thousand’ + *=**e**es* → *niif**bo**es* ‘one thousand’, and *ta-knin**u**ʔ* ‘we clean’ + *=**e**e* ‘3SG.ACC’ → *takniin**ʔo**e* ‘we clean it’. See Edwards (2020: 248–252) for additional examples and discussion.

Despite the evidence that the vowel-initial enclitics are disyllabic and contain a foot, forms with a sequence of two identical vowels are frequently realised with a short vowel. This is a consequence of the stress patterns of Meto. Stress in Meto is penultimate, but enclitics are extra-metrical and do not bear stress; e.g. Amfo'an *ai* ‘fire’ + *=ees* → /aidʒees/ [ˈʔaidʒɛs]. Unstressed vowel sequences often have a shorter duration than stressed vowel sequences in Meto (Edwards 2020: 98–99).

Consonant epenthesis only occurs after vowel-final words. After consonant-final words, the enclitic is simply attached to the stem. Thus, all varieties discussed in this chapter have *tuaf* ‘person’ + *=ees* → *tuafees* ‘a person’ and *sii-t* ‘song’ + *=ees* → *siitees* ‘a song’, for example. CVC-final stems similarly do not trigger consonant epenthesis.[6]

In some cases, the final vowel of a VV-final host undergoes assimilation to the quality of the previous vowel after consonant epenthesis. The quality of the vowel before assimilation determines the type of epenthetic consonant. This occurs in Kotos, Roi'is, and Timaus, after all hosts except hosts with final /Va/ or, in

[5]This process has been attested in Amanuban, Roi'is Amarasi, and Kopas from Oepaha village.

[6]In this environment, final CV → VC metathesis occurs to differing extents in different varieties of Meto; e.g. Kotos Amarasi *muʔit* + *=ees* → *muiʔtees* ‘an animal’.

Timaus, /e/, as seen in *ha**u*** + *=ees* ⟶ Kotos *ha**a**g^{w}ees*, Roi'is *ha**a**boes*, or Timaus *ha**a**dʒees* 'a tree'. See Appendix A for examples in addition to those in Table 4.

Consonant epenthesis is an automatic process which occurs whenever a vowel-initial enclitic attaches to a vowel-final host, affecting all morphemes of all word classes without exception, including other enclitics, as well as new loanwords (see Section 3.3 for examples). Examples of epenthesis with word classes other than nouns are given in Appendix A.

The description given above covers nearly all the Meto data. However, rare combinations of morphemes sometimes have unexpected patterns of consonant epenthesis. For example, Edwards (2020: 244ff) describes the patterns of epenthesis for Kotos Amarasi when a vowel-initial enclitic attaches to another vowel-initial enclitic. In this case, unexpected epenthesis of /g^w/ can occur. Thus, for example, Kotos *oe* + *=ee* '3DET' ⟶ *oodʒee* 'the water' has expected insertion of /dʒ/ after final /e/. However, the addition of *=een* 'PERF' to *oodʒee* 'the water' produces *oodʒee**g^w**een* 'the water already' with unexpected epenthesis of /g^w/. In Kotos we would expect /dʒ/ to be inserted after /e/ and would only expect /g^w/ to be inserted after /a/, /o/, or /u/. Whenever such an unexpected consonant epenthetic consonant occurs, it corresponds to the default epenthetic consonant (Section 5.2). While it is important to note that such instances do occur, we do not discuss them further in this chapter as they are a minor pattern in the language.

3.2 Epenthesis, not deletion

An alternative analysis of the data presented in the previous section would be to propose that the consonants which appear before vowel-initial enclitics are part of the stem or enclitic, and are deleted in certain contexts. They could be analysed as the initial segment of the enclitic, or they could be analysed as the final segment of the stem. There is evidence against both analyses.

Firstly, the consonants which occur before vowel-initial enclitics are completely predictable based on the final vowel of the clitic host. In cases of synchronic deletion, on the other hand, the quality of the deleted consonants are typically not phonologically predictable (Harris 2011).

Secondly, if these consonants are actually the initial segment of the enclitic, their absence after stems with final /Ca/ is inexplicable. Other consonant-initial enclitics freely occur with /Ca/-final stems. Two examples are Kotos *n-ana* '3-get' + *=kau* '1SG.ACC' ⟶ *naankau* 'got me' and Roi'is *ku-snasa* '1SG-rest' + *=heen* 'PERF' ⟶ *kusnaasheen* 'I had rested'. There are also no restrictions on clusters involving epenthetic consonants, as shown by forms such as Kotos *faafdʒees* 'a pig' or *neeng^{w}ees* 'a day' (among many others in Table 5). There are also roots with initial clusters which involve the segments which arise in epenthesis. Examples include Amfo'an *nguah* [nguah] ~ [ŋguah] ‘coconut’ and Roi'is *bdʒae* [βʒaɛ] ‘cow’.

Thirdly, if these consonants were the final segment of the stem, this would entail that they are deleted in all environments except before a vowel-initial enclitic. This consonant deletion would occur in a disparate collection of environments with no clear phonological or phonetic motivation. It would also be different to other consonant-final words, such as *tuaf* ‘person’, for which such deletion does not occur.

Furthermore, Mooney (2021) points out that plural enclitic allomorphy also supports the analysis of stems after which consonant epenthesis occurs as vowel-final. This is because the plural enclitic has different forms after vowel-final and consonant-final stems. Stems after which consonant epenthesis occurs do not take the allomorphs found with consonant-final stems.

After consonant-final stems, the plural enclitic has a vowel-initial form. Kotos has *=ein/=eni*, Amanuban has *=eun/=enu*, and Amfo'an has *=een*. Examples are given in the first four rows of Table 7.[7] However, after vowel-final words the

[7]The plural enclitic after consonant-final stems in Roi'is and Baikeno is *=iin/=ini*. Timaus has variation between *=iin/=ini* and *=een* for the plural enclitic after consonant final stems. Kotos also has sporadic instances of *=enu/=uun* after consonant-final roots.

Table 7: Plural enclitic allomorphy

Stem	Kotos	Amanuban	Amfo'an	Translation
a-pao-t	*apaot=ein*	*apaot=eun*	*apaot=een*	‘guards’
kuan	*kuan=ein*	*kuan=eun*	*kuan=een*	‘villages’
tuaf	*tuaf=ein*	*tuaf=eun*	*tuaf=een*	‘people’
too mfaun	*too mfaun=ein*	*too mfaun=eun*	*too mfaun=een*	‘many people’
koro/kolo	*koro=n*	*kolo=n*	*kolo=n*	‘birds’
umi/ume	*umi=n*	*ume=n*	*ume=n*	‘houses’
fafi	*fafi=n*	*fafi=n*	*fafi=n*	‘pigs’
aan feto	*aan feto=n*	*aan feto=n*	*aan feto=n*	‘daughters’
hau	*hau=ŋgʷein*	*hau=nuu*	*hau=nuug*	‘trees’
too	*too=ŋgʷein*	*too=nuu*	*too=nuug*	‘citizens’
bifee	*bifee=ŋgʷein*	*bifee=nuu*	*bifee=nuug*	‘women’
oe	*oe=ŋgʷein*	*oe=nuu*	*oe=nuug*	‘kinds of water’

plural enclitic has a different form, depending on the exact shape of the stem to which it attaches. After CV-final stems, the plural enclitic is *=n* in all known varieties of Meto. Examples are given in the middle four rows in Table 7. After stems which end in a vowel sequence (VV-final stems) there is a diversity of forms: Kotos has *=ngʷein/=ngʷeni* [ŋgwɪn]/[ŋgwɪni], Amanuban has *=nuu*, and Amfo'an has *=nuug*.[8] Examples are given in the final four rows of Table 7.

If the medial consonant in forms such as Kotos or Amfo'an *haugʷees*, or Amanuban *hauwees* 'a tree' were underlyingly part of the host, we would expect the plural enclitic to take the forms found with consonant-final stems: Kotos **haugʷ=ein*, Amanuban **hauweun*, and Amfo'an **haugʷeen* 'trees'. That these forms do not occur is evidence that the stems are underlyingly vowel-final roots.

3.3 Productivity

Consonant epenthesis in Meto is highly productive and applies to all eligible words. Vowel-final loans, as well as instances of code-switching, trigger consonant epenthesis. Examples of such loans/code switches that have entered Kotos Amarasi via Malay are given in Table 8 to illustrate.

Table 8: Consonant epenthesis with loans/code switching

Malay		Kotos		Output	Translation
R.T.†	[erte]	*erte**i***	+ *=ii*	*ertee**dʒ**ii*	'the R.T. (neighbourhood)'
H.P.†	[hape]	*hape**i***	+ *=ii*	*hapee**dʒ**ii*	'the H.P. (mobile phone)'
T.V.	[tivi]	*tif**i***	+ *=ii*	*tiif**dʒ**ii*	'the TV'
lemari	[ləmari]	*ləmar**i***	+ *=ii*	*ləmaar**dʒ**ii*	'the wardrobe'
peti	[peti]	*pet**i***	+ *=ii*	*peet**dʒ**ii*	'the casket'
sore	[sore]	*sor**e***	+ *=ii*	*soor**dʒ**ii*	'the afternoon'
penatua	[pənatua]	*pentu**a***	+ *=ii*	*pentua**gʷ**ii*	'the church elder'
K.K.†	[kaka]	*kaaka**a***	+ *=esa*	*kaakaa**gʷ**esa*	'one K.K. (family head)'
oto	[oto]	*ot**o***	+ *=ii*	*oot**gʷ**ii*	'the car'
rokok	[rokoʔ]	*rok**o***	+ *=ii*	*rook**gʷ**ii*	'the cigarette'
ibu	[ibu]	*ib**u***	+ *=ii*	*iib**gʷ**ii*	'the mother'
sapatu	[sapatu]	*sapat**u***	+ *=ii*	*sapaat**gʷ**ii*	'the shoes'

† R.T. = *rukun tetangga*, H.P. = *hand phone*, K.K. = *kepala keluarga*

[8] Baikeno appears to have *=mbiin/=mbini* after VV-final forms, though the Baikeno form requires confirmation. The form of the plural enclitic in Buraen Roi'is and Timaus after VV-final forms is currently unknown due to lack of data. Kotos has sporadic instances of *=nuu* after VV-final roots (Edwards 2020: 234–244).

While some of these examples (e.g. *oto* 'car') are probably loans that have been integrated into the language, others, such as *ləmari* 'wardrobe' (with unassimilated /l/ and /ə/),[9] are foreign insertions or instances of code-switching. Such data shows that consonant epenthesis in Meto is fully productive and is not morphologically or lexically restricted to a subset of the lexicon.

3.4 Consonant insertion in other environments

Apart from the epenthesis which is the focus of this chapter and was described above, other consonant insertion processes are attested in Meto. The first is a process of glottal stop epenthesis, which occurs in two environments, and the second is a process of word-final consonant insertion.

3.4.1 Glottal stop epenthesis

Glottal stop epenthesis occurs when a CV- syllable is prefixed to vowel-initial stems. This process is most clearly exemplified by verb roots which take consonantal C- agreement prefixes when intransitive and syllabic CV- prefixes when transitive. Examples from Amfo'an are given in Table 9, with the third person agreement prefixes *n-* or *na-*. This epenthesis occurs occurs at an affix boundary in the environment /CV-_V to resolve hiatus between a prefix and a root.

Table 9: Glottal stop epenthesis: Amfo'an

	Intransitive	Transitive	Translation
'rise, get up'	*n-fena*	*na-fena-b*	'raise, get someone up'
'closed, blocked'	*n-ʔekaʔ*	*na-ʔekaʔ*	'close, block'
'go up, ascend'	*n-sae*	*na-sae-b*	'put up, lift up'
'drink'	*n-inu*	***na-ʔinu-t***	'give a drink to someone'
'see'	*n-ita*	***na-ʔita-b***	'show, make see'
'see, observe'	*n-aila*	***na-ʔaila-b***	'cause to face towards'
'lift'	*n-aiti*	***na-ʔaiti***	'make lift, raise'
'run, flee'	*n-aena*	***na-ʔaena-b***	'make flee'

In Meto, all vowel-initial words undergo word-initial glottal stop epenthesis. e.g. Amfo'an /iko-n/ [ˈʔikɔn] 'tail' and /asug/ [ˈʔasug] 'dog'. That is, there are no

[9] The foreign segments /l/ and /ə/ would be assimilated in Kotos as /r/ and /a/ respectively, as seen in examples such as Malay /bətul/ ⟶ Kotos *batuur* 'truly' among many others.

phonetically vowel-initial words.[10] However, some roots have underlying glottal stops which occur in all environments, including after consonantal prefixes. Examples from Amfo'an include *n-ʔekaʔ* ‘close’ (from Table 9), *n-ʔelah* ‘remain quiet’, and *n-ʔonen* ‘pray’ among many others.

We distinguish between underlying and automatic word-initial glottal stops. However, for roots which never take a C- prefix the evidence is ambiguous between whether their initial glottal stop is epenthetic or underlying. The evidence for automatic word-initial glottal stops is discussed at more length in Edwards (2017).

There are two main pieces of evidence that some forms have an epenthetic initial glottal stop. Firstly, words with an initial consonant cluster optionally have prosthesis of [a] word-initially in some cases and a glottal stop also occurs before this prosthetic vowel; e.g. Amfo'an /bnaog/ ⟶ [ˈbnaɔg] ~ [ʔaˈbnaɔg] ‘ship’, /klulu-f/ ⟶ [ˈkluluf] ~ [ʔaˈkluluf] ‘finger, toe’.[11] That a glottal stop occurs before a prosthetic vowel shows that glottal stop epenthesis is productive word-initially. Secondly, many instances of an initial glottal stop are epenthetic from a comparative perspective; e.g. Proto-Malayo Polynesian *ikuR > /iko-n/ ⟶ [ˈʔikɔn] ‘tail’ and *asu > /asug/ ⟶ [ˈʔasug] ‘dog’.

To summarise, glottal stop epenthesis clearly occurs at affix boundaries in the environment /CV-_V and there is also evidence that it occurs word-initially.

3.4.2 Word-final consonant insertion

An additional kind of consonant insertion occurs in some varieties of Meto after a vowel-final word when it occurs as the last member of the noun phrase (NP). This includes cases when such words are the only member of the noun phrase, and thus also includes citation form.[12] This kind of consonant insertion is known to occur in Amfo'an, Timaus, Baikeno, Fatule'u, Kopas, and some varieties of Molo.[13] This process of NP-final consonant insertion involves the same consonants as those which occur before the vowel-initial enclitics.

The root, without any final consonant, occurs before attributive modifiers. Examples of nouns in citation form and before modifiers in Amfo'an are given in Table 10. See Culhane (2018) for further discussion of this process in Amfo'an.

[10] Given this, some other analysts (e.g. Steinhauer 1996, Mooney 2021) have analysed all word-initial glottal stops as underlying.

[11] In our transcriptions the prosthetic vowel is separated by a vertical line; e.g. *a|bnaog* ‘ship’ in Table 10.

[12] The citation form is the form given as a translation under elicitation and that selected by most native speakers as the headword in a dictionary.

[13] In Baikeno, Fatule'u and Molo this consonant insertion only occurs after VV-final words.

Table 10: Amfo'an attributive modification

Citation form		Modifier			Phrase	
*sisi**dʒ***	'meat'	*metoʔ*	'dry'	→	*sisi metoʔ*	'dried meat'
*atoni**dʒ***	'man'	*munif*	'young'	→	*atoni munif*	'young man'
*bidʒae**l***	'cow'	*fuidʒ*	'wild'	→	*bidʒae fuidʒ*	'wild cow'
*ume**l***	'house'	*bubuʔ*	'wild'	→	*ume bubuʔ*	'round house'
*a|bnao**g***	'ship'	*kolog*	'bird'	→	*bnao kolog*	'aeroplane'
*neno**g***	'day'	*a-hunu-t*	'first'	→	*neno ahunut*	'first day'
*asu**g***	'dog'	*anaʔ*	'small'	→	*asu anaʔ*	'puppy'
*kulu**g***	'teacher'	*feʔug*	'new'	→	*kulu feʔug*	'new teacher'

It is not possible to analyse this process of consonant insertion as the same process which is the focus of this chapter. This is because the two processes occur in different environments and affect different words. The NP-final consonant insertion is not phonologically predictable but is determined by the syntactic position of a given word and primarily affects nouns.[14] On the other hand, epenthesis before vowel-initial enclitics occurs in a specific phonological environment and affects all words regardless of word class. Additionally, epenthesis before vowel-initial enclitics takes place in varieties of Meto which do not have NP-final consonant insertion, such as Amanuban, Kotos, and Roi'is.

4 Typological and theoretical context

This section provides relevant typological and theoretical context for the Meto data outlined in Section 3. It provides an overview of how epenthesis has been defined in the literature, showing that Meto can be considered a legitimate case of epenthesis (Section 4.1). It then surveys attested epenthetic consonants (Section 4.2), demonstrating that the epenthetic consonants attested in Meto are of typological interest. It then surveys how consonant epenthesis patterns have been accounted for (Section 4.3, 4.4).

4.1 Defining epenthesis

Defining what exactly constitutes consonant epenthesis has been an topic of considerable discussion. Cases of "minimal" epenthesis – that is, considered to be

[14] Verbs with an unexpressed object can also have final consonant insertion (Culhane 2018: 39ff).

minimally disruptive of transitions between vowels – such as insertion of glides to resolve hiatus, or insertion of glottal stops at prosodic boundaries, are widely accepted to be epenthesis. There are various cases, however, where there has been considerable discussion as to whether a given pattern is actually epenthesis, such as "intrusive *r*" in various varieties of English (see Vaux & Samuels 2017 and Morley 2017 for overviews), /t/ insertion in Ajyíninka Apurucayali (Arawakan, Peru, see Lombardi 2002, de Lacy 2006, Staroverov 2015, Morley 2015), and /g/ insertion in Buriat (Mongolic, Russia/Mongolia/China, see Morley 2015, Vaux & Samuels 2017, Staroverov 2014, 2020).

Such discussions have arisen, in part, due to different restrictions on what is defined as epenthesis.[15] An overview of the criteria proposed in the literature is given in (2).

(2) Different criteria of epenthesis proposed in the literature:
   a. occurs in a phonological environment, not morphologically restricted (Lombardi 2002, de Lacy 2006, Morley 2015);
   b. is the only process in given phonological context (Lombardi 2002, de Lacy 2006),
   c. shows evidence of being synchronically active (Morley 2015);
   d. epenthetic segment is invariant (Lombardi 2002, de Lacy 2006, Morley 2015).

Requirement (2a) makes explicit that epenthesis must be a phonological process. This excludes cases of morphologically conditioned consonant insertion which have sometimes been included in the epenthesis literature. An example is /ɾ/ insertion in Anejom̃ (Austronesian, Vanuatu), which has often been included in discussions of epenthesis (e.g. Vaux & Samuels 2017), but is limited to compounds, see Staroverov (2014: 186).

Requirement (2b) refers to a requirement that no other process occurs in the context where epenthesis occurs. This excludes instances where consonant epenthesis is one of several attested hiatus resolution strategies. For instance in Rutooro (Atlantic-Congo, Uganda, Bickmore 2021), hiatus resolution is achieved by

[15] The likelihood that a given pattern is considered to be epenthesis also appears to be theoretically motivated. For example, there has been wide acceptance of /t/ insertion in Ajyíninka Apurucayali as a case of epenthesis (e.g. McCarthy 2002, de Lacy 2006), because a coronal consonant would be relatively unmarked under an Optimality Theory framework. Buriat /g/ insertion, on the other hand, has not been widely accepted as a legitimate case of epenthesis, and /g/ is a highly marked epenthetic consonant within an Optimality Theory framework. However, Morley (2008: 117) demonstrates that the evidence for either of these processes being legitimate cases of epenthesis is, in fact, comparable.

either consonant insertion, deletion, or diphthongisation. Which process occurs depends on the quality of the vowels. Consonant insertion in Rutooro would not be considered a legitimate case of epenthesis according to criterion (2b).

Requirement (2c) specifically excludes cases where a consonant process may have been productive in the past, but is no longer productive. An example is dorsal insertion in Buriat (Mongolic), which has sometimes been included in the epenthesis literature, but does not show evidence of being synchronically productive (Staroverov 2020). A requirement by Morley (2015) is to exclude patterns where less than 65% eligible morphemes participate, to ensure that the epenthesis pattern is robust.

Requirement (2d) excludes cases of assimilatory epenthesis in which the quality of the epenthetic segment varies according to the adjacent vowels (de Lacy 2006: 79). When this criteria has been proposed, this does not mean that cases of assimilatory epenthesis are excluded entirely from being considered cases of epenthesis. Instead, it is to limit discussions to cases of default epenthesis – the invariable insertion of one segment – which are of greater theoretical interest. Default and assimilatory epenthesis are discussed in detail in Section 4.3.

According to the different criteria in (2), consonant insertion in Meto is a legitimate case of epenthesis. It occurs in a phonological environment (hiatus at the boundary of two feet, criteria 2a) and is the only process attested to resolve hiatus in this environment (criterion 2b). It is synchronically productive (criterion 2c). In most cases, the quality of the inserted consonant is determined by the previous vowel, and thus does not fulfill criterion (2d). However, there are some instances in Meto which can be classified as default epenthesis. See Section 5 for detailed discussion of this matter.

4.2 Attested epenthetic consonants

The most common epenthetic consonants in hiatus position are glides (especially homorganic glides), laryngeal consonants, and, more rarely, rhotics /ɹ/, /r/ and coronal consonants such as /t/ (de Lacy 2006, Casali 2011). Of these, insertion of glides is by far the most widely attested (Picard 2003, Uffman 2007, Casali 2011).

Several of the epenthetic consonants attested in Meto, namely /dʒ/, /b/, and /gʷ/, have not been previously attested among accepted cases of epenthesis. These consonants have also not been reported for any cases where it is contested as to whether epenthesis is the best analysis, with the exception of possible insertion of /g/ in Buriat, in which case the process is highly disputed (see Section 4.1). Epenthesis of /l/, which is attested in Meto, has been reported for several varieties of English (e.g. Gick 2002, 1999, Kijak 2010). However, none of these instances have been shown to be robust patterns (Staroverov 2014: 7). Therefore, that Meto attests robust epenthesis of /l/ is also of typological interest.

4.3 Explaining the typology of epenthetic consonants

The common occurrence of certain consonants, such as glides, in epenthesis processes, and the non- or rare occurrence of others, has been accounted for by appealing to a number of factors.

Articulatory and perceptual factors, as well as phonetic "naturalness", have been used to explain the common occurrence of glides and laryngeal consonants epenthetically (Blevins 2008b). For example, epenthesis of /j/ after /i/ in hiatus can arise from gestural overlap. Similarly, from a perceptual perspective, insertion of /j/ between /i/ and another vowel could be explained in terms of /j/ not being particularly perceptually salient to hearers in this context, as it does not require significant articulatory changes in the transition from /i/ to the following vowel (Steriade 2009, Morley 2012).

There are also various theoretical accounts of attested epenthetic consonants, as well as predictions about possible epenthetic consonants. These accounts typically rely on a distinction between "default" and "non-default" or "assimilatory" epenthesis (e.g. de Lacy 2006, Morley 2012, de Lacy & Kingston 2013). In cases of default epenthesis, one segment is invariably inserted in a particular phonological environment. For example, many languages attest default epenthesis of /ʔ/ before vowel-initial words. Examples include Maltese (Mitterer et al. 2019), Czech (Šimáčková et al. 2012), and Meto (see Section 3.4). On the other hand, in cases of assimilatory epenthesis, the quality of the epenthetic segment varies and can be analysed as determined by the place and manner of articulation of the adjacent vowels (de Lacy 2006: 79). Typical examples include /j/ as the epenthetic consonant after front vowels and /w/ after back vowels. Examples of languages with this kind of epenthesis abound. Two examples are Woleaian (Austronesian, Federated States of Micronesia, Sohn 1975) and Cantonese (Tibeto-Burman, China, see Hashimoto 1972). Some languages demonstrate both default and assimilatory epenthesis, such as epenthesis of /j/ and /w/ next to high vowels, and epenthesis of /ʔ/ next to other vowels. Examples of languages which demonstrate this kind of epenthesis pattern include Kalinga (Austronesian, Philippines, see Geiser 1970) and Malay (Ahmad 2005). In some cases for Meto, the inserted segments vary depending on the quality of the vowel and can be considered as instances of assimilatory epenthesis (Section 5.1). In other cases, however, /j/, /b/ or /gʷ/ is the default inserted consonant (Section 5.2).

Default epenthesis has received considerable attention in the theoretical literature. This is because in an Optimality Theory framework the quality of default epenthetic consonants is expected to be determined by markedness (McCarthy & Prince 1994, Lombardi 2002, de Lacy 2006). “Markedness” in phonology typically refers to a preference for certain kinds of structures which are “unmarked” (higher frequency, less complex, less phonetically difficult) over others which are more “marked” (McCarthy 2002, de Lacy 2006).[16] In Optimality Theory, epenthesis is considered to be one of several kinds of “repairs” that phonological inputs can undergo to make them less marked. For example, consonant epenthesis results in syllables with onsets, which are considered to be less marked than onsetless syllables (de Lacy 2006). It is also expected that the quality of the epenthetic consonant which resolves hiatus is optimal with respect to markedness constraints, that is, minimally marked (Lombardi 2002, de Lacy 2006, Casali 2011). What exactly makes a consonant more or less marked is debated.[17] However, the general assumption is that inherent properties of synchronic phonology play a role in determining the quality of epenthetic consonants – in particular, that, all else being equal, the epenthetic consonant employed by a language will have the universally least marked place of articulation (Lombardi 2002, Blevins 2008a, Casali 2011). Various hierarchies of consonant place of articulation markedness have been proposed, (e.g. Kean 1975, Paradis & Prunet 1991, Lombardi 2002: 4, de Lacy 2006: 2). All rank labial and dorsal consonants as more marked than coronal and glottal. This predicts a universal preference for coronal and glottal consonants and avoidance of labial and dorsal consonants. Some have gone so far as to predict that labial and dorsal consonants are not possible epenthetic segments (e.g. de Lacy 2006: 82). However, labial and dorsal consonants /g^w/ and /b/ are attested default epenthetic segments in Meto (see Section 5.2).

Proposals about markedness and consonant epenthesis are not without controversy. Various linguists have questioned the claim that any particular place of articulation is universally unmarked (e.g. Hume 2003, Rice 2007, 2011). More broadly, Optimality Theory proposals about preferred epenthetic segments have been found not to be borne out cross-linguistically (Morley 2015, Vaux & Samuels 2017). There is also controversy regarding markedness as an explanation of phonological patterns. This is because there are examples of sound patterns

[16] Markedness is used in many other senses, see Haspelmath (2006), Bybee (2011) and Hume (2011). For an overview of the differences between the use of markedness in Optimality Theory in comparison to other contexts see McCarthy (2002: 15).

[17] Markedness has been defined, for example, on the basis of articulatory factors (Archangeli & Pulleyblank 1994), perceptual factors (Steriade 2009), and abstract factors such as implicational relationships (McCarthy 2002: 15).

contradicting markedness claims (see Hume 2005: 183 for examples). Moreover, sound patterns attributed to markedness can be accounted for by reference to phonetics, language use, language change (Bybee 2001, 2011, Blevins 2004) or frequency effects and predictability (Hume 2005).

Another way that consonant epenthesis patterns have been explained is by examining their diachronic sources. Blevins (2008a) proposes that "natural" or "minimal" consonant insertion processes, like intervocalic glide epenthesis, reflect the phonologisation of earlier phonetically conditioned sound change. On the other hand, "unnatural" patterns can be accounted for as the result of multiple changes, such as intervocalic glide epenthesis undergoing subsequent glide fortition, or reanalysis of a deleted consonant as being epenthetic (Blevins 2008a). We observe these same kinds of sound changes in Meto, which have resulted in the consonant insertion patterns attested. The diachronic approach has the potential to provide us with insights not offered by synchronic accounts (see Section 6).

4.4 Synchronic accounts of assimilatory epenthesis

In Meto, which consonant is inserted is usually determined by the quality of the previous vowel, and the process can therefore be considered assimilatory epenthesis. However, the inserted consonant is similar to the preceding vowel to differing extents. Insertion of /j/ after front vowels and /w/ after back vowels in Amanuban can be straightforwardly analysed as maximally similar to the surrounding vowels. Similarly, other inserted consonants (such as /l/ after /e/ in Amfo'an) can also be identified as sharing similar features (Culhane 2018: 51, Mooney 2021). However, what features are shared between the vowel and epenthetic consonants in other cases (such as insertion of /r/ after /i/ in Timaus) is unclear.

Cases of assimilatory epenthesis documented in the literature involve insertion of glides, [ʋ], [v], [ʝ] (Morley 2012: 72), and [ɣ] (de Lacy 2006: 80). In such cases, the quality of the inserted segments is typically explained in terms of sharing features with the surrounding vowels. For example, Staroverov (2014: 56) proposes that /ʋ/ after /oː/ in Dutch occurs because it is featurally similar to the vowel in terms backness and height (being non-high). Similarly, de Lacy (2006: 80) proposes that epenthesis of [ɣ] in Brahui (Dravidian, South Asia) after low back vowels is motivated by assimilation to the vowels in terms of dorsality, voice, and continuancy.

Cases of assimilatory epenthesis which involve segments other than glides have also been also accounted for in terms of allophony. For example, Staroverov

(2014: 78) accounts for insertion of [ʝ] and [v] in Kalaallisut (Eskimo-Aleut, Greenland) as a result of allophony. In Kalaallisut, [j, w] and [ʝ, v] are in complementary distribution. The glides [j, w] only appear after [i, u], while the fricatives [ʝ, v] occur in other environments. Under this analysis, the actual inserted consonant is /j/ or /w/ – which is most featurally similar to /i/ or /u/, but can be realised as [ʝ] or [v] in certain contexts.[18]

Aside from these examples, the synchronic analysis of assimilatory epenthesis has received considerably less attention than that of default epenthesis. One issue which has not been addressed is the extent to which a given inserted consonant needs to be similar to surrounding vowels in order be considered a case of assimilatory epenthesis; no cut-off point has been proposed.

Returning to the case of Meto, we could potentially propose a cut-off point for how similar to the conditioning vowels a epenthetic consonant needs to be in order to be considered assimilatory epenthesis. However, the different epenthetic consonants exist on a spectrum. Some patterns are highly assimilatory (e.g. Amanuban), while others are less assimilatory (e.g. Timaus). Proposing such a cut-off point would draw an arbitrary distinction between processes which otherwise demonstrate the same synchronic behaviour. As result, we do not draw a cut-off point in our discussion of how to analyse the Meto data synchronically (Section 5). We also demonstrate how this spectrum of more and less assimilatory consonants has arisen as the result of various diachronic changes (Section 6).

5 Synchronic accounts of Meto consonant epenthesis

In this section we briefly outline some of the ways in which Meto consonant epenthesis has been analysed from a synchronic perspective. There are two patterns of consonant epenthesis. Most epenthetic consonants are determined by the previous vowel and have been analysed as resulting of feature spreading (Section 5.1), while epenthesis after hosts with final /Va/ has not been analysed as determined by the final vowel of the host and instead involves default epenthetic consonants (Section 5.2).

5.1 Assimilatory epenthesis: Spreading analysis

In most cases in Meto, the quality of the inserted segment is determined by the preceding vowel, and can be considered a process of assimilatory epenthesis as

[18] For Meto, it is not possible to propose that [gʷ], [b] or [dʒ] are allophones of glides. This is because varieties of Meto with these obstruents do not have glides (Section 2).

defined in the literature (Section 4). Assimilatory epenthesis in Meto has been analysed within Autosegmental Phonology (Edwards 2020: 215–233), Optimality Theory (Mooney 2021), as well as a combination of both (Culhane 2018: 48–57). While these accounts differ in many details, they all draw on the notion that consonant epenthesis results, at least in part, from the place and/or manner features of a vowel spreading onto a consonant which does not have any pre-defined features. This follows other accounts of assimilatory epenthesis (de Lacy 2006, Staroverov 2014, see also Section 4.4) and is based on the assumption that the quality of the inserted consonant is determined by the features it shares with with a preceding vowel.

For example, under a spreading analysis, [+LABIAL] spreads after /o/ and /u/ in Baikeno and Buraen Roi'is to yield /b/. However, in other varieties, a spreading analysis would entail that both [+LABIAL] and [+VELAR] spread to yield /w/ (Amanuban) or /gʷ/ (Kotos, Amfo'an). While variations on the spreading analysis can be invoked, the reasons for why different features spread in different varieties is not fully explained.

The Timaus data, however, present a challenge for the spreading analysis. Epenthesis of /l/ after /e/ can be analysed by proposing that both are [+CORONAL, -HIGH] (Culhane 2018: 51) or [+CORONAL, -DORSAL] (Mooney 2021). Similarly, /gʷ/ and /o/ are both labio-velar, and thus the insertion of /gʷ/ after /o/ can be attributed to these features spreading. However, it is difficult to account for epenthesis of /r/ after /i/ as a result of feature spreading. It is especially difficult to identify features which could spread to result in epenthesis of /dʒ/ after /u/ – particularly given epenthesis of /gʷ/ after /o/.

5.2 Default epenthesis

Default epenthesis occurs after stems with final /Va/. The epenthetic consonants inserted after such stems are summarised in (3) below.

(3) Epenthesis after hosts with final /Va/:
   (a) epenthesis of /j/ /Va_=V (Amanuban);
   (b) epenthesis of /b/ /Va_=V (Baikeno);
   (c) epenthesis of /gʷ/ /Va_=V (Kotos, Amfo'an, Timaus).

The reason that the spreading analyses cannot be readily extended to cover such cases is because epenthesis does not occur after stems with final /Ca/. E.g. Kotos *nua* + *=een* ⟶ *nuagʷeen* with epenthesis contrasts with *n-ana* + *=ee* ⟶ *naanee* ‘gets it’ without epenthesis. If spreading (e.g. of [+LOW] and/or [+VOICE]) were at play after stems with final /a/, the lack of epenthesis after stems with final /Ca/ is unexplained. This indicates that epenthesis of these consonants after /Va/ is not conditioned by the previous vowel.

Recall from Section 4 that typically a binary distinction is made between two kinds of epenthesis: assimilatory and default. The former is typically defined as cases where surrounding vowels determine the quality of the epenthetic consonant. In the case of the latter, they do not. On this basis, epenthesis after /Va/ could be considered a case of default epenthesis.

This proposal – that there is default epenthesis of consonants at enclitic boundaries after certain vowels – gains some support from the variety of Kotos Amarasi spoken in Fo'asa' hamlet. In this variety of Meto, /g/ (not labio-velar /gʷ/) is inserted after all vowel-final hosts before an enclitic, except when the host ends in /Ca/, in which case epenthesis is optional. Examples are given in Table 11.

Table 11: Fo'asa' consonant epenthesis (Edwards 2020: 232)

Stem		Enclitic	Fo'asa'	Translation
umi	+	*=ee*	*uimgee*	'the house'
peti	+	*=ee*	*peitgee*	'the casket'
n-rari	+	*=ee*	*nrairgee*	'finishes it'
n-soʔi	+	*=ee*	*nsoiʔgee*	'counts it'
fee	+	*=ee*	*feegee*	'the wife'
n-moʔe	+	*=ee*	*nmoeʔgee*	'does it'
hau	+	*=ii*	*haugii*	'the tree'
neno	+	*=ees*	*neoŋgees*	'one day'
na-ʔura	+	*=een*	*naʔuureen ~ naʔuurgeen*	'has started raining'
n-sosa	+	*=ee*	*nsoosee ~ nsoosgee*	'buys it'

Mooney (2021) reports nearly identical data for Kotos Amarasi from the village Oekabiti and analyses it as spreading of [+voice] with epenthesis of the place and manner features, with the least marked place/manner being selected.[19] Whatever the exact analysis, the data presented in this section demonstrates that some kind of default epenthesis occurs at clitic boundaries.

Given the evidence for default epenthesis, an alternative synchronic analysis of the different epenthetic consonants might be to propose that the default

[19]See Mooney (2021) for details on how /g/ is determined to be the consonant with the least marked place and manner features.

consonant is inserted in all instances and changes according to the quality of the preceding vowel. This would be very similar to the analysis of Kalaallisut discussed in Section 4.4. Thus, for instance, we could propose that in Amfo'an /gʷ/ → [l] /e_ and /gʷ/ → [dʒ] /i_. While /gʷ/ → [dʒ] /i_ might be reasonable, /gʷ/ → [l] /e_ is questionable due to the lack of phonetic similarity between the two consonants. Furthermore, for Timaus, statements such as /gʷ/ → [r] /i_ or /gʷ/ → [dʒ] /u_ lack any clear phonetic motivation for the realisations proposed. This analysis also runs into problems for Baikeno, as [b] is attested after front vowels in all varieties of Meto. Examples from Baikeno include *na-ʔebok* 'ignore', *na-ʔnae-baʔ* 'make great', *bibi* 'goat', and *mi-baʔe* 'you (pl.) play'.

6 Diachronic account of Meto epenthesis

The main problem faced by synchronic accounts of consonant epenthesis in Meto is that they do not explain the diversity of consonants inserted in different varieties of Meto. Under the analyses that have been proposed, there is no clear motivation as to why certain features spread in some varieties but not others. A diachronic perspective allows us to gain a much more cohesive and unified explanation for the diversity of epenthetic consonants; the different consonants are the result of sound changes applying to different extents in each variety of Meto.

In this section we outline how the different consonant epenthesis processes in Meto have developed from a diachronic perspective. Most of this section is focused on cases where the quality of the epenthetic consonant is determined by the final vowel of the clitic host. The development of default epenthesis is discussed in Section 6.5. All Proto-Malayo-Polynesian (PMP) reconstructions found in this section are from Blust & Trussel (2020) and all Proto-Rote-Meto (PRM) reconstructions are from Edwards (2021).

The series of sound changes that have occurred after front and back vowels are summarised in (4) and (5) respectively below. Each variety of Meto discussed in this chapter has carried out each series of sound changes in (4) and (5) to different extents.

(4) /V[+FRONT]_=V $\quad \emptyset > j > dʒ > \begin{cases} r \\ (\text{*r} >)\ l\ \text{/e\_ (or direct *j} > l) \end{cases}$

(5) /V[+BACK]_=V $\quad \emptyset > w > g^w > \begin{cases} b \\ \text{*g} > dʒ\ \text{/u\_} \end{cases}$

6.1 Glide insertion

The first change is glide insertion, whereby a process of phonetic insertion of [j] and [w] to resolve hiatus underwent phonologisation. This kind of phonologisation of a glide insertion process is widely attested cross-linguistically (see Blevins 2008a: 4-6). This change alone yielded the epenthesis seen in Amanuban. Phonetic insertion of glides is also attested word-medially after high vowels, but does not usually occur after mid vowels. Two examples from Amanuban are *ue* → [ˈʔuwɛ] ~ [ˈʔʊɛ] 'rattan', and *bia* → [ˈbija] ~ [ˈbia] 'cow'.

6.2 Glide fortition

The next stage in the development of consonant epenthesis is glide fortition, given in (6) below. These changes affect all varieties of Meto examined in this chapter except Amanuban.

(6) Glide fortition:

  a. *j > *dʒ*

  b. *w > *g*^{w}

Glide fortition also occurs word-medially to different extents in many varieties of Meto. Examples from Kotos, Amfo'an, and Baikeno are given in Table 12 alongside Amanuban cognates which usually retain a glide, as well as available PMP and PRM reconstructions which show that these glides were originally automatic transition glides.

Table 12: Word-medial glide fortition

PMP	*duha	*ia	*laqia	—	*kahiw+*qaRuhu
PRM	*dua	*ia	*laia	—	*kaiou
Amanuban	*nuaʔ*	*ia, ii*	*nai**j**eeʔ*	*bia, bie*	*ʔa**i**oo, ʔa**j**oo*
Kotos	*nua*	*ia, i**dʒ**a*	*nai**dʒ**eer*	*bi**dʒ**ae*	*ʔai**dʒ**oʔo*
Amfo'an	*nu**g**a*	*i**dʒ**a, i**dʒ**e*	*nai**dʒ**ee-l*	*bi**dʒ**ae-l*	*ʔai**dʒ**ao-g*
Baikeno	*nu**b**an*	*i**dʒ**e*		*bi**dʒ**ae-l*	
gloss	'two'	'here'	'ginger'	'cow'	'casuarina'

Glide fortition is a fairly well-attested change cross-linguistically and many examples similar to that posited for Meto occur in other Austronesian languages. Examples include Chamorro (Blust 2000: 87), many languages of the Aru Islands

(Collins 1982: 127–133, Blust 2014: 55, Nivens 2017), several languages of Borneo (Smith 2017: 73–76, Blevins 2025 [this volume], Blust 2025 [this volume]) as well as a number of Oceanic languages (Ross 1988: 137, 169, 321).

Epenthesis of /b/ in Baikeno and Buraen Roi'is could be due to direct fortition of *w > *b*, or it could be from intermediate *gʷ. The change *gʷ > *b* is fairly well attested. It has occurred in Borneo (Blust 2013: 612–613), Proto-Celtic (Matasović 2009: 9), and most varieties of Greek before non-front vowels (Sihler 1995: 156).

Evidence that *w > *gʷ > *b* occurred in Buraen Roi'is comes from the fact that varieties of Meto surrounding Buraen (Kotos and other varieties of Roi'is) have /gʷ/. It thus seems unlikely that Buraen Roi'is would have undergone *w > *b* independent of *w > *gʷ* in neighbouring varieties of Meto. Instead, it is more likely that all these varieties of Meto underwent *w > *gʷ*, with subsequent *gʷ > *b* in Buraen Roi'is.

In addition to Buraen Roi'is, a number of other varieties of Meto have epenthesis of /b/. Those varieties include Baikeno (discussed in this chapter, Section 3.1), Miomafo (Steinhauer 1996: 483), Molo (Mooney 2021), Biboki (based on the texts in Neonbasu 2005), Fatule'u, and the Nai'benu variety of Amfo'an (unpublished fieldnotes by the authors).[20] Given the evidence for *w > *gʷ > *b* in Roi'is Amarasi, we tentatively suggest that all varieties of Meto with epenthesis of /b/ have also undergone the change *w > *gʷ > *b*.

6.3 Epenthesis of /l/ after /e/

Baikeno, Amfo'an, and Timaus all have epenthesis of /l/ after /e/-final words. There are a number of ways in which epenthesis after /e/ behaves differently from epenthesis of other consonants.

Firstly, in those varieties of Meto where vowel assimilation usually accompanies consonant epenthesis, vowel assimilation does not accompany epenthesis of /l/. For example, Timaus *ai* + *=ees* ⟶ *aarees* ‘a fire’ with assimilation can be compared with *oe* + *=ees* ⟶ *oelees* ‘a (body of) water’ without assimilation.

Secondly, /e/ is the only vowel after which different consonants are (currently known) to be inserted in a single variety of Meto. In Baikeno, /Ve/-final words trigger epenthesis of /l/, but /Ce/-final words trigger epenthesis of /dʒ/. There is also at least one word in our Baikeno data for which epenthesis of /l/ or /dʒ/ occurs: *bale* + *=ess* ⟶ *baallees* ~ *baaldʒees* ‘a place’. Similarly, /l/ or /dʒ/ are inserted after /e/ in the variety of Molo described by Mooney (2021).[21]

[20] Nai'benu originates from Ambenu where Baikeno is spoken.

[21] Mooney (2021) states that /dʒ/ is inserted after words with final /le/ and that /l/ is inserted after

Given that /dʒ/ is from *j (Section 6.2) and that Baikeno and Molo have both /dʒ/ and /l/ after /e/, it is simpler to propose that /l/ is also ultimately from *j than from some other source. If /l/ did not develop from *j, we would be forced to posit that ∅ > *j did not occur after some cases of /e/ in Baikeno and Molo, but did occur after other cases of /e/. This seems highly unlikely. Instead, it is simpler to posit that ∅ > *j /V[+front]_=V was a universal change with this *j then undergoing subsequent changes.

There are at least two ways in which *j could have developed into /l/. Firstly, it could be due to a direct change of *j > *l*. This is an unusual sound change and *l > *j* would be more expected. Nonetheless, *j > *l* is attested in a small number of Austronesian languages. Examples include Uruangnirin [urn] and Kowiai [kwh] of western Papua, as well as some Oceanic languages (Ross 1988: 200, 204). Because *j > *l* is an unusual sound change, and because the data attesting this sound change are not widely available, we exemplify it below. Examples of *j > *l* in Uruangnirin and Kowiai are given in Table 13, alongside cognates in nearby languages which retain *j unchanged.[22]

Table 13: *j > *l* in Uruangnirin and Kowiai

gloss PMP	'crocodile' *buqaya	'I, 1sg' *i-aku	'dog' *asu†	'fire' *hapuy	'liver' *qatay	'calcium' *qapuR
Fordata	*bwea*	*jaʔa*	*jaha*	*jafu*	*jata-n*	*jafur*
Onin	*puaja*	*jai*		*jafi*	*jata-n*	*lofin*
Sekar	*biawa*	*jai*	*jasi*	*jafi*	*jata-n*	*jafer*
Uruangnirin	*puala*	*lau*	*lasi*	*lafi*	*lata-n*	*lafur*
Kowiai		*la(u)*		*laɸ*	*lata*	*laɸor*

† Reflexes of *asu, *hapuy, *qatay, and *qapuR have a prosthetic/epenthetic glide added to historically vowel-initial words. This epenthesis happened after *q/*h > ∅.

Examples of *j > *l* in Oceanic languages are most clearly exemplified by Proto-Oceanic *puqaya > Mekeo *uala* 'crocodile', *maya > Mekeo *mala* 'tongue', and *iau > **yau > East Mekeo *lau* '1sg' (Jones 1998: 563–566).[23]

other words with final /e/. Only three examples are given, making it hard to judge how regular a pattern this may be. These examples are: *a|ʔnoʔe + =ee ⟶ a|ʔnooʔlee* 'the lontar palm', *a-toof lele + =ee ⟶ atoof leeldʒee* 'the farmer', and *bale + =ee baaldʒee* 'the place'.

[22] Uruangnirin data come from Visser (2019), Sekar and Onin data from Donohue (2010), Fordata data from Drabbe (1932), and Kowiai data from Walker & Walker (1991).

[23] Here we use double asterisk ** to refer to intermediary forms.

Apart from Austronesian languages, similar *j > l^j occurred in Slavic after labial consonants (Shevelov 1964, Carlton 1990, Wandl & Kavitskaya 2022 Kavitskaya & Wandl 2025 [this volume]). In Eastern Latvian dialects, *j > l^j has occurred in more environments (Endzelīns 1923: 110, 607–609).

Secondly, epenthesis of /l/ could be due to *j > *dʒ > *l*. Given that all varieties of Meto with epenthesis of /l/ have undergone *r > *l* (Edwards 2021: 66), this may have been *dʒ > *r > *l*. This sound change already occurred once in the history of Meto, affecting PMP *z which is taken to have been a palatal affricate [dʒ] (Blust 2013: 554, 577). Examples of PMP *z > Meto *r* > *l* are given in Table 14 to illustrate. Note, however, that this change went through intermediate Proto-Rote-Meto *ɗ and it might thus be challenged whether this is truly a case of *dʒ > *r* > *l*.

Table 14: PMP *z [dʒ] > *r* > *l*

Gloss	‘way’	‘far’	‘rain’	‘ladder’	‘handspan’	‘point’
Phonetic	[**dʒ**alan]	[**dʒ**auq]	[qu**dʒ**an]	[harə**dʒ**an]	[**dʒ**aŋkal]	[tu**dʒ**uq]
PMP	*zalan	*zauq	*quzan	*haRəzan	*zaŋkal	*tuzuq
PRM	*ɗalan	*ka-ɗoo	*uɗan	*eɗa	*ɗaŋga	*tuɗu
Kotos	*ranan*	*ʔroo*	*uran*	*eraʔ/k*	*raka-t*	*n-ruru*
Roi'is	*ranan*	*roo*	*urun*	*eraʔ*		*n-ruru*
Amanuban	*lanan*	*ʔloo*	*ulan*	*elaʔ/k*	*laka-t*	*a|n-lulu*
Baikeno	*lalan*	*ʔloo*	*ulan*	*elaʔ*		*n-lulu*
Amfo'an	*lalan*	*a|ʔloo-g*	*ulan*	*elak*	*laka-t*	*a|n-lulu*
Timaus	*lalan*	*a|ʔloo-*g^w	*ulun*			

Additional examples of *dʒ > *r* and *dʒ > *l* in Meto can be found in Malay loans, as [dʒ] is assimilated as /r/ or /l/ according to the liquid each variety of Meto has. Examples include Malay *baju* [badʒu] ‘shirt’ > Kotos *baru*, Amfo'an *soobalu-g*, as well as Malay *jadi* ‘be, become’ > Kotos and Roi'is *n-rari*, Amanuban *a|n-lali*.

Whatever the exact change(s) that led to epenthesis of /l/, we need to specify that they only occurred after /e/. This can be accounted for as a case of assimilation, as /e/ shares more similar features with /l/ than it does with /j/ ~ /dʒ/. The segments /e/ and /l/ can be viewed as both [+coronal] and [-high], as opposed to /j/~/dʒ/ which are [+high] (Culhane 2018: 51), or /e/ and /l/ can be viewed as [+coronal] as opposed to [+dorsal] /i/ and /j/~/dʒ/ (Mooney 2021).

Furthermore, we need to specify that the changes that led to /l/ in Baikeno only occurred after words with a final vowel sequence, and not after CV-final word; e.g. *oe* + *=ees* ⟶ *oelees* ‘one (body of) water’ and *bifee* + *=ees* ⟶ *bifeelees* ‘one woman’, as opposed to *mone* + *=ees* ⟶ *moondʒees* ‘a husband’ and *ume* +

=ees ⟶ ***uumdʒees*** ‘a house’. The lack of *j/*dʒ > *l* after CV-final words in Baikeno can be explained by the fact that CV-final words also undergo metathesis before vowel-initial enclitics. If this metathesis developed before *j/*dʒ > *l* /e_ then *j/*dʒ in forms like *uumdʒees* would not have been in the correct conditioning environment for this change.

Amfo'an and Timaus, where /l/ is always epenthesised after /e/-final words, do not have obligatory metathesis before vowel-initial enclitics. As a result, in these varieties of Meto *j/*dʒ > *l* /e_ was still eligible to occur as the consonant was in the appropriate conditioning environment.

6.4 Timaus developments

Timaus has undergone two additional changes which have led to its synchronic system of consonant epenthesis. According to their own accounts, speakers of Timaus trace their origin to Amfo'an, specifically to Timau mountain which is located in the Amfo'an area. Given this, it is likely that Timaus developed from a system like that in Amfo'an where /dʒ/ is inserted after /i/-final words, /l/ after /e/-final words, and /gʷ/ after /o/ and /u/-final words.

The two changes Timaus has undergone which have altered this Amfo'an system are *dʒ > *r* and *gʷ > *dʒ* /u.

6.4.1 Timaus *dʒ > *r*

The sound change *dʒ > *r* does not require much discussion. It is not an unusual sound change. Examples of *dʒ > *r* in Meto have already been given in Section 6.3 above. Another case of *dʒ > *r* in Austronesian languages comes from Northwest Solomonic (Ross 1988: 221). The change *dʒ > *r* has also occurred word-medially in Timaus, as the examples in Table 15 show. In these cases Timaus /r/ is ultimately derived from the glide *j, still attested in the Amanuban cognates.

Table 15: Timaus medial *dʒ > *r*

PMP	*kahiw+*qaRuhu	*laqia	*bayawak		
PRM	*kaiou	*laia	*ɓaiafa		
Amanuban	*ʔaioo, ʔa**j**oo*	*nai**j**eeʔ*	*ba**j**afaʔ*	*bia ~ bie*	
Kotos	*ʔai**dʒ**oʔo*	*nai**dʒ**eer*		*bi**dʒ**ae*	*tai**dʒ**onif*
Timaus	*ʔa**r**oo-gʷ*	*na**r**ee-l*	*ba**r**afa, bai**r**afa*	*bi**r**ae-l*	*tai**r**onif*
translation	‘casuarina’	‘ginger’	‘monitor lizard’	‘cow’	‘jackfruit’

Additional support for positing *dʒ > *r* in Timaus comes from the fact that there is a certain degree of variation between /dʒ/ and /r/ in this variety of Meto in environments where /r/ is expected. There is no variation between /dʒ/ and /r/ in environments where /dʒ/ is expected. For example, in environments where /r/ is expected, one speaker in our Timaus corpus has six instances of /dʒ/ and 11 instances of /r/. The word for 'cow' also shows variation between *bidʒael* and *birael* for this speaker, even in a single text. While most speakers have completed the *dʒ > *r* sound change, this speaker probably reflects an older state of the language before the sound change was complete.[24]

6.4.2 Timaus *g^{w} > *dʒ* /u

The second change that Timaus has undergone is *g^{w} > *dʒ* before or after *u. This is a case of dissimilation. Similar dissimilation (though not as extreme) is seen in other varieties of Meto which have *g^{w} > *g* in certain environments.

Most varieties of Meto have an unrounded allophone of /g^{w}/ before round vowels. Recall from Section 2 that /g^{w}/ is phonetically realised as [ɡw] ~ [ɣw] (a sequence of a voiced velar plosive/fricative followed by a labio-velar glide) or as [ɡ] ~ [ɣ] without a labio-velar glide. The distribution of these allophones of /g^{w}/ is stated in (7) below. This can be understood as dissimilation of the labial place feature of the consonant before a rounded vowel.

(7) Realisation of /g^{w}/:
   a. /g^{w}/ ⟶ [ɡ]~[ɣ] /_V[+ROUND]
   b. /g^{w}/ ⟶ [ɡw]~[ɣw] elsewhere

For example, while Kotos and Amfo'an have epenthesis of / g^{w}/ before vowel-initial enclitics, before the reflexive enclitic *=oo-* /g^{w}/ is realised as unrounded [ɡ]. Two examples from Kotos include *na-kneʔo* 'twists' + *=oo-n* 'REFL-3SG.GEN' ⟶ /naknee**ʔg^{w}**oon/ ⟶ [nakˈnɛːʔ**ɡ**ɔn] and *na-tinu* 'worries' + *=oo-n* ⟶ /natiin**g^{w}**oon/ ⟶ [naˈt̪iːŋ**ɡ**ɔn] (Edwards 2020: 102).

Many varieties of Meto also have word-final *g^{w} > *g* (or /g^{w}/ ⟶ [ɡ]). Recall from Section 3.4 that Amfo'an has a process of NP-final consonant insertion whereby a voiced velar obstruent is inserted after back vowels. In the variety of Amfo'an spoken in Soliu village, the consonant inserted in this context is usually labio-velar [ɡw], while in the variety of Amfo'an spoken in Lelogama (where

[24] The speaker with variation between /dʒ/ ~ /r/ is one of the oldest Timaus speakers recorded. He estimated that he was born shortly after 1936, putting his age at around 80 when recorded in 2017.

most of our data comes from), the consonant inserted is plain velar [g]. Given that Lelogama Amfo'an has labio-velar [gw] before most vowel-initial enclitics, this can be understood as another environment in which labial dissimilation occurs, in this case /gʷ/ ⟶ [g] /V[+ROUND]_#. We posit that Timaus has taken this dissimilation one step further, with dissimilation of the velar place feature in addition to the labial place feature. Examples of word-final consonant insertion in Soliu Amfo'an, Lelogama Amfo'an, and Timaus are given in Table 16.

Table 16: NP-final consonant insertion /V[+BACK]_

		Amfo'an			
PMP	PRM	Soliu	Lelogama	Timaus	Translation
*kutu	*kutu	*hutugʷ*	*hutug*	*hutidʒ*	‘head-louse’
*asu	*asu	*asugʷ*	*asug*	*asidʒ*	‘dog’
*təbuh	*tefu	*tefugʷ*	*tefug*	*tefidʒ*	‘sugar cane’
*batu	*batu	*fatugʷ*	*fatug*	*fatidʒ*	‘stone’
*baqəRu	*beu-k	*feʔugʷ*	*feʔug*	*feʔidʒ*	‘new’
*qaləjaw	*ledo	*nenogʷ*	*nenog*	*nenugʷ*	‘sky; day’
	*lifu	*nefogʷ*	*nefog*	*nefugʷ*	‘lake’
*zauq	*ka-ɗoo	*ʔloogʷ*	*ʔloog*	*ʔloogʷ*	‘far’

As can be seen from the data in Table 16, Timaus does *not* have dissimilation of *gʷ > *dʒ* after historic *o. Timaus also attests vowel shifts in word-final position: *o > *u* /gʷ and *u > *i* /dʒ. Given this last change, it is tempting to posit that *u > *i* occurred first, with subsequent *gʷ > *dʒ* as a case of assimilation. However, final *u > *i* does not occur in NP-medial position nor before consonants other than /dʒ/. An example of retention of *u = *u* in each environment is *la**ku** lolar* ‘sweet potato’ and an example before a consonant other than /dʒ/ is *ma-fat**u**-ʔ* ‘stony’. Instead, Timaus has undergone a process of consonant dissimilation, followed by processes of vowel assimilation, as laid out in (8).

(8) Timaus NP-final changes:

   a. *gʷ > *dʒ* /u

   b. *u > *i* /dʒ

   c. *o > *u* /gʷ

Timaus has also undergone a change of *g > *dʒ* word-medially. In some varieties of Amfo'an there is a process whereby /gʷ/ [g] is optionally inserted before the vowel sequence /ua/. Timaus has optional insertion of /dʒ/ in the same environment, with subsequent *u > *i*.[25] Examples are given in Table 17, in which the Timaus forms have almost certainly developed from forms with earlier *g, as still attested in Amfo'an. Additionally, before the vowel sequence *oa, Timaus has optional insertion of /g/, though there is currently only one example in our data: *noah* ~ *ŋguah* 'coconut'.

Table 17: Timaus medial *g > *dʒ*

PMP	*buaq		*duha	*buaq	*uRat
PRM	*bua-k	*ɓua	*dua	*mbuah	*uat
Kotos	*fua-f*	*na-bua*	*nua*	*puah*	*ua-f*
Amfo'an	*a|fguaʔ*	*na-bgua*	*a|ngua*	*a|pguah*	*a|guaʔ*
Timaus	*fdʒia-f*	*na-bdʒia*	*ndʒia*	*pdʒiah*	*dʒia-f*
translation	'fruit'	'gather'	'two'	'betel nut'	'fortune, palm lines'

While the precise mechanism behind consonant insertion in the environments /ua/ and /oa/ remains to be worked out, this data shows that the Timaus changes in (8) are not restricted to clitic boundaries.

6.5 Development of default epenthesis

The final aspect of consonant epenthesis in Meto which needs to be accounted for is epenthesis after stems with final /Va/, as stated in (3) above and repeated as (9) below. (Data from Buraen Roi'is is currently lacking.)

(9) Epenthesis after hosts with final /Va/:
   a. epenthesis of /j/ /Va_=V (Amanuban);
   b. epenthesis of /b/ /Va_=V (Baikeno);
   c. epenthesis of /gʷ/ /Va_=V (Kotos, Amfo'an, Timaus).

[25] It is worth noting that the processes of consonant insertion illustrated in Table 17 are optional and there is variation between speakers and villages as to whether or not such insertion occurs. A single speaker can also have variation for some words.

While epenthesis of /b/ in Baikeno can be accounted for partly as a result of $^*g^w$ > *b* (Section 6.2), the best explanation that we can offer for epenthesis of /g^w/ or /j/ after stems with final /Va/ is to suggest it arose by analogy with epenthesis after other VV-final stems. In Amanuban, this would be analogy with insertion of /j/ after /Vi/ and /Ve/ (e.g. *oe* + *=ees* ⟶ *oejees* 'a water'), while in other varieties it would be analogy with insertion of /g^w/ after /Vo/ and /Vu/ (e.g. Amfo'an *meo* + *=ees* ⟶ *meo*g^w*ees* 'a cat').

Unlike epenthesis after other vowels, default epenthesis probably did not arise from an Amanuban-like stage in all varieties of Meto. If they *had* developed from such a stage, we would probably expect epenthesis of /dʒ/ in varieties other than Amanuban as a result of *j > *dʒ*, or we would expect epenthesis of /w/ in Amanuban as the precursor to /g^w/.

Similarly, epenthesis of /g/ after all vowels in Fo'asa' Kotos (Section 5.2) seems to be due to analogy with epenthesis of this segment elsewhere. That is, epenthesis of /g/ in Fo'asa' has expanded from occurring only after /o/, /u/, and /Va/ to occurring after all stems.

This explanation is quite unsatisfying. The only consolation we can offer at this stage is that there remain many varieties of Meto for which no data on consonant epenthesis has yet been collected. It may be that one of these varieties of Meto holds the key to understanding epenthesis after stems with final /Va/. It may also be the case that such data will force us to revise certain aspects of the diachronic account we have given in the previous sections.

7 Sociolinguistic factors

An additional factor to be considered in understanding consonant epenthesis in Meto is the possible influence of sociolinguistic factors. At this point, we can only offer some preliminary observations based on our conversations with Meto speakers. A thorough investigation of the role of language and identity among different groups of Meto speakers remains to be carried out.

Our conversations with Meto speakers show that the different patterns of consonant epenthesis in different varieties and dialects are often salient to speakers. They are aware of the patterns, and that they differ between varieties of Meto. For example, when Edwards first travelled to the Amfo'an speaking area, he was accompanied by speakers of Amanuban who told him that "all the words there end in <g>". Similarly, when Culhane first arrived in Lelogama to undertake more intensive work on Amfo'an, her main consultant told her: "Here in Amfo'an we add consonants at the end of sentences. That's how you know someone is from

Amfo'an". Both statements show that the processes of consonant insertion in Amfo'an are seen by both insiders and outsiders as distinctive of their variety of Meto. Such observations are not only made about gross differences between different varieties of Meto – such as the presence of /g/ in Amfo'an compared to its absence in Amanuban – but also about fine-grained differences, such as the occurrence of /gʷ/ or /g/ in word-final position. Different varieties of Kopas have insertion of either /gʷ/ or /g/ in similar environments to that found Amfo'an (see Section 6.4.2). In the village of Tunfe'u [g] is inserted; *hau* ⟶ *haag* 'tree, wood', while in the village Usapisonba'i /gʷ/ is inserted; *hau* ⟶ *haagʷ* 'tree, wood'. When in Usapisonba'i, Edwards told one of his consultants that he had been to Tunfe'u and that there they said *haag* for 'tree'. To this the consultant responded: "Yes, they speak differently there. Here we say *haagʷ*".

In the context of Timor, it does not seem likely that different identities are themselves the trigger for the changes we outlined in Section 6. Instead, it seems more likely that once changes have occurred, they *became* salient markers of identity and are reinforced as such. This may potentially be part of the explanation for the persistence of the typologically rare systems of consonant insertion found in Meto. Indeed, the kinds of comments from speakers outlined above demonstrate their metalinguistic awareness of correspondences between linguistic systems, which is one of the mechanisms of generating diverse structures identified by Evans (2019). Meto also demonstrates several features of the kind of social setting which favours linguistic signalling of group-membership distinctions: small speech communities, multilingualism, and awareness of alternative systems (Evans 2019: 582–584).

8 Conclusions

This chapter has examined consonant epenthesis in Meto, whereby various consonants are regularly inserted after vowel-final words when they are followed by vowel-initial enclitics. We have shown that consonant epenthesis in Meto adheres to the definitions of epenthesis proposed in the literature, but involves segments which are otherwise unattested.

Some of the epenthetic consonants are analysable as cases of default epenthesis, while others are analysable as determined by the place and manner of articulation of the preceding vowels. However, the diversity of consonants seen in the same environments across different varieties of Meto – such as /w/, /gʷ/, /b/, or /dʒ/ after final /u/ – is not well-explained under a synchronic account. Furthermore, some of the patterns of consonant epenthesis in Meto involve epenthetic consonants, the qualities of which are not transparently determined by the preceding vowels. The best synchronic account, unsatisfying as it is, may be that consonant insertion in Meto is a static pattern which is most likely simply learned by the speakers in childhood.[26]

A diachronic account provides a different perspective on consonant epenthesis in Meto. It allows us to explain the diversity of epenthetic consonants observed in a more cohesive way. The epenthetic consonants attested are the result of sequences of sound changes which have applied to different extents in different varieties of Meto. The two series of sound changes we propose in (4) and (5) are repeated as (10) and (11) below.

(10) /V[+FRONT]_=V $\quad \varnothing > \textit{j} > \textit{dʒ} > \begin{cases} \textit{r} \\ (^*\text{r} >)\ \textit{l}\ /\text{e\_}\ (\text{or direct } ^*\text{j} > \textit{l}) \end{cases}$

(11) /V[+BACK]_=V $\quad \varnothing > \textit{w} > \text{g}^{w} > \begin{cases} \textit{b} \\ ^*\text{g} > \textit{dʒ}\ /\text{u\_} \end{cases}$

These sound changes are attested elsewhere in Meto, as well as crosslinguistically. Thus, while several of the epenthetic consonants in Meto have not been found in other languages, the sound changes we propose are. Our findings support Blevins's (2008a, 2025 [this volume]) prediction that "unnatural" patterns of consonant insertion, like "unnatural" sound changes, often develop from "natural" patterns through the accumulation of sound changes.

In this chapter, we have also briefly touched on the possible role of social factors on the patterns of consonant epenthesis attested in Meto. Initial conversations with speakers indicate that they are highly conscious of the different patterns of consonant insertion. Their awareness of these differences, including of those which are at a phonetic level, suggests that they have become markers of group identity.

The data presented in this chapter also has several implications for phonological typology and theory. The first is that Meto displays otherwise unattested epenthetic consonants, including consonants such as /g^{w}/, which do not adhere to theoretical predictions about possible epenthetic segments. This therefore calls for a revision of theoretical predictions about consonant epenthesis. The occurrence of /g^{w}/ as a default epenthetic segment in Meto also parallels the findings of Morley (2015) and Vaux & Samuels (2017), who demonstrate that Optimality

[26] Thanks goes to an anonymous reviewer for pointing this out. Nonetheless, it is important to recall that the process is highly productive and applies to novel loanwords (Section 3.3). This indicates that speakers are learning something like a rule rather than just associations between individual lexical items and certain consonants.

Theory predictions about preferred epenthetic segments are not borne out cross-linguistically.

In addition, Meto has a spectrum of epenthetic consonants which are transparently analysable as determined by the preceding vowel to differing extents. This raises questions about the extent to which an epenthetic consonant must be similar to adjacent vowels in order to be considered assimilatory epenthesis. How to delimit assimilatory epenthesis, and whether a binary distinction between default and assimilatory epenthesis is a useful one, remains to be investigated.

Abbreviations, glosses, and symbols

|	separates prosthetic vowel	DET	determiner
0	zero person	PERF	perfect
1	first person	PMP	Proto-Malayo Polynesian
2	second person	PRM	Proto-Rote-Meto
3	third person	REFL	reflexive
ACC	accusative	SG	singular

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Appendix A Additional data

In this appendix we provide additional data exemplifying the patterns of consonant epenthesis described in Section 3. Data is drawn from the sources given in (1).

A.1 Amanuban

Table 18: Amanuban VV#

stem	enclitic	output	translation
*i**i***	*=een*	*ii**j**een*	‘this/here now’
*me**i***	*=ees*	*mei**j**ees*	‘one table’
*te**i***	*=ees*	*tei**j**ees*	‘one (pile of) dung’
*kle**i***	*=ees*	*klei**j**ees*	‘one week’
*fa**i***	*=ees*	*fai**j**ees*	‘one night’
*muiʔ fu**i***	*=ees*	*muiʔ fui**j**ees*	‘one wild animal’
*n-tu**i***	*=ee*	*ntui**j**ee*	‘writes it’
*bife**e***	*=ees*	*bifee**j**ees*	‘one woman’
*n-fe**e***	*=ee*	*nfee**j**ee*	‘gives it’
*fe**e***	*=ees*	*fee**j**ees*	‘one wife’
*n-sa**e***	*=een*	*nsae**j**een*	‘has risen’
*no**e***	*=ees*	*noe**j**ees*	‘one river’
*u**e***	*=ee*	*ue**j**ee*	‘the rattan’
*n-ti**a***	*=een*	*ntia**j**een*	‘has arrived’
*neno ha**a***	*=een*	*neno haa**j**een*	‘has been four days’
*neno nu**a***	*=een*	*neno nua**j**een*	‘has been two days’
*na-tu**a***	*=een*	*natua**j**een*	‘has dwelt’
*na-fu**a***	*=een*	*nafua**j**een*	‘has born fruit’
*a|n-hanu**a***	*=oo-n*	*anhanua**j**oon*	‘spread (itself)’
*si**o***	*=een*	*sio**w**een*	‘nine now’
*na-kle**o***	*=ee*	*nakleo**w**ee*	‘traps it’
*na-mne**o***	*=een*	*namneo**w**een*	‘truly/really now’
*bna**o***	*=ees*	*bnao**w**ees*	‘one ship’
*to**o***	*=ees*	*too**w**ees*	‘one population’
*ʔlo**o***	*=een*	*ʔloo**w**een*	‘has been a long time’
*ki**u***	*=ees*	*kiu**w**ees*	‘one tamarind tree’
*kool oto ʔbi**u***	*=ees*	*kool oto ʔbiu**w**ees*	‘one turtledove’
*nme**u***	*=een*	*nmeu**w**een*	‘early morning now’
*na-mna**u***	*=ee*	*namnau**w**ee*	‘remembers her/him/it’
*n-fee=ka**u***	*=ee*	*nfeekau**w**ee*	‘gives it to me’

Table 19: Amanuban CV#

stem	enclitic	output	translation
*in**i***	*=aa*	*in**i**j**aa***	'her/his (possession)'
*n-ek**i***	*=ee*	*nek**ij**ee*	'takes it'
*las**i***	*=ees*	*las**ij**ees*	'one matter'
*n-soʔ**i***	*=ee*	*nsoʔ**ij**ee*	'counts it'
*n-ful**i***	*=ee*	*nful**ij**ee*	'persuades her/him'
*mi-hin**e***	*=ee*	*mihine**j**ee*	'you (pl.) know it'
*t-hek**e***	*=ee*	*theke**j**ee*	'catches it'
*bal**e***	*=ees*	*bale**j**ees*	'one place'
*an-moʔ**e***	*=ee*	*anmoʔe**j**ee*	'does it'
*um**e***	*=ees*	*ume**j**ees*	'one house'
*n-it**a***	*=ee*	*niitee*	'sees it'
*n-nen**a***	*=ee*	*nneenee*	'hears it'
*na-tan**a***	*=ee*	*nataanee*	'asks her/him'
*n-sos**a***	*=ee*	*nsoosee*	'buys it'
*n-sub**a***	*=ee*	*nsuubee*	'buries it'
*kil**o***	*=ees*	*kilo**w**ees*	'one kilogram'
*kaun las**o***	*=ees*	*kaun laso**w**ees*	'one poisonous snake'
*aan fet**o***	*=ees*	*aan feto**w**ees*	'one girl'
*n-lol**o***	*=ee*	*nlolo**w**ee*	'kills it'
*n-poh**o***	*=ee*	*npoho**w**ee*	'touches it'
*nif**u***	*=ees*	*nifu**w**ees*	'one pool'
*mep**u***	*=ee*	*mepu**w**ee*	'the work'
*tab**u***	*=ees*	*tabu**w**ees*	'one time'
*na-msop**u***	*=een*	*namsopu**w**een*	'has finished'
*ʔtub**u***	*=ees*	*ʔtubu**w**ees*	'one hill'

A.2 Kotos

Table 20: Kotos VV#

stem	enclitic	output	translation
*kmi**i***	*=ii*	*kmi**idʒ**ii*	‘the urine’
*kre**i***	*=ees*	*kre**edʒ**ees*	‘one church/week’
ai	*=ee*	***aadʒ**ee*	‘the fire’
*n-po**i***	*=ena*	*npo**odʒ**ena*	‘has exited’
*oo fu**i***	*=ii*	*oo fu**udʒ**ii*	‘the wild bamboo’
*bife**e***	*=ees*	*bife**edʒ**ees*	‘one woman’
*na-se**e***	*=oo-n*	*nase**edʒ**oon*	‘excuse oneself’
*bidʒa**e***	*=ee*	*bidʒa**adʒ**ee*	‘the cow’
*no**e***	*=ee*	*no**odʒ**ee*	‘the river’
*o**e***	*=ee*	*o**odʒ**ee*	‘the water’
*i**a***	*=een*	*i**agʷ**een*	‘here already’
*n-te**a***	*=een*	*nte**agʷ**een*	‘has arrived’
*na**a***	*=een*	*na**agʷ**een*	‘there already’
*nu**a***	*=een*	*nu**agʷ**een*	‘two already’
*mi-tu**a***	*=ee*	*mitu**agʷ**ee*	‘we occupy it’
*ʔ-pe**o***	*=ee*	*ʔpe**egʷ**ee*	‘sees it’
*bna**o***	*=ii*	*bna**agʷ**ii*	‘the ship’
*n-sa**o***	*=ee*	*nsa**agʷ**ee*	‘weds him/her’
*o**o***	*=ee*	*o**ogʷ**ee*	‘the bamboo’
*u-sbo**o***	*=ee*	*usbo**ogʷ**ee*	‘I smoked it’
*na-ni**u***	*=ee*	*nani**igʷ**ee*	‘bathes him/her’
*nme**u***	*=ii*	*nme**egʷ**ii*	‘it is morning’
*ha**u***	*=ee*	*ha**agʷ**ee*	‘the wood/tree’
*seka**u***	*=een*	*seka**agʷ**een*	‘who already’
*kfu**u***	*=ee*	*kfu**ugʷ**ee*	‘the star’

Table 21: Kotos CV#

stem	enclitic	output	translation
*na-hin**i***	*=ee*	*nahiin**dʒ**ee*	‘knows it’
*n-ek**i***	*=ee*	*neik**dʒ**ee*	‘takes it’
*faf**i***	*=ee*	*faaf**dʒ**ee*	‘the pig’
*n-rom**i***	*=ee*	*nroom**dʒ**ee*	‘likes it’
*n-sur**i***	*=ee*	*nsuur**dʒ**ee*	‘heals it’
*n-hek**e***	*=ee*	*nheek**dʒ**ee*	‘catches it’
*n-mes**e***	*=aah*	*nmees**dʒ**aah*	‘just alone’
*kas**e***	*=ee*	*kaas**dʒ**ee*	‘the foreigner’
*n-moʔ**e***	*=ee*	*nmooʔ**dʒ**ee*	‘does it’
*mon**e***	*=ee*	*moon**dʒ**ee*	‘the husband’
*n-it**a***	*=ee*	*niitee*	‘sees it’
*nem**a***	*=een*	*neemeen*	‘has come’
*na-tam**a***	*=ee*	*nataamee*	‘makes it enter’
*n-sub**a***	*=ee*	*nsuubee*	‘buries it’
*n-tup**a***	*=een*	*ntuupeen*	‘has slept’
*na-rek**o***	*=een*	*nareek**gʷ**een*	‘has become better’
*nef**o***	*=ee*	*neef**gʷ**ee*	‘the lake’
*kanf**o***	*=ee*	*knaaf**gʷ**ee*	‘the mouse’
*ʔaidʒoʔ**o***	*=esa*	*ʔaidʒooʔ**gʷ**esa*	‘a casuarina tree’
*kor**o***	*=ee*	*koor**gʷ**ee*	‘the bird’
*bik**u***	*=ii*	*biik**gʷ**ii*	‘the curse’
*n-ket**u***	*=ee*	*nkeet**gʷ**ee*	‘cuts it’
*man**u***	*=ees*	*maan**gʷ**ees*	‘one chicken’
*n-ot**u***	*=ee*	*noot**gʷ**ee*	‘burns it’
*hut**u***	*=ii*	*huut**gʷ**ii*	‘the headlouse’

A.3 Buraen Roi'is

Table 22: Buraen Roi'is VV#

stem	enclitic	output	translation
*kre**i***	*=ees*	*kre**edʒ**ees*	‘one week’
*te**i***	*=aa*	*te**edʒ**ia*	‘the faeces’
*n-tu**i***	*=ee*	*ntu**udʒ**ee*	‘writes it’
*bife**e***	*=ii*	*bife**edʒ**ii*	‘the daughter’
*fe**e***	*=aa*	*fe**edʒ**ea*	‘the wife’
*fuun se**o***	*=ii*	*fuun se**eb**ui*	‘the ninth month’
*no**o***	*=ees*	*no**ob**oes*	‘the first time’
*matsa**o***	*=ee*	*matsa**ab**oe*	‘married him/her’
*bna**o***	*=ii*	*bna**ab**ui*	‘the ship’
*n-ha**o***	*=ee*	*nha**ab**oe*	‘feeds it’
*iik hi**u***	*=ii*	*iik hi**ib**ui*	‘the shark’
*ku-mna**u***	*=ee*	*ku-mna**ab**oe*	‘I remember it’

Table 23: Buraen Roi'is CV#

stem	enclitic	output	translation
*m-er**i***	*=ee*	*meer**dʒ**ee*	‘took it’
*bon**i***	*=ee*	*boon**dʒ**ee*	‘the term of address’
*braf**i***	*=aa*	*braaf**dʒ**ia*	‘the sea cucumber’
*tas**i***	*=ee*	*taas**dʒ**ee*	‘the sea’
*um**i***	*=ee*	*uum**dʒ**ee*	‘the house’
*n-haʔmuʔ**i***	*=ee*	*nhaʔmuuʔ**dʒ**ee*	‘makes him/her suffer’
*ku-hin**e***	*=ee*	*kuhiin**dʒ**ee*	‘I know it’
*meʔ**e***	*=aa*	*meeʔ**dʒ**ea*	‘the red ones’
*afu me**e***	*=aa*	*afu mee**dʒ**ea*	‘soil somewhere’
*ren**e***	*=ee*	*reen**dʒ**ee*	‘the field’
*mon**e***	*=aa*	*moon**dʒ**ea*	‘the husband’
*aan fet**o***	*=ii*	*aan feet**bu**i*	‘the daughter’
*aan fet**o***	*=aa*	*aan feet**bo**a*	‘the daughter’
*nen**o***	*=ees*	*neen**bo**es*	‘one day’
*kor**o***	*=aa*	*koor**bo**a*	‘the bird’
*n-ror**o***	*=ee*	*nroor**bo**e*	‘kills it’
*nif**u***	*=ees*	*niif**b**oes*	‘one thousand’
*noo ten**u***	*=ii*	*noo teen**bu**i*	‘the third time’
*mep**u***	*=ii*	*meep**bu**i*	‘the work’
*feot koʔ**u***	*=ii*	*feot kooʔ**bu**i*	‘the eldest daughter’
*akuarium koʔ**u***	*=ees*	*akuarium kooʔ**b**oes*	‘a big aquarium’
*m-top**u***	*=ee*	*mtoup**b**oe*	‘we receive it’
*t-ot**u***	*=ee*	*toot**b**oe*	‘burns it’

A.4 Baikeno

Table 24: Baikeno VV#

stem	enclitic	output	translation
*a**i***	*=aa*	*ai**dʒ**aa*	'the fire'
*fa**i***	*=ees*	*fai**dʒ**ees*	'one night'
*me**i***	*=aa*	*mei**dʒ**aa*	'the table'
*kle**i***	*=ees*	*klei**dʒ**ees*	'one week/church'
*n-to**i***	*=ee*	*ntoi**dʒ**ee*	'carved it'
*n-po**i***	*=een*	*mpoi**dʒ**een*	'has come out'
*n-fe**e***	*=ee*	*nfee**l**ee*	'gives it'
*bife**e***	*=ees*	*bifee**l**ees*	'one woman'
*bidʒa**e***	*=ee*	*bidʒae**l**ee*	'one cow'
*na-ta**e***	*=ee*	*natae**l**ee*	'responds to her/him'
*o**e***	*=aa*	*oe**l**aa*	'the water'
*no**e***	*=ii*	*noe**l**ii*	'the river'
*nu**a***	*=een*	*nua**b**een*	'two now'
*moolk=a**a***	*=ee*	*moolkaa**b**ee*	'speech now'
*ka=ʔloʔo=f**a***	*=een*	*kaʔloʔofa**b**een*	'not long now'
*me**o***	*=ees*	*meo**b**ees*	'one cat'
*n-pa**o***	*=ee*	*npao**b**ee*	'waits for her/him'
*n-ta**o***	*=ee*	*ntao**b**ee*	'puts it'
*kali**u***	*=ees*	*kaliu**b**ees*	'one crab'
*n-ail name**u***	*=ee*	*nail nameu**b**ee*	'sees it clearly'
*ha**u***	*=ees*	*hau**b**ees*	'one tree'
*na-mna**u***	*=ee*	*namnau**b**ee*	'remembers her/him'

Table 25: Baikeno CV#

stem	enclitic	output	translation
*uk**i***	*=ii*	*uuk**dʒ**ii*	‘the banana’
*in**i***	*=ii*	*iin**dʒ**ii*	‘her/his things’
*n-fin**i***	*=ee*	*nfiin**dʒ**ee*	‘passes it’
*lel**i***	*=ee*	*leel**dʒ**ee*	‘the jerry can’
*u-lal**i***	*=ee*	*ulaal**dʒ**ee*	‘finishes it’
*n-hel**i***	*=ee*	*nheil**dʒ**ee*	‘cuts it’
*n-pen**i***	*=ee*	*npein**dʒ**ee*	‘gets it’
n-ita	*=ee*	*niitee*	‘sees it’
n-nena	*=ee*	*nneenee*	‘hears it’
n-ana	*=ee*	*naanee*	‘gets it’
na-tona	*=ee*	*natoonee*	‘tells him/her’
*um**e***	*=ee*	*uum**dʒ**ees*	‘one house’
*liʔaan mon**e***	*=ee*	*liʔaan moon**dʒ**ee*	‘the son’
*t-moʔ**e***	*=ee*	*tmooʔ**dʒ**ee*	‘does it’
*bal**e***	*=ees*	*baal**l**ees, baal**dʒ**ees*	‘one place’
*nen**o***	*=ee*	*neen**b**ees*	‘one day’
*bel**o***	*=ii*	*beel**b**ii*	‘the monkey’
*ʔbaʔ**u***	*=ees*	*ʔbaaʔ**b**ees*	‘one bat’
*buk**u***	*=ii*	*buuk**b**ii*	‘the book’

A.5 Amfo'an

Table 26: Amfo'an VV#

stem	enclitic	output	translation
*ʔ-saksi**i***	*=ee*	*ʔsaksii**dʒ**ee*	‘I witness it’
*kli**i***	*=ee*	*klii**dʒ**ee*	‘the church’
*fa**i***	*=ees*	*fai**dʒ**ees*	‘one night’
*n-fee=ka**i***	*=ee*	*nfeekai**dʒ**ee*	‘gives it to us’
*a**i***	*=ee*	*ai**dʒ**ee*	‘the fire’
*t-suta**i***	*=ee*	*tsutai**dʒ**ee*	‘we bear it’
*m-fe**e***	*=ee*	*mfee**l**ee*	‘we give it’
*bife**e***	*=ees*	*bifee**l**ees*	‘the woman’
*u-na**e***	*=een*	*unae**l**een*	‘I have grown’
*o**e***	*=aa*	*oe**l**aa*	‘the water’
*ha**a***	*=een*	*haa**gʷ**een*	‘four already’
*ta-bgo**a***	*=een*	*ta-bgoa**gʷ**een*	‘we have gathered’
*t-ta**o***	*=ee*	*ttao**gʷ**ee*	‘we put it’
*mi-na**o***	*=een*	*mi-nao**gʷ**een*	‘we have gone’
*klo**o***	*=ees*	*kloo**gʷ**ees*	‘one far away (thing)’
*sasi**u***	*=ee*	*sasiu**gʷ**ee*	‘the sparks’
*nme**u***	*=aa*	*nmeu**gʷ**aa*	‘tomorrow’
*ha**u***	*=ee*	*hau**gʷ**ee*	‘the tree’
*a**u***	*=ee*	*au**gʷ**ee*	‘my thing’

Table 27: Amfo'an CV#

stem	enclitic	output	translation
*n-tef**i***	*=ee*	*nteef**dʒ**ee*	'makes a roof'
*ʔ-pen**i***	*=ee*	*ʔpeen**dʒ**ee*	'I get it'
*faf**i***	*=ees*	*faaf**dʒ**ees*	'one pig'
*las**i***	*=ee*	*laas**dʒ**ee*	'the matter'
*t-soʔ**i***	*=ee*	*tsooʔ**dʒ**ee*	'counts it'
*on**i***	*=aa*	*oon**dʒ**aa*	'the bee'
*aton**i***	*=ees*	*atoon**dʒ**ees*	'one man'
*mab**e***	*=een*	*maab**l**een*	'has become evening'
*nan**e***	*=een*	*nane**l**een*	'there already'
*liʔaan mon**e***	*=ees*	*liʔaan moon**l**ees* ~ *liʔaan mone**l**ees*	'a boy'
*a|n-hon**e***	*=ee*	*anhone**l**ee*	'invites him'
*a|n-tal**a***	*=ee*	*antaalee*	'forbids her/him'
*na-tam**a***	*=ee*	*nataamee*	'makes her/him enter'
*na-san**a***	*=ee*	*nasaanee*	'accused her/him'
*uisnen**o***	*=aa*	*uisneen**g**ʷaa*	'God'
*nen**o***	*=ees*	*neen**g**ʷees*	'one day'
*ot**o***	*=ee*	*oot**g**ʷee*	'the car'
*nif**u***	*=aa*	*niif**g**ʷaa*	'the pool'
*anah ten**u***	*=een*	*anah teen**g**ʷeen*	'three children already'
*bifee feʔ**u***	*=aa*	*bifee feeʔ**g**ʷaa*	'the new woman'
*tab**u***	*=ees*	*taab**g**ʷees*	'one time'
*n-ot**u***	*=ee*	*noot**g**ʷee*	'burns it'

A.6 Timaus

Table 28: Timaus VV#

stem	enclitic	output	translation
*n-polo=ka**i***	*=ee*	*npoloka**ar**ee*	'splits it for us'
*a|n-fa**i***	*=een*	*anfa**ar**een*	'has become night'
*kle**i***	*=ees*	*kle**er**ees*	'one week'
*ʔ-so**i***	*=ee*	*ʔso**or**ee*	'I count it'
*bira**e***	*=aa*	*birae**l**aa*	'the cow'
*u-ʔna**e***	*=ena*	*uʔnae**l**ena*	'I had grown up'
*me**e***	*=aa*	*mee**l**aa*	'wherever'
*fe**e***	*=esa*	*fee**l**esa*	'one wife'
*o**e***	*=ees*	*oe**l**ees*	'one body of water'
*kuan a**a***	*=een*	*kuanaa**gʷ**een*	'the village now'
*meel a**a***	*=een*	*meelaa**gʷ**een*	'wherever now'
*nteniʔ f**a***	*=een*	*nteniʔ fa**gʷ**een*	'not again'
*m-ta**o***	*=ee*	*mta**agʷ**ee*	'put/do it'
*t-pe**o***	*=ee*	*tpe**egʷ**ee*	'we say it'
*to**o***	*=aa*	*to**ogʷ**aa*	'the populace'
*a|ʔlo**o***	*=een*	*a|ʔlo**ogʷ**een*	'has been a long time'
*na-mna**u***	*=ee*	*namna**adʒ**ee*	'remembers it'
*na-honi-s=ka**u***	*=ii*	*nahoniska**adʒ**ii*	'gives birth to me'
*na-mfa**u***	*=een*	*namfa**adʒ**een*	'is now many'

Timaus from the village Sanenu, where most of our Timaus data comes from, has undergone an *e > *a* /C_(C)# sound change. The first four examples in Table 29 show epenthesis of /l/. This is because the final /a/ comes from earlier /e/. For the other seven examples, which do not trigger trigger epenthesis of /l/, the final /a/ comes from earlier *a. Note also that Sanenu Timaus appears to have assimilation of inserted /r/ ⟶ /l/ after final /l/, though there is only one example in our data: *na-lali* 'finish' + *=een* ⟶ **nalaalreen* ⟶ *nalaalleen* 'has finished'.

Table 29: Timaus CV#

	stem	enclitic	output	translation
	*naʔlas**i***	*=aa*	*naʔlaas**r**aa*	‘Amarasi’
	*faf**i***	*=aan*	*faaf**r**aan*	‘the pig’
	*n-ek**i***	*=ee*	*neek**r**ee*	‘takes it’
	*m-ait**i***	*=ee*	*mait**r**ee*	‘picks it up’
	*naʔ**i***	*=ee*	*naaʔ**r**ee*	‘the pot’
*an**e** >	*ana*	*=aa*	*ana**l**aa*	‘the rice field’
*-hin**e** >	*u-hina*	*=ee*	*uhina**l**ee*	‘I knew it’
*bal**e** >	*bala*	*=ees*	*bala**l**ees*	‘one place’
*-mlil**e** >	*mi-mlila*	*=ii*	*mimlila**l**ii*	‘we were happy’
	*nim**a***	*=ena*	*niimena*	‘has been five’
	*n-tek**a***	*=ee*	*nteekee*	‘calls it’
	*pah**a***	*=ee*	*paahee*	‘the country’
	*n-an**a***	*=ee*	*naanee*	‘gets it’
	*na-han**a***	*=ee*	*nahaanee*	‘cooks it’
	*ʔ-bab**a***	*=ee*	*ʔbaabee*	‘I helped him’
	*n-tuʔ**a***	*=een*	*ntuuʔeen*	‘has stopped’
	*n-sok**o***	*=ee*	*nsook**gw**ee*	‘spoons it out’
	*m-pol**o***	*=ee*	*mpool**gw**ee*	‘we split it’
	*n-kon**o***	*=ee*	*nkoon**gw**ee*	‘passes it’
	*n-tiklot**o***	*=een*	*antiklootg**w**een*	‘cuts it down’
	*nen**o***	*=ii*	*neen**gw**ii*	‘the sky’
	*kot**o***	*=ii*	*koot**gw**ii*	‘the hyacinth beans’
	*lek**o***	*=ii*	*leek**gw**ii*	‘the good things’
	*mus**u***	*=ii*	*muus**dʒ**ii*	‘the enemy’
	*a/ʔtub**u***	*=ees*	*a/ʔtuub**dʒ**ees*	‘one hill’
	*klaas ten**u***	*=ee*	*klaas teen**dʒ**ee*	‘the three classes’
	*mep**u***	*=een*	*meep**dʒ**een*	‘work already’

Chapter 6

Reconciling the debate about final obstruent voicing: The phonology of Lakota obstruent lenition

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Word-final obstruent voicing has been claimed to be unavailable as a synchronic phonological process due to universal markedness constraints. However, Evolutionary Phonology (Blevins 2004) predicts the possibility of such a phonological rule, and purports to show it in various languages, touching off a debate with Kiparsky (2006, 2008). Searching for a more robust example, Blevins et al. (2020) provide a phonetic study of voicing in Lakota. They show that Lakota has phonetic alternations between voiceless and voiced stops, with the voiced stops appearing in final position. They therefore claim the language has a synchronic phonological rule of final obstruent voicing. We call into question the assumed phonological status of final voicing in Lakota. Phonetically, Lakota does have only voiced stops in final position, but at the same time final fricatives are neutralised to the voiceless series. We show that, rather than neutralizing stops toward a marked or complex structure, Lakota has only a process of phonological lenition in weak positions: sonorisation of stops and devoicing of fricatives. Under the assumption that manner of articulation is a structural property, a single lenition process can produce final voiceless fricatives but final voiced stops.

1 Introduction

When one considers the expression "phonological diversity", it is interesting to think about its sources. That is, what is it that gives richness to the phonological systems of the world? In this regard, what comes to mind first are typolog-

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ically unusual or geographically restricted sound classes and/or segmental inventories. For example, a phonological use of phenomena such as non-pulmonic airstream mechanisms or non-modal voice qualities contributes great richness to the inventory of sounds found in the world's languages. An additional source of diversity is a wide range of phonological processes across languages, ranging in scope from allophonic changes to phonologically conditioned morphological alternations. These processes show diversity both in the types of sounds that undergo changes and the types of changes that are actually observed. In this contribution, we consider what is assumed to be an unusual phonological process, namely, final-obstruent voicing, but suggest that it represents diversity not as a phonological process per se, but rather as a somewhat unusual mapping between phonology and phonetics. Unlike final obstruent devoicing, which is quite widespread (though perhaps not as ubiquitous as sometimes assumed, see Iosad (2025 [this volume])), final voicing has been described in just a few languages, including Lezgian (lezg1247; Yu 2004), Somali (soma1255; Blevins 2006), and Lakota (lako1247; Rood 2016). Here we focus on the latter of these.

Following Trubetzkoy (1939), a number of modern phonological models would explain the much more common pattern of word-final or syllable-final obstruent devoicing and, conversely, the rarity of a word-final voicing rule, as the result of an Optimality Theory markedness constraint: e.g. *VoicedObs# or *VoicedCoda (Wetzels & Mascaró 2001, Lombardi 1999). This would lead to a substantive universal, one relating to attestation rather than formal principles (Hyman 2008), that can be stated as follows: word-finally one can find only unvoiced obstruents. The common assumption is that the presence of this constraint in Universal Grammar leads to an a priori expectation that final obstruents are voiceless, and this expectation guides language acquisition and language change (Kiparsky 2006, 2008; see also Broselow 2018). The foundations of this constraint supposedly have phonetic justification – final position is associated with a decrease in the transglottal airflow required to maintain phonation (see e.g. Ohala 1997).

This expectation is encoded somewhat differently in so-called representational approaches, including frameworks such as Government Phonology (Kaye et al. 1990, Charette 1991), Dependency Phonology (Anderson & Jones 1974, Anderson & Ewen 1987, Botma 2004), Strict CV (Scheer 2004), and Radical CV Phonology (van der Hulst 2020). In these models, at least some traditional "markedness" properties can be described in terms of representational complexity (Ulfsbjorninn 2017), by which greater complexity is based on the number of phonological features. For example, in a true voicing language such as Polish or Russian, voiced obstruents are said to contain a feature [voice], while voiceless obstruents are claimed to be unspecified for laryngeal features (e.g. Beckman et al. 2013). In other words, the voiced obstruents contain an extra feature, which makes them more complex. According to these models, we do not expect to find patterns of complexity reversal in positions of neutralization. (Harris 1997, 2005, Cyran 2010, Ségéral & Scheer 2001).[1] On this view, word-final devoicing is not an instance of strengthening, but instead is a loss of a laryngeal feature, resulting in final plain voiceless stops in weak positions such as syllable codas. Under the assumption that voiced obstruents are more representationally complex than plain ones, the former should be dispreferred in final position.

Conversely, in the approach known as Evolutionary Phonology (Blevins 2004), markedness does not have any formal status. In this framework, the typological frequency of final devoicing falls out from phonetic constraints that are not formally encoded in grammar. Since there is no formal restriction on a rule which would make final obstruents voiced, and we could, therefore, expect to find such a pattern. In fact, we probably should expect to find such a pattern since, as Kiparsky (2006) shows, there are multiple reasonable diachronic pathways towards this outcome. The EP perspective touched off an animated debate between Blevins and Kiparsky, since they apparently represent diametrically opposed views on the place of grammar in language acquisition and language change. In that context, the existence and phonological status of word-final obstruent voicing has become a *cause célèbre* of the debate. Blevins (2004) presents a number of supposed empirical cases for word-final or syllable-final voicing. However, Kiparsky (2006) argues against them, casting doubt on each one (e.g. Lezgian, Somali). Blevins et al. (2020) seem to recognise this and their study on Lakota, which inspired the present contribution, is offered as a more convincing example of word-final obstruent voicing.

The putative process of final voicing in Lakota is exemplified in Table 1, which are taken from Blevins et al. (2020: 301). Note that in the first and third forms, prevocalic /p/ and /k/ surface as voiced [b] and [g] syllable-finally, while /t/ in the second form surfaces as [l]. The central argument of the Blevins et al. (2020) paper (stated explicitly on p. 297) is that alternations like these in Lakota constitute a robust example of a language with a true synchronic phonological process

[1]A reviewer calls this position into question, citing Iverson & Salmons (2011), who summarise cases in which word-final voiceless stops may be aspirated. Thus, for example, they argue that final devoicing in German, which is said to neutralise the laryngeal contrast, is in fact a case of final fortition. While the universality of the representational perspective on final neutralization is beyond the scope of this chapter, there is phonetic evidence that Iverson and Salmons' description of German is incorrect. Roettger et al. (2014), in a set of experiments that addressed the question of orthography, found robust evidence for incomplete neutralization of the German voicing contrast. This evidence was confirmed in a replication study (Roettger & Baer-Henney 2019).

of obstruent voicing which is supported by phonological evidence. However, as we show, the Lakota pattern apparently does not qualify as a truly phonological process. We claim that phonologically it is a weakening process, a type of sonorisation, as reflected in the alternation between /t/ and [l] in Table 1, while the realization of [b, g] in Table 1 as fully occluded stops is a purely phonetic effect. Representational confusion between voiced stops and sonorants is expected under the assumptions of representational models in which manner of articulation is a structural property (e.g. Steriade 1993, Schwartz 2016), as we shall see in Section 4.

Table 1: Lakota word and syllable-final voicing (Blevins et al. 2020: 301)

		Truncated (word-final)	Reduplicated (syllable-final)
/p/	/topa/ ‘four’	/tob/ ‘four’	/tobtopa/ ‘by fours’
/t/	/napota/ ‘to wear out footwear’	/napol/ ‘to wear out footwear’	/napolpota/ ‘wearing out footwear’
/k/	/ʃoka/ ‘to be thick’	/ʃog/ ‘to be thick’	/ʃogʃoka/ ‘to be thick’

2 Lakota and final obstruent voicing

2.1 Phonetics or phonology?

If there is both acoustic and impressionistic evidence of a given phonetic phenomenon, can we assume that the phenomenon qualifies as phonological? We believe that the answer to this question is no. The velar nasal and the glottal stop in English come to mind as familiar examples. The latter is attested as an allophone of /t/ or as a boundary marker before initial vowels (see e.g. Cruttenden 2001). The former is restricted in its distribution, and is sometimes analysed as an underlying nasal-stop cluster (see e.g. Smith 1982). We suggest that similar forces underlie the appearance of voiced stops in Lakota. In other words, what we see phonetically is not always phonological.

The main claim that we adhere to, first advanced by Rood (2016), is that voiced stops in Lakota are phonological sonorants that may be phonetically realised as stops. The phonetic voicing of stops is a result of a sonorization process. In the discussion describing Lakota and advocating the EP approach, Blevins et al. (2020) mention Rood’s claim. However, instead of considering its merits, Blevins et al. (2020: 296) present the Lakota data with respect to a perceived dichotomy between so-called "traditional markedness" approaches and "phonetic-historical" approaches, such that it appears their goal is to undermine the former.

2.2 The status of voiced stops in the Lakota consonant system

An inventory of the Lakota consonant system, based on descriptions in Blevins et al. (2020: 299) and Rood (2016), appears in Table 2. The main focus of our discussion will be on the voiced stops, since their phonological status may be assumed to be relevant to the question of whether the phonology of Lakota has a rule of final obstruent voicing. Before proceeding, however, it is worth noting that Lakota is a language with both aspiration and ejection in its stop system. In many languages with both of these features in its system of stops, voicing is not contrastive. This was apparently also the case in Proto-Siouan (Rankin et al. 1998), which gave rise to Lakota. Similar systems, with aspiration and ejection but not voicing, are found in many other indigenous languages of the Americas (Maddieson 1984). In South America, these include Cusco Quechua (cusc1236), Bolivian Quechua (nort2976, sout2991), Central and Chilean Aymara (cent2142, sout2996), Uru (uruu1244), Kallawaya (call1235), and Chipaya (chip1262), to name just a few (Lev et al. 2015). In North America, these include Nuxalk (bell1234; Nater 1984) in the Salishan family, as well as Navajo (nava1243; McDonough & Ladefoged 1993) and Apache (west2615; Gordon et al. 2001) in the Athabaskan family, to name just a few.

Of the two voiced stops in Lakota, only the bilabial [b] has been claimed to be phonemic. The distribution of the velar [g], as pointed out by both Rood (2016) and Blevins et al. (2020), is completely predictable. Rood (2016: 235) compiles a list of six forms with prevocalic [b] that suggest possible phonemic status for the voiced bilabial stop in Lakota. These forms are given in (1).

(1) Lakota words with prevocalic [b] (Rood 2016: 235)

   a. *bébela* 'baby'
   b. *ʃkíbibila* 'black capped chickadee'
   c. *bá* 'to blame'
   d. *ábela* 'scattered'
   e. *ka-bú* 'to play the drum' (*ka-* 'by hitting'; *bu-* 'make a hollow noise')
   f. *wahíbu* 'I left to come'

As argued by Rood (2016: 36), for each of the words in (1), there is a factor that may cast doubt on whether [b] is a truly phonological entity. The first form,

Table 2: Inventory of Lakota consonants, after Rood 2016 and Blevins et al. 2020.

	labial	dental/alveolar	post-alveolar (palatal)	velar	glottal
unaspirated voiceless stops and affricates	p	t	t͡ʃ	k	ʔ
ejective stops and affricates	p’	t’	t͡ʃ ’	k’	
aspirated stops and affricates	p^{h}	t^{h}	t͡ʃ ^{h}	k^{h}	
voiced stops	b?			g?	
voiceless fricatives		s	ʃ	x	h
voiced fricatives		z	ʒ	ɣ	
lateral sonorants		l			
nasal sonorants	m	n			
glides	w		j		

bebela, is almost certainly a borrowing from French. The second, *ʃkíbibila*, is apparently an onomatopoetic bird name which in some dictionaries also appears with voiceless stops. The forms, *ba*, *abela*, and *kabu* apparently contain [b]-initial roots. However, the first is not widely known, and the second is shown with [p] in an earlier dictionary (Rood 2016: 36). The final form is described by Rood as archaic. In sum, the relative rarity of the voiced bilabial stop prevocalically suggests marginal, if any, phonological status for the consonant.

Both Rood and Blevins et al. agree that in Lakota, there is no voicing contrast in consonant clusters. An inventory of Lakota monomorphemic consonant clusters, adapted from Blevins et al. (2020: 302), is given in the table in Table 3. Notably, voiceless obstruents can form clusters with each other (e.g. *pte* 'water buffalo'; *tke* 'to be heavy'; *psa* 'reed, straw'; examples from Blevins et al. 2020: 302). However, in two-member clusters, when C2 is a nasal or lateral, C1 underlying voiceless stops surface as voiced stops or nasals (*ble* 'lake', *gma* 'walnut'; Blevins et al. 2020: 302), and phonetically voiceless stops cannot appear in this position. In the table below, the checkmarks indicate sequences involving no changes in consonant quality. The shaded cells indicate gaps in the cluster inventory. Finally, the clusters where voiceless stops surface as voiced are indicated with segmental symbols. What the data from cluster phonotactics clearly shows is that C1 in word-initial clusters does not contrast for voicing.

Table 3: Lakota monomorphemic clusters (C1C2), adapted from Blevins et al. (2020: 302)

	C2									
C1	p	t	k	tʃ	s	ʃ	m	n	l	w
p		✓		✓	✓	✓		mn	bl	
t			✓							
k	✓	✓		✓	✓	✓	gm	gn	gl	gw
s	✓	✓	✓	✓			✓	✓	✓	✓
ʃ	✓	✓	✓	✓			✓	✓	✓	✓
x	✓	✓		✓			✓	✓	✓	✓

Rood (2016) provides some additional cases of changes that suggest a connection between voiced stops and sonorants in Lakota. First of all, there is a rule by which stop + [l] clusters become nasalised when they precede a nasal vowel: *bla* + *ĩ* > *mnĩ (kte)* 'I will go', cf. *bla* 'first person agent' (Rood 2016: 242). Similarly, stops may become allophonically nasalised if they are preceded by a nasal vowel, and are variably realised as: [b, $^{\text{m}}$b], [m$^{\text{b}}$] or [m], [g], [$^{\text{ŋ}}$g], [ŋ$^{\text{g}}$] or [ŋ] (Rood 2016: 239). Finally, Rankin (2001), cited in Rood (2016: 236) observed that the glide /w/ is found before any vowel of the language, except /u/. However, /wu/ sequences instead surface as [bu], although, as reported by Rood (2016: 236), no examples are given. This pattern may be seen to support the claim that the [b] is an underlying sonorant. In attempting to explain the distribution of /w/, positing underlying /b/ would require a rather unnatural rule weakening /b/ to [w] before all vowels except /u/.

While the discussion above raises questions about the phonological status of voiced stops in Lakota, it is worth noting that beyond Lakota, sonorisation of stops is quite a common phonological process. The results of sonorisation can be quite phonetically diverse, ranging from full vocalisation: /p, t, c, k/ [β̞, ə̯, j, ɰ] in Maxakalí (maxa1247; see Gudschinsky, Gudschinsky et al. 1970, Silva 2015, Silva et al. 2020), to consonantal sonorants, as well as fricatives. In fact, in many systems one gets mixed outcomes with both sonorants and fricatives resulting from weakening: /p, t, k, d/ > [ɸ, s, x, ɾ] (Ontena Gadsup (gads1258); Frantz & Frantz 1966, Frantz 1994), or: /b, p, t, q/ > [w, f, r, x] (Seereer Siin, McLaughlin 2000).[2] Each of the cases discussed here may be suggested to fall into the category of lenition, or weakening. Stop weakening is often described as "spirantisation" and it produces fricatives. Often, however, these purported fricatives have such weak noise that they might be better described as approximants. Sonorisation, therefore, as a product of stop lenition is probably even more common than is reported. Spanish "spirantisation" is an example (Salinas 2015), since the "fricatives" [β̞ , ð̞ , ɣ̞] it produces lack robust aperiodic noise and are difficult to distinguish from approximants.

In sum, these cases constitute evidence in support of a strong representational connection between stops and sonorants, which we suggest is exemplified in Lakota. A phonological sketch of that connection is presented in Section 4. At the same time, it is worth noting that sonorisation of stops is incontrovertibly attested in Lakota, since [l] surfaces as the outcome of the "voicing" of final /t/ (see the 2$^{\text{nd}}$ example in Table 1). Therefore, our basic claim is that the phonological change that Blevins et al. (2020) refer to as "voicing" of final /p/ and /k/ is better characterised as sonorisation, even if it results in phonetic stops. In other words, we will build on Rood's position that [b], [l], and [g] in Lakota are phonologically sonorants.

[2]The most distinct aspect of obstruents is their potential for voice contrasts. Laryngeal contrast in sonorants, as in Burmese (Bhaskararao & Ladefoged 1991), is quite uncommon (Maddieson 1984).

At first glance, this appears to be the kind of phonology/phonetics mismatch that is common and expected in Substance Free approaches to phonology (Hale & Reiss 2008, Blaho 2008, Chabot & Scheer 2019). These approaches argue against the incorporation of phonetic considerations into models of phonological representation or computation. Since [b, l, g] apparently constitute a phonetically unnatural class, their parallel behaviour in Lakota might be taken as evidence in support of such an approach.

At the same time, in Section 4, we show that from the perspective of models in which segments are split into smaller structural entities (e.g. Steriade 1993, Schwartz 2016), the phonological commonalities of Lakota [b, l, g] may be linked to explicit phonetic properties. Phonologically, all three of the sounds may be unified as redundantly voiced segments with occlusion, whereas the noise bursts of [b] and [g] are phonetic details that are not encoded in the representation. In the case of [b], the exclusion of the release burst may stem from a phonetic universal by which labially produced noise is weak in amplitude, hence the typological rarity of bilabial fricatives (Ladefoged & Maddieson 1996). In the case of [g], the exclusion of the burst may stem the fact that the noise spectrum of dorsal releases is highly context-dependent (Stevens 1998). For the phonology of Lakota, it may therefore be preferable to treat the burst as a redundant feature, rather than attempt to interpret its acoustic variability.

2.3 Final obstruents in Lakota: A unified process of weakening

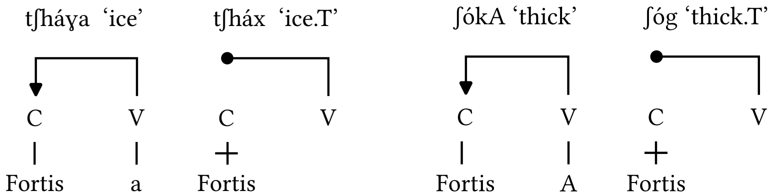
At this point we proceed to one of the more interesting aspects of final obstruents in Lakota – the asymmetrical behaviour between final stops and final fricatives – an issue that Blevins et al. (2020) do not attempt to explain. Fricative obstruents are unambiguously contrastive for laryngeal features prevocalically, as shown in (2). However, this contrast is neutralised in coda and final positions in truncated forms in (3) (some with reduplicated roots), where fricative obstruents surface phonetically as voiceless (examples from Blevins et al. 2020: 300). A comparison of the examples in (3) with those in Table 1 makes it clear that while final stops in Lakota apparently show voicing, final fricatives undergo devoicing.

(2)	/si/	‘foot’	/zi/	‘yellow’
	/ʃota/	‘smoke’	/leʒa/	‘urinate’
	/xolya/	‘being gray’	/ɣopa/	‘snore’
(3)	/tʃhaɣa/	‘ice’	/tʃax/	‘ice’
	/leʒa/	‘urinate’	/leʃleʒa/	‘urinate often’
	/koza/	‘wave’	/koskos/	‘wave’

Since stop voicing and fricative devoicing happen in the same position, it is desirable to provide a unified phonological explanation for both cases.

The first step in this explanation is to adopt an assumption that both stop voicing and fricative devoicing occur in what might be considered a phonologically weak position – the coda of a syllable, either word-finally, or in the C1 position of consonant clusters. The unity of these positions may be envisioned in a Strict CV approach (Ségéral & Scheer 2001, Scheer 2004), which posits that phonological structure is made of an alternating string of onsets and nuclei (C and V slots). Under this view, all consonants are obligatorily followed by a V-slot, which "licenses" them. However, in the case of non-prevocalic consonants, V-slots are empty and cannot "license" their onsets, which renders them weak. In this way, the commonalities between syllable codas in word-final position and C1 in two-member consonant clusters fall out directly from the postulates of the model. In each case, an onset is "unlicensed". More traditional approaches cannot provide this unity – it must be stipulated, since they contain no representational link between clusters and codas.

A Strict CV visualization of phonological weakness is shown in Figure 1. There we see a unification of environments where the obstruent's laryngeal feature ([fortis]; for discussion of this choice of specification, see Section 3) is permitted when licensed by an adjacent filled V-slot. As we see in Figure 1, [fortis] cannot be licensed before an empty V-slot and it is consequently deleted, which is shown by the crossed-out association lines.

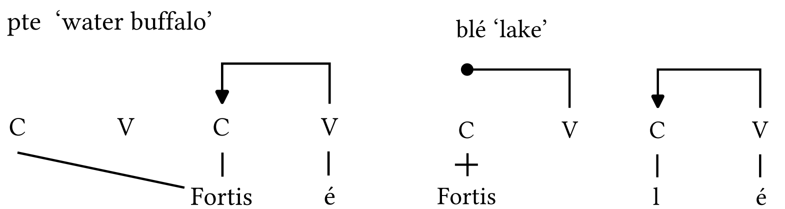


(a) Fricative (b) Stop

Figure 1: Laryngeal specification licensing – a visualization in the Strict CV framework (T indicates "truncated", as shown in Table 1 and example 3)

In Strict CV, when a phonological feature is licensed, it may spread to unlicensed positions. This is shown in the representation of two-member clusters in Figure 2. C1 is unlicensed since it is followed by an empty V-slot, and thus cannot support a laryngeal contrast. Meanwhile, C2 is licensed by the filled V-slot to its right. Consequently, the C2 [fortis] specification of /t/ in *pte* 'water buffalo' is in a strong position and is allowed to spread to /p/. By contrast, in *ble* ‘lake’ the C2, a sonorant, has no laryngeal specification, while the C1 stop is unlicensed, so the entire cluster is cannot support a laryngeal feature.

In looking at Figure 1, the reader might notice that removing [fortis] results in voicing in stops, but devoicing in fricatives. We take up the question of how this is possible in Section 3 and Section 4. In Section 3, we show how to characterise the laryngeal specification properly, while in Section 4 we show how weakening leads to devoicing in fricatives and voicing in stops. In Figures 1 and 2, we merely offer a visualization of phonological strength, for which Strict CV is well suited. At the same time, Strict CV is not well-equipped to deal with the asymmetry between stops and fricatives. For this purpose, in Section 4, we adopt the representations of the Onset Prominence framework (e.g. Schwartz 2016), in which manner of articulation is represented structurally (cf. Steriade 1993).[3]



(a) Obstruent (b) Sonorant

Figure 2: C1C2 clusters and lenition

In the meantime, it is worth noting that if we accept Blevins et al.’s (2020) interpretation and posit final voicing as a phonological rule, we would need two separate and contradictory rules to handle the processes, one of fricative devoicing and one of stop voicing. By contrast, in Figures 1 and 2, we show how these processes may be unified as loss of a specification in weak position. The table in Table 4 summarises our perspective on phonological strength and weakness in

[3]Reviewers and editors of this chapter have commented on the fact that we use two separate representational models (Strict CV and OP) to explain the Lakota voicing data. There are number of arguments why this choice has been made. First of all, Strict CV would require stipulation to deal with the manner-based asymmetry, a phenomenon for which OP is well-suited to describe. At the same time, OP’s phonotactic mechanisms would be required to explain the cluster data, and these mechanisms are sufficiently complex so as to require a much longer introduction than would be desirable for a volume such as this. Strict CV is more economical for showing a unified view of phonological weakness. At the same time, it should be mentioned that Strict CV and OP share the important assumption that all consonants are “onsets” by default, and that this onset status is built into their representations, rather than being derived by some sort of “syllabification” rules.

Lakota. Voiceless stops weaken to what might be called "hard" sonorants (pronounced as stops in the case of the labial and velar), while fricatives lose their laryngeal contrast in favour of the voiceless series.

Table 4: Lakota consonantal lenition – strong and weak positions

Strong		Weak	
Laryngeal contrasting fricatives	s, ʃ, x, z, ʒ, ɣ	Neutralised fricatives - voiceless	s, ʃ, x
Voiceless stops	p, t, k	"Hard" sonorants	b, l, g

3 Voiced can be unmarked

One of the most provocative and insightful aspects of Evolutionary Phonology is the elimination of markedness as an element in phonological grammars. The term "markedness", of course, has been used to mean many different things (for discussion, see Hume 2011). The meaning excised from Blevins' model is that of "less optimal". That is, for Evolutionary Phonology, phonological processes are not goal-oriented – they do not serve to make sound systems more optimal, contrary to what is assumed in theories such as Optimality Theory (Prince & Smolensky 1993).

Without markedness, Evolutionary Phonology suggests that there is no a priori expectation for final voicing to be any "worse" than final devoicing. Rather, the typological rarity of final voicing is attributed to phonetic factors that work against the evolution of such a pattern. For the most part, we are sympathetic to this outlook – markedness is a concept that we feel has been overused (again, see Hume 2011), and phonetics may indeed explain a lot of sound patterns. For that reason, in the privative frameworks in which we work, markedness per se has no formal status. Instead, a more explicit designation is employed – a given entity may be phonologically specified or unspecified. This strategy makes no reference to typological frequency, difficulty in production, or other factors that are traditionally associated with markedness, but are often contradictory in nature (again, see Hume 2011). We therefore use the term "unmarked" synonymously with "unspecified", raising the question of what an unspecified phonological object may look like phonetically. In the case of obstruent voicing, a mainstream tradition (see e.g. Beckman et al. 2013) tells us that voiceless is unspecified. Here we offer arguments that the opposite may be true.

Assuming that phonological specifications reflect observable phonetic properties, a natural conclusion is that voicing during the production of obstruents should reflect the presence of a phonological feature [voice]. In this sense, any systemic change in whether phonation is observed, be it voicing or devoicing, should constitute a phonological process. If we are to accept this proposition, final voicing in Lakota would certainly qualify for phonological status. However, when talking about "observable phonetic properties", we need some kind of a reference point. If our reference point is silence, then periodicity in stop closures is clearly an observable property. A question which is not often asked, however, is whether silence is an appropriate reference point. Silence is a property of voiceless stop closures, which act as crucial acoustic "landmarks" for listeners in parsing the signal to access linguistic content (see Stevens 2002). Therefore, it is reasonable to suggest that silence is an observable phonetic property itself, rather than a reference point.

An alternative view of acoustic reference points for phonological features is offered by Traunmüller's (1994) Modulation Theory, in which linguistic content, including phonological features, is encoded as modulations of a carrier signal. According to Modulation Theory, the ideal carrier is a voiced, schwa-like vocoid with evenly spaced formants. This vocoid serves as acoustic background for the transmission of an utterance and bears phonological features, as well as extra-phonological information such as the speaker's age, sex, or emotional state. Since the carrier is voiced, periodicity by itself, at least during stop closure, is not a modulation, and voicing is not a good candidate for phonological status. If this idea is taken to its logical conclusion, we must assume that voicing processes in stops entail the loss of specification.

The claim that voiced consonants are phonologically unspecified is widely accepted for so-called "aspirating" languages such as English and German (Iverson & Salmons 1995). In these languages, it is aspirated stops that are assumed to bear a phonological feature. By contrast, for so-called "voicing" languages such as Polish or French, many scholars (see discussion in e.g. Beckman et al. 2013) assume that voiceless obstruents are unmarked, and that voiced obstruents are specified with a feature [voice]. At the same time, however, this question is far from being settled. In particular, a number of recent proposals have argued that fully voiced obstruents are unspecified in Hungarian (Blaho 2008), Breton (Iosad 2012), Southwest Polish (Cyran 2014), Dutch (van der Hulst 2015), and Italian (Balogné Bérces & Huszthy 2018).

The representational claim in the proposals mentioned above is compatible with phonetic evidence on the perception of voice contrasts in voicing languages. For example, in languages such as Polish and Dutch, a lack of phonetic voicing typically does not induce voiceless percepts (van Alphen & Smits 2004, Schwartz & Arndt 2018, Schwartz et al. 2019). In this connection, VOT (voice onset time) category boundaries between /p t k/ and /b d g/ are often safely above zero. In Dutch, Spanish, and Japanese (Flege & Eefting 1987a,b, Wilson & Hashimoto 2013), for example, a voiceless stop with VOT of around 20 ms, but with F0 and F1 cues matching those of voiced stops, is not in fact perceived as voiceless. If the contrast were based on [voice] and VOT, we would expect the category boundaries of zero, and all items without pre-voicing to be perceived as voiceless. Additionally, in two-series laryngeal systems, equivalence classification (Flege 1987), by which bilinguals and L2 learners confuse phonetic categories between languages, is consistently greater for the voiced series than for the voiceless series (see Schwartz 2022 for discussion). Taken together, these findings suggest that lenis stops are phonologically equivalent in voicing and aspiration languages, regardless of whether they are in fact voiced. Since no one denies that lenis stops in aspirating languages are unspecified, we must conclude the same for fully voiced stops.

A question that immediately arises with regard to this claim concerns cases of regressive voicing assimilation, which is attested only in languages with fully voiced stops (van Rooy & Wissing 2001, Wetzels & Mascaró 2001). Textbook treatments (see e.g. Gussenhoven & Jacobs 2017) of this phenomenon assume a process by which a [voice] specification spreads from C2 to C1 in the cluster, implying that [voice] must be an active phonological specification. In other words, the question may be formulated as follows: how can you have regressive voicing without a feature [voice]?

There are a number of problems with the textbook interpretation that can be gleaned from a careful phonetic study of the process. First of all, based on findings from Dutch and Hungarian (Jansen 2004) it appears that the neutralization that is said to occur from regressive voicing is phonetically incomplete. Even when phonetic voicing is present in these contexts, the underlying voicelessness of C1 is observable in other acoustic parameters such as F0 and burst amplitude. If regressive assimilation took place according to the textbook depictions (such as Gussenhoven & Jacobs 2017), we would expect complete neutralization in these contexts, wiping out all the cues to voicelessness, rather than just the lack of voicing in the closure. An additional fact about regressive voicing contexts is that the actual source of voicing in C1 of obstruent clusters is the preceding vowel, rather than C2. That is, voicing always "bleeds" (see Davidson 2016), or spills over, from the preceding vowel into the cluster. An illustration of voicing bleed is shown in an acoustic display in Figure 3 below. The figure shows a case of putative regressive voicing assimilation (t → d/_d) in Polish *zbyt długo* [zbɨd dwugɔ] 'too long' (after Schwartz 2019). In the figure, it is clear that there is phonetically more voicing in C1, the supposed "target" of assimilation, then there is in C2, the supposed "trigger". The closure of C1 is fully voiced, while voicing bleed from the preceding vowel ceases about halfway through the closure of C2. Phonetic studies that have compared the amount of voicing in C1 vs. C2 in assimilation contexts (Hallé & Adda-Decker 2011, Schwartz 2019) have consistently found more voicing in C1 than in C2.

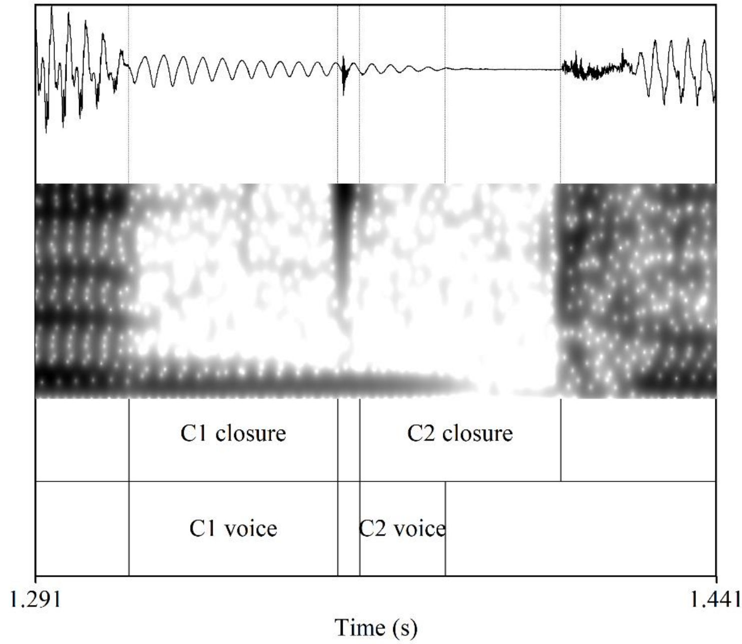


Figure 3: Acoustic illustration of regressive voicing in Polish *zbyt długo* [zbɨd dwugɔ] 'too long' (after Schwartz 2019). The top tier shows closures of final /t/ and initial /d/. The bottom tier shows the voiced portions of those closures.

The aforementioned textbook representation of regressive voicing implies a claim that [voice] spreads from right to left. However, what is clear from the studies described above and visible in the acoustic display in Figure 3, is that in putative regressive voicing contexts, phonetic voicing spreads from left to right.[4] Thus, if we accept the textbook account, we are forced to claim that phonetic and

[4]This is to be expected considering the aerodynamics involved in phonation – the constrictions of two consonants lead to an increase in pressure in the supralaryngeal cavity, hindering transglottal airflow (see e.g. Stevens 1998, or any textbook that discusses the aerodynamics of phonation). As a result, as pressure increases, phonation ceases gradually and cannot restart until the constriction is released.

phonological voicing processes show completely opposite directionality. While we accept that phonology can and does undo phonetic processes, we are not comfortable with the claim that phonology can reverse the direction of a phonetic process. The textbook representation of regressive [voice] spreading, however, implies that we accept just such a claim. In sum, the phonetic evidence, and the desire to avoid controversial claims about the phonetics-phonology relationship, suggest an interpretation that regressive voicing is a phonetic rather than a phonological process, despite the conventional accounts of phonological spreading.

The discussion above, which may at first glance seem like something of a digression, is intended to provide insight into phonetic voicing processes more generally. In particular, we have shown how basic phonetic principles can support a claim that phonetically voiced stops need not be phonologically voiced. Regardless of the status of [voice] in voicing languages, Lakota appears to have more in common with aspiration languages, as pointed out by Rood (2016), since aspiration is contrastive in its stop system, while voicing for the most part is not. There is, therefore, no reason to assume that [voice] is active in the phonology of the language. Rather, it appears as if obstruents are specified for a feature denoting voicelessness. Lakota is unusual in that this feature produces phonemic contrast in fricatives, but apparently not (or only marginally) in stops. Without a feature [voice], the phenomenon of final voicing, described by Blevins et al. (2020), cannot qualify as a phonological process of voicing. It must be something else. To complete the story about Lakota, we need to examine the representational connections between obstruents and sonorants, which is the focus of the following section.

4 The phonological structure of consonants in Lakota

Since we have suggested that a feature [voice] may be absent from two-series laryngeal systems, despite the well-known opposition between voicing and aspiration languages, an obvious question that arises is how to account for the voicing-aspiration distinction without recourse to a feature [voice]. A possible solution is offered by representational models in which obstruents are divided into smaller structural units, such as Aperture Theory (AT; Steriade 1993) or the Onset Prominence framework (OP; see Schwartz 2016, 2017). In both of those models, a stop consists of multiple positions corresponding to the closure and release phases in their production. One of these positions, derived from the transition from a stop to the following vowel (A_{max} in AT; Vocalic Onset, or VO, in

OP), is voiced by default. In essence, this position may be interpreted as part of the acoustic carrier signal, as envisioned in Modulation Theory and discussed in the previous section. Voicing during closure in stops, when it occurs, need not denote the presence of a phonological feature, but rather the emergence of the carrier in the absence of a salient modulation, i.e. a feature denoting voicelessness. Meanwhile, unvoiced /b, d, g/ in aspiration languages, such as English, are attributable to aerodynamic constraints on phonation. In most aspiration languages (but see Helgason & Ringen 2008 on Swedish, or Jacewicz et al. 2009 on Southern US English), there is no motivation to overcome these constraints, since the timing of the laryngeal feature induces long VOT and a perceptually robust contrast even in the absence of voicing (see Schwartz 2017, 2022 for further discussion of two-series laryngeal typology).

Now we are ready to describe voicing phenomena in Lakota. This will be done using Onset Prominence representations. Before proceeding, we offer a brief introduction to the model; see Schwartz (2016, 2017) for a more thorough presentation. Onset Prominence representations are derived from a hierarchy of phonetic events associated with a stop-vowel sequence, typologically the most common "syllable" type across languages. The fundamental building block in OP is, therefore, a prosodic unit, a stop-vowel CV that provides the material from which "segmental" representations may be constructed. The stop-vowel hierarchy is shown in the tree structure on the left in Figure 4. Each layer of the tree on the left in Figure 4 is labeled for the phonetic event in the stop-vowel sequence from which it is derived. At the top of the hierarchy is Closure (Closure; C), the defining property of stops. The next level down is Noise (N), which is derived from aperiodic noise associated with stop release bursts, affrication, aspiration, and frication. Below Noise is the Vocalic Onset (VO) level, derived from the CV transition in the stop-vowel sequence and reflecting its periodicity and formant movement. At the bottom of the hierarchy is the Vocalic Target (VT) node, which encodes the more or less steady formant targets associated with vowels.

The structures in Figure 4 reveal the OP perspective on the relationship between prosodic and segmental units in phonology. From the tree on the left, categories of manner of articulation are derived, as shown in the remaining five trees. These categories are defined in terms of binary nodes which encode the phonetic events from the stop-vowel hierarchy that are present in the articulation of a given segment type. By contrast, unary nodes appear when the event associated with the given level of the hierarchy is absent. For example, stops contain closure, noise, and release, so their top three layers are binary in Figure 4. Nasals lack noise bursts, so their Noise node is unary, fricatives lack closure as shown by their unary C node, and so on.

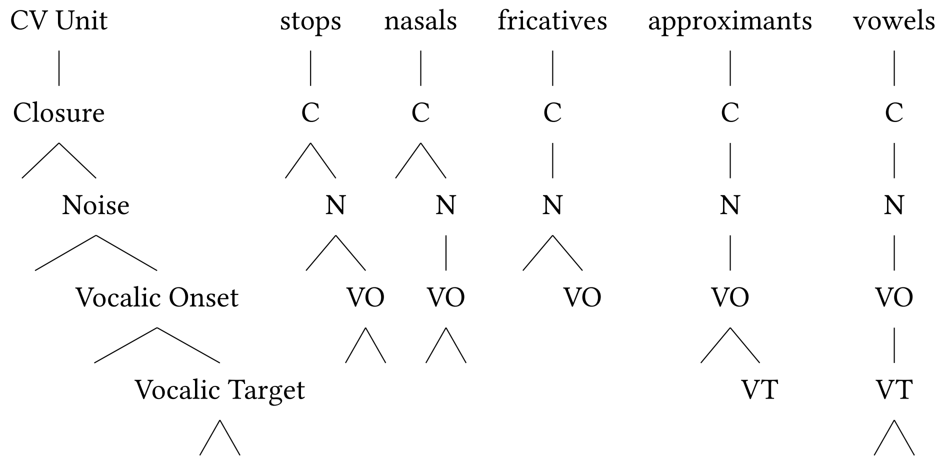


Figure 4: The Onset Prominence hierarchy (left) and OP manner categories (the following five graphs)

In the OP framework, place and laryngeal specifications are encoded as feature annotations to the terminal nodes of the tree structures. As mentioned in the previous section (see also Schwartz 2017), the laryngeal specification we assume is a single [fortis] feature. Therefore, in a two-series "voicing" language, the opposition between /b, d, g/ and /p, t, k/ would be that the latter contain [fortis], while the former are unspecified. As a result, the annotation would appear as [fortis]/∅ on the VO node.[5]

Now we may turn to the link between stops and sonorants in Lakota. This is shown in the representations in Figure 5. They first show the structure of stops in most languages, where stops contain Closure (C), Noise (N), and Vocalic Onset (VO) nodes, second, sonorant-like stops in Lakota, and third, nasals/laterals as they appear in most languages.[6]

For OP, the difference between stops and sonorants lies in the status of the Noise node. In sonorants, the node is absent, and in the representations in Figure 5, it is absent from phonetic stops in Lakota. Therefore, the question that

[5]Although the representation of Lakota aspirates and ejectives is orthogonal to the discussion in this chapter, we may speculate about how best to represent them. Aspirated stops, would assign [fortis] to the Noise node, while ejective stops would either assign [fortis] to the Closure node, or require an additional [constricted glottis] feature on the VO node.

[6]In OP, whether or not laterals contain the Closure node corresponds to the variable status of /l/ with respect to the feature [continuant]. This point is orthogonal to the discussion here, since in OP it is the Noise node that is responsible for the sonorant-obstruent distinction.

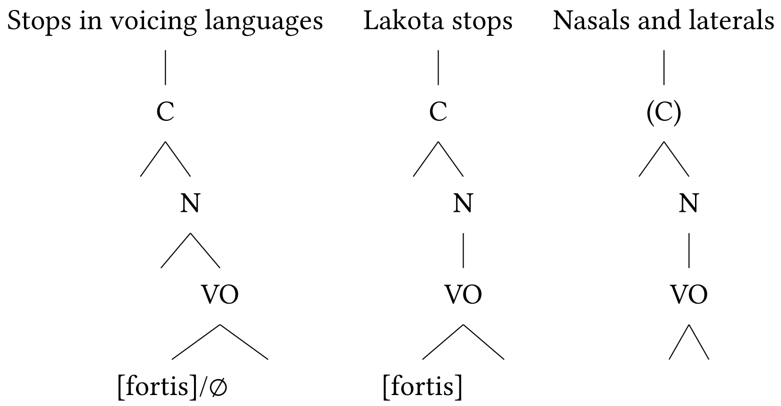


Figure 5: OP structures for stops in typical voicing languages, Lakota stops, and nasals/laterals

must be addressed is how an integral part of the phonetic production of stops, the noise burst, may be eliminated from the representation. A simple phonetic explanation presents itself. Stop release bursts are transient acoustic events that are extremely short in duration (Stevens 1998: 348). This is in contrast to other aperiodic noise events following stop release, including frication, aspiration, and affrication, which last much longer. Thanks to this transience, we can identify a clear phonetic underpinning to the claim that non-aspirated stops in Lakota may lack a Noise node – the bursts may not be acoustically robust enough to be represented.[7] Additional motivation for this postulate may be found in light of the fact that Lakota also contains aspirated stops and ejectives, which produce more robust aperiodic noise. The prominent noise associated with aspirates and ejectives may serve to reduce the perceptual robustness of the noise associated with non-aspirated pulmonic stops.

[7]This postulate, in turn, raises an additional question of why stops in most languages are assumed to contain the Noise node (cf. Aperture Theory, in which stops do not contain A_f corresponding to frication.). One answer to this question is that the default phonetics-phonology mapping in OP is transparent – stops without the Noise node present an opaque mapping and should be uncommon. Another answer concerns the representation of spirantization processes by which stops are lenited into fricatives – this process may be represented in OP as the loss of the Closure node (e.g. Schwartz 2016: 45), while the fricative that remains of course contains Noise. It is for this reason that OP is preferable to Aperture Theory (Steriade 1993), in which A_f is absent from the representation of stops. That is, in AT, stops contain no aperiodic element, which greatly complicates the representation of spirantization processes, in which both input and output contain such an element.

The postulate that stop release bursts may be ignored for phonological representation is not as radical as it may seem. For an analogical case, consider voicing in vowels. In most languages, specific aspects of voice quality (stiffness, slackness, creak, etc.) are not perceived as part of a vowel's phonological representation in terms of location on a two-dimensional F1/F2-based vowel chart. Yet vowels across languages are overwhelmingly voiced. Thus, we may assume that voicing itself is a phonetic enhancement mechanism, which renders the formants that define vowel quality more perceptually robust. Likewise, we suggest the need for phonetic enhancement may turn Lakota sonorants into stops.

With the stop-sonorant connection in place, we consider what happens in final position in Lakota, which is also somewhat unusual from the OP perspective. The VO node in OP representations derives from the CV transition of a stop-vowel sequence. In final position, we may expect this node to be absent. This gives rise to neutralization, since VO is the node which houses the feature denoting a laryngeal contrast. Alternatively, if the laryngeal contrast is maintained, we may assume the VO node has been reconstructed (see Schwartz et al. 2021). Voicing of stops in Lakota arises from a slightly different process. Instead of neutralization targeting the structural node, it removes the [fortis] feature, but leaves the VO node intact. What is left is representationally equivalent to the sonorant in Figure 5, and is phonetically voiced. This is shown in representations in Figure 6.

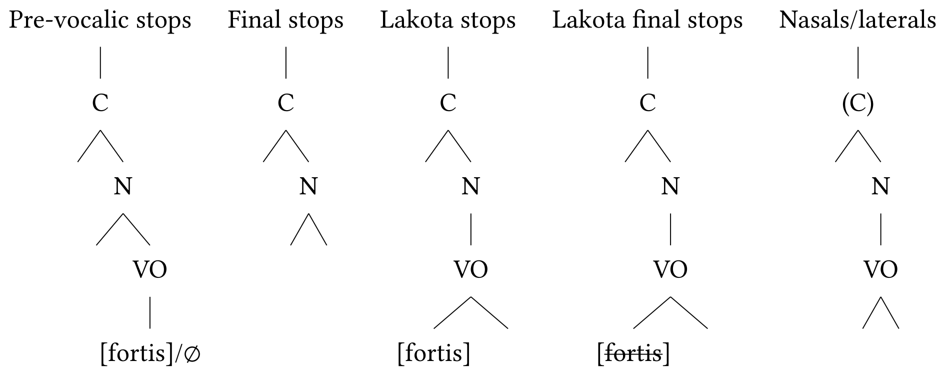


Figure 6: Initial vs. final position for stops and nasals/laterals: Lakota vs. most languages

OP's structural interpretation of manner of articulation provides insight into Rood's claim that voiced stops in Lakota are in fact sonorants, which is reflected in the fact that final /t/ is voiced to [l] and not to [d]. Importantly, the OP perspective shows how confusion can arise between stop and sonorant categories, which in OP are constructed from the same representational materials. The phonological link between stops and sonorants is evident in the representations in Figures 5 and 6. Each contains Closure and VO nodes, so it is a simple matter to envision confusion between voiced stops and sonorants. Indeed, as discussed earlier, the sonorization of stops is a commonly attested process.

At the same time, assuming we are correct and (unaspirated and pulmonic) stops in Lakota are indeed phonologically equivalent to sonorants, it is worth considering possible explanations or interpretations for what appears to be a relatively unusual mismatch between the phonological representation and the acoustic signal. One possibility, mentioned earlier, is that the release bursts associated with the stop productions constitute a phonetic enhancement device aimed at preserving the structure of the consonant. In final voicing contexts, this may be thought of as a compensation for the loss of the [fortis] specification. In other words, producing non-phonological release bursts prevents further weakening, or even deletion, of the consonant. In this connection, it is worth emphasizing once more the fact that /t/ is voiced to [l] rather than to [d]. Weakened coronal stops have a tendency to be realised as flaps, non-sibilant fricatives, or weak approximants, which from the perspective of OP would presumably entail the loss of the Closure (and sometimes Noise) node. The lateral realization serves to preserve the (medial) Closure of a coronal stop, which would otherwise be susceptible to weakening. This step is of course not feasible in the case of labials and velars, so they surface as voiced stops to preserve their structures shown in Figures 5 and 6.

In the representations in Figure 6, we also gain some insight into the OP perspective on phonological strength and weakness, which is somewhat more intricate than the "licensing" approach in Strict CV described in Section 3. In essence, the larger the structure and the more feature annotations it contains, the stronger it is. A prevocalic stop (the leftmost tree in Figure 6) encodes the CV transition as the VO node. This node may be absent from final and pre-consonantal positions (the second tree from the left in Figure 6). The loss of the VO node may be thought of as a form of weakening. An alternative option in the model posited in Figure 6 for Lakota (the third tree from the left), is that a feature specification may be lost but the structural node is preserved. In Figure 6, therefore, we can see that there are multiple mechanisms that may be described as weakening in OP, each with a different output.[8]

[8]A third mechanism, not shown in Figure 6, is to trim the tree from the top, turning binary nodes into unary ones. For example, taking a binary Closure node and making it unary provides a natural expression of spirantization processes that are common in intervocalic position. Since we are dealing with final position here, a thorough discussion of intervocalic position is beyond the scope of this chapter.

The final aspect of Lakota voicing neutralization that must be accounted for is the asymmetry between stops and fricatives. This is shown in the representations in Figure 7. Note that stops and fricatives in Lakota in Figure 7 differ with regard to whether the VO node is present. Recall that VO in OP representations derives from the CV transitions of consonants in "onset" position. These transitions are crucial for consonant perception in the case of stops, considering the transient acoustic nature of stop releases (Wright 2004). By contrast, fricatives contain robust "internal" acoustic cues to their identity (Wright 2004). As a result, listeners are less reliant on the CV transition for fricative identification, and so their phonological representation is more likely to lack the VO node. Because of this, both initial and final fricatives in Lakota contain only a Noise node, which can and does support a laryngeal contrast.

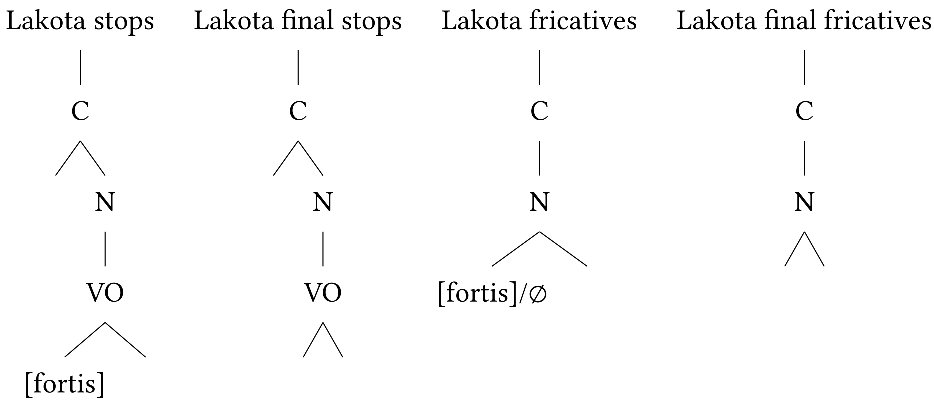


Figure 7: Stops vs. fricatives in Lakota

The representational postulates in Figure 7 explain the asymmetry between stop voicing and fricative devoicing in Lakota. Unlike VO, which is voiced by default since it derives from a voiced part of the signal, the Noise node is by default voiceless. The reason is that a constriction sufficient to induce frication noise hinders airflow through the glottis and voicing. In this connection, if we consider Modulation Theory's notion of an acoustic carrier from the perspective of OP, we can arrive at a situation in which laryngeally unmarked stops can be voiced since they contain VO, but unmarked fricatives can be voiceless because they do not. As a result, the loss of the [fortis] feature surfaces as voicing in stops with a preserved VO node, but devoicing in fricatives. To make such an analysis possible, we must assume that the [fortis] feature is an abstract entity, whose phonetic realization is dependent on the level of the OP hierarchy at which it occurs.

The take-home message from the phonological perspective presented in this chapter is that that the neutralization patterns observed in Lakota may be thought of in terms of weakening or loss (cf. Harris 2009) of a representational primitive. We are not talking about phonological voicing or devoicing processes here, since we do not posit a [voice] feature that corresponds to any unified phonetic correlate. Rather, the phonetic effects of neutralization differ as a function of a manner of articulation, which is represented structurally in the OP model.

A final point to consider in this discussion is how more traditional approaches might handle the Lakota facts. If we assume, as Blevins et al. do, that final voicing in Lakota is a process that is phonological in the traditional sense, an Optimality Theory analysis would have to posit an empirically unmotivated constraint *VoicelessCoda, which outranks *VoicedCoda, but only when the obstruent is a stop and not a fricative. Clearly, there is no way such an analysis could work without a great deal of questionable stipulation. Rood's solution to this problem, as outlined above, is based on a classification of Lakota stops as sonorants, a claim with which we agree. Our primary critique of Rood's solution is that he provides no explanation of the origins of the representations he adopts. That is, while observing the phonological connection between stops and sonorants in Lakota, he offers no story about how stops and sonorants may be linked representationally.

5 Conclusion

This chapter has shown that, in Lakota, both final voicing of stops and final devoicing of fricatives may be easily analysed as the result of a weakening process in which a phonological specification is lost. Our fundamental claim in this regard is that the feature [voice] is not active in the phonology of Lakota. Therefore, what Blevins et al. (2020) observe in their phonetic study cannot be not a case of phonological voicing. A more fundamental contribution of this chapter is the perspective it provides on how mismatches can arise between phonological category membership and phonetic realization. Such cases often involve attributing phonological status to something that is absent in the acoustic signal, a strategy which underlies e.g. the commonly-invoked "empty nucleus" postulate. Final voicing in Lakota, however, requires the opposite strategy – suggesting that something present in the acoustic signal is not a phonological entity. Pulmonic stop release bursts, which are present in the acoustic signal, appear to have no phonological status in Lakota.

It has been also shown in this chapter, we hope successfully, that when a given phonetic property lacks phonological status, it need not be the case that there is a mismatch between phonetics and phonology. In other words, phonetic considerations may in fact underlie the non-phonological status of a given phonetic property. We suggest that pulmonic stop release bursts in Lakota, instead of comprising part of the phonological representation of a consonant, constitute a phonetic enhancement device to preserve a weakened consonant from further weakening or deletion. This hypothesis underlies the stop-sonorant connection that explains both the final voicing of Lakota stops and the difference in behaviour between final stops and fricatives in Lakota. More generally, we suggest that a deeper understanding of phonological diversity in the languages of the world requires an approach based on refined phonological representations that directly encode positional and contextual effects, as well as perceptual ambiguities found in the acoustic signal.

List of abbreviations

AT	Aperture Theory
C	Closure node (in Onset Prominence framework)
N	Noise node (in Onset Prominence framework)
OP	Onset Prominence
VO	Vocalic Onset node (in Onset Prominence framework)
VOT	voice onset time
VT	Vocalic Target node (in Onset Prominence framework)

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Part III

Rare prosodic phenomena

Chapter 7

Typology and evolution of minimal vowel systems in Central Chadic (Afroasiatic)

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The chapter summarises arguments and presents selected data in support of the reconstruction of a minimal vowel system *a, *ə for the proto-language of the Central branch of the Chadic language family within the Afroasiatic phylum. In this system, */a/ is the only vowel phoneme and *ə is a non-phonemic "intrusive" vowel. *i and *u occur in phonetic surface realisations representing not separate phonemes but conditioned allophones of the approximants *j and *w.

Certain reconstructed segments may "prosodise" by dissociating from articulatory features, which turn into "floating" suprasegmental features (= "prosodies") that re-associate with other segments within the word. Thereby, labialisation and palatalisation create, by raising, fronting and back-rounding, prosody-induced "colourings" of other segments. These diachronic processes yield a plethora of phonetic surface realisations of vowels and (new) series of palatalised and labialised (but also prenasalised and glottalised) consonants in the modern languages, quite a few of which are characterised by very rich surface consonant inventories and multi-vowel systems.

The chapter discusses the evolution of the minimal vowel system in Proto-Central Chadic in cross-linguistic typological perspective and points out potential implications for the reconstruction of Proto-Afroasiatic. The chapter tentatively proposes a speculative hypothesis according to which the ultimate common proto-language may have been completely "vowelless".

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1 Introduction

1.1 Aims and focus

This paper focuses on typological and historical insights gained from the internal and comparative reconstruction of vowel systems in the languages of the Central (also referred to as "Biu-Mandara") branch of the Chadic language family in West and Central Africa. Until quite recently, vowels in Chadic languages were considered to be nearly impossible to reconstruct by the application of a classic comparative method under the Neogrammarian Hypothesis, because of an apparent absence of regular sound correspondences of vowels between pairs of languages. In the available literature (e.g. Newman 1977a, 2006, Jungraithmayr & Shimizu 1981, Stolbova 2016, Wolff 2017), therefore, there is hitherto no consensus on the number, quality, and distribution of contrastive vowels with regard to lexical reconstructions for common Proto-Chadic (PC) or even those for individual branches of the family, such as Proto-Central Chadic (PCC). Severe analytical problems result from the fact that present-day Chadic languages are synchronically described as possessing any number between one (always /a/) and 17 short and long oral vowels (Wolff 2017). So far, no overarching theoretical and typological account has been proposed that would provide a coherent relationship between the highly different synchronic vowel systems that one finds in Chadic languages, not to mention a satisfactory historical account of how these various synchronic systems have developed from a common proto-language. This deplorable lack of solid lexical comparisons and reconstructions from Chadic continues to have negative effects also on the reconstruction of the deepest proto-language, Proto-Afroasiatic (PAA), which is genetically ancestral to Chadic (Greenberg 1963, Newman 1980).

The paper explores and summarises the diachronic hypotheses which allow the reconstruction of a historical scenario of vocalogenesis. According to this scenario, the common proto-language (PC) was characterised by a minimal vowel system. This system then historically underwent various processes of phonologisation of (i) allophones of segmental phonemes, and (ii) variants of an almost fully predictable pro- and epenthetic vowel schwa. The synchronic reflexes in modern Chadic languages are multi-vowel systems. Some modern languages, however, have retained variants of the original minimal vowel system. The proposed historical scenario of vocalogenesis would explain the considerable typological variation of vowel systems in modern Chadic languages, which has hitherto intrigued and frustrated researchers.

After addressing the central notion of a minimal vowel system (Section 1.2), the paper briefly introduces the Central Chadic languages (Section 1.3). It then sketches out a number of non-trivial characteristics of Central Chadic phonology and introduces a non-canonical ("prosodic") methodological approach to Chadic phonology, which is argued to best capture both synchronic and diachronic features of this language family (Section 1.4). The introductory section closes with a short illustration of a multi-tiered approach to Central Chadic phonology (Section 1.5).

In Section 2, the paper focuses on the vocalic domain in Central Chadic languages and its segmental and salient suprasegmental ("prosodic") units. This section aims to show why and how a non-canonical prosody-based approach allows relevant generalisations concerning the underlying phonological system that are missed by non-prosodic approaches.

In Section 3, the paper embeds the results and insights gained from the prosody-based phonological analysis of the vocalic domain in Central Chadic within a global cross-linguistic typological survey of minimal vowel systems. The section ends with an outlook on the implications for historical typology of Afroasiatic vowel systems and suggests directions for further typological and comparative research.

Section 4 presents a short summary.

1.2 Minimal vowel systems as "rarities" in cross-linguistic perspective

Since early works by Trubetzkoy (1925, 1939) on vowel systems, as well as those by Jakovlev (1923) and particularly Kuipers (1960) on Northwest Caucasian Kabardian, so-called minimal vowel systems have received controversial interpretations in phonological theory. They might be considered phonological rarities. While all natural human languages would appear to possess vowels in phonetic surface realisations, this is arguably not so on increasingly abstract levels of phonological representation. In the presence of only one or no phonemic vowels at all in individual languages and language groups, the notion of vowel system as such and the universal existence of vowel systems in human languages becomes disputable. One-vowel and no-vowel phonological inventories for individual languages and language groups have been postulated cross-linguistically in the past (see Section 3), but have almost automatically provoked doubt and alternative proposals; see Anderson (2016: 59–117) for a survey of literature on minimal vowel systems in typological perspective.[1]

Minimal vowel systems have been described for individual languages or small groups of languages in diverse parts of the world (for details and sources see

[1]The author acknowledges valuable comments by Cormac Anderson, one of the editors of the present volume, on an early version of this paper.

Section 3): Northwest Caucasian (Kabardian, Abkhaz, Ubykh); Goidelic (Modern Irish); languages of Papua New Guinea (Sepik-Ramu: Ndu; Nor-Pondo: Yimas; Piawi: Haruai); Marshallese; Chinese languages (including Mandarin); Upland Yuman (Walapai); Salishan (Nuxálk/Bella Coola); Arandic languages; Anindilyakwa; Berber/Amazigh (Tashelhiyt); Chadic (Central Chadic). The present chapter focuses on Central Chadic languages, which together with distantly related Tashelhiyt (Berber/Amazigh) within Afroasiatic, represent the African continent in this survey.

Central to a typological approach to minimal-vowel systems is the recognition of a special phonological status of two approximants, */j/ and */w/, and their relation to high vowels [i] and [u].[2] The essential structural ambivalence (indicated by the feature specification [±syll]) of these approximants has earned them the labels "semi-vowels" and "semi-consonants" in traditional phonological literature; Semitic scholarship speaks of "weak radicals". This ambivalence, which some authors consider to essentially dissolve the distinction between vowels and consonants, motivates a review of the vocalic space in languages. For my historical reanalysis of Central Chadic languages, IPA *j and *i on the one hand, and *w and *u on the other, are not different phonemes, but rather conditioned allophones of each other in perfect complementary distribution. This raises the ontological question as to the phonological status of vowels and consonants. It is revealing that by reference to Manaster-Ramer & Bicknell (1995), Anderson (2016: 112) reports:

> There is nothing at all odd about a language with the vowel system /i a u/, with a CVCV syllable structure, and with distinct semivowels /j w/, the authors argue, but if these features are combined, then the vowels /i u/ and the semivowels /j w/ will always be in complementary distribution, and the difference between them cannot be considered phonemic. That being the case, it makes no difference in most versions of phoneme theory, whether one writes /j/ and /w/, or /i/ and /u/, but it is inconsistent to do both.

In the context of discussing Mandarin Chinese, Anderson (2016: 71) further references Hockett (1955: 75) by saying that "[i]n his own terminology, /i/ and /u/ are not strictly speaking vowels, given the fact that they can occur both as syllable peak and syllable margin". Note also that in his seminal analysis of *Die*

[2]Note that in established practice for African including Chadic languages, IPA /j/ is usually rendered by the graphic symbol /y/. I will follow this established usage in the body of this paper.

Silbenauslautgesetze des Hausa [The laws pertaining to syllable coda in Hausa],[3] a West Chadic language, Klingenheben (1927) made it a point to transcribe conventional /y/ and /w/ in Hausa as vowels /i̯/ and /u̯/ and explicitly stated his motivation for doing so.

This particular view on the relationship between the approximants IPA /j, w/ and the high vowels [i, u] is central to the present paper (Section 2.3). It further links a proposed analysis to the diachronic hypothesis about an underlying "vowelless" system (see Section 3):

> Given the existence of vowelless analyses of a number of languages [...] it is unclear if the existence of a distinct class of vowels is a phonological universal at all. If these analyses are omitted from consideration, then it would indeed be possible to state an absolute universal for the world's vowel systems: all languages have /a/ (Anderson 2016: 102).[4]

This generalisation by Anderson is supported by the author's research on Central Chadic languages, as reported in the present paper. It will be shown that, if one assumes an underlying minimal vowel system, the latter can be based on one vowel phoneme only, which must be */a/. If the description is based on a two-vowel system, this will be a vertical system in which the phonemic vowels are */a/ ([+low, -high]) and */ə/ ([-low, -high]). Given the role that the approximants /j/ and /w/ play in forming "purely consonantal" roots in Chadic and generally in Afroasiatic languages, they are best grouped together with the consonants rather than with the vowels. Structurally, therefore, surface [i] and [u] do not count as manifestations of vowel phonemes, which leaves *a and *ə as basic vowels in a minimal vertical vowel system.

1.3 Central Chadic languages

Central Chadic languages form one of four branches of the Chadic family. Within the Afroasiatic language phylum, this family is linked to Ancient Egyptian, Berber (Amazigh), Cushitic, Semitic, and possibly the Omotic languages. In a cross-linguistic perspective, Central Chadic would now appear to be the largest known group of languages assumed to share the so-called minimal vowel systems – at least in the diachronic perspective.

[3] Known as "Klingenheben's Law"; for an English translation see Newman (2004).

[4] This would be at variance with Comrie's (1991) description of Haruai, who prefers to transcribe the single phonemic vowel as /ə/ (Anderson 2016: 102). The exact phonetic identification of such basic central vowels, whether [ɐ, ɨ] or [a, ə] is of no concern here; the established convention in Chadic linguistics is the graphic representation <a, ə>.

Altogether 196 Chadic languages (according to Eberhard et al. 2021) are spoken west, south and east of Lake Chad in Central Africa and constitute the largest family within the Afroasiatic language phylum (Greenberg 1963, Newman 1980). Most of them are under-researched (Newman 2006, Frajzyngier & Shay 2012, Meyer & Wolff 2019, Wolff in press). The 79 known Central Chadic (aka Biu-Mandara) languages (Eberhard et al. 2021) form the largest and most diverse branch within Chadic.

Chadic languages in general have been notorious for escaping the successful application of the comparative method with regard to vowels (cf. Newman 1977a, Jungraithmayr & Shimizu 1981, Stolbova 2016, Wolff 2017, 2022a). Within the Chadic family, the languages of the Central Chadic branch, in particular sub-branch A, have long been considered to be phonologically and grammatically the least archaic with regard to retaining typological features from its Afroasiatic genetic heritage. Both views have recently been challenged by the author (Wolff 2009, 2011, 2017, 2022a, 2023).

1.4 Some non-trivial (morpho-)phonological features of Central Chadic languages

Central Chadic languages are notorious for their typological diversity in terms of their phonological and morphological systems, but they also share a number of non-trivial phonological features, some of which will be considered in this sub-section.

1.4.1 A note on data transcription conventions

A recurrent problem in Chadic typological and comparative linguistics is the absence of standardised transcription conventions and the often unknown linguistic expertise of colonial, missionary, and field linguists, who have compiled and made available primary linguistic data over the last 150 years and more. One finds fairly exact phonetic transcriptions for some language data and rather broad transcriptions for others, which often aim at simultaneously suggesting "practical" orthographies for literacy purposes. One finds also transcriptions that are obviously oriented at representing the phonemes of the language. Often the chosen transcription conventions differ from linguist to linguist, occasionally even for the same language. In the absence of phonetically and phonologically reliable transcriptions for many if not most (Central) Chadic languages, one has to make do with the transcriptions found in the available data, including the particular database (Gravina 2015) that my most recent work is based on. These original transcriptions of data will always be given in *italics* in this chapter.

In particular the graphic symbols <i, u, e, o> are structurally ambivalent. In broad transcriptions, which are often intended to inform "practical" orthographies for hitherto unwritten languages and which are readily available on a typewriter or computer keyboard, < i, u> in Central Chadic languages may represent:

- either syllabified conditioned allophones of underlying */y/ and */w/,
- or "coloured" variants of non-phonemic [ə] (schwa) under Y- and W-prosody effects (see below), which would be the conventionalised transcriptions of phonetically more precise [ɪ] and [ʊ] in the absence of phonological contrasts between /i~ɪ/ and /u~ʊ/.

In turn, <e, o> may represent:

- either /a/ under Y- and W-prosody effects (see below), which would be the conventionalised transcriptions of phonetically more precise [ɛ] and [ɔ] in the absence of phonological contrasts between /e~ɛ/ and /o~ɔ/,
- or a lowered variety of [i, u]) (i.e. syllabified /y, w/) under the appropriate conditions, such as in the neighbourhood to /a/ in an adjacent syllable.

These transcription conventions often blur what is going on both phonetically and phonologically, namely that phonetic [ɛ] and [ɔ] represent /a/, and [ɪ] and [ʊ] represent schwa, while [e] and [o] often represent lowered /i/ and /u/. Therefore, high vowels in Central Chadic transcriptions are prima facie ambivalent with regard to their phonological status. I argue that only solid phonological and lexical reconstruction will answer to this challenge and, by taking notice of the effects of Y- and W-prosodies, provide unequivocal identification of the respective source segments in the proto-language. For comparative purposes, they need to be assessed from a historical point of view as to whether they are allophones of phonemic */y/ and */w/ or variants of non-phonemic schwa.

Different transcription conventions may also concern graphic representations [ə] and [ɨ] on the one hand, and [ɪ, ɨ] and [ʊ, ʉ] on the other. In most of Chadic linguistic literature, and followed by the author in this chapter, [ə] represents schwa under ∅-prosody (= absence of Y- and W-prosody). While [ə] has become standard transcription of schwa in Chadic linguistics, [ɨ] would be phonetically probably more precise for a number of Chadic languages. Therefore, some authors (including Gravina 2014, 2015) prefer to render prosodically "uncoloured" schwa as [ɨ]. This is not a trivial issue, since the graphic representation ə (IPA) suggests a central mid vowel, while ɨ (IPA) suggests a central high vowel. For the purpose of this paper and also elsewhere, it is assumed that [ɪ] does and [ɨ] may represent [ə] under Y-prosody, while [ʊ] and [ʉ] represent [ə] under W-prosody.[5] In individual cases and with some sources, however, the interpretation of [ɨ] as raised and non-round (if not slightly fronted) schwa under Y-prosody might involve over-analysis, namely where the source uses [ɨ] to symbolise a true central vowel (under ∅-prosody) that is conventionally labelled "schwa". In case of doubt, the data should be checked against the original source (cf. Gravina 2015).

1.4.2 Root-and-pattern structure

Recent historical-comparative research (Wolff 2022a, 2023) has proposed an early and rather basic root-and-pattern structure as important Afroasiatic typological heritage in Central Chadic languages, and probably in Chadic as a whole. This means that reconstructed lexical items in PCC, like in PC and in PAA, consist of a skeleton of consonants (also known as radicals), i.e. a "root", in which the approximants */y/ and */w/ count as consonants. This is also why they are called "weak radicals" in traditional Semitic scholarship (e.g. Åkesson (2001)). The only phonemic vowel */a/ (see Section 1.4.4) could be added to these roots in medial interconsonantal positions, which is called the "pattern".[6]

[5]The question whether in all or some Chadic languages schwa should be treated as a central mid or rather a high vowel (see Roberts 2001) cannot be considered settled. The alternative hypothesis that there were two short central vowels [ə] and [ɨ] as in some Berber languages has never been suggested as likely for Chadic. Rather and more plausibly, Y-prosody can be assumed to either front non-high /ə/ to [ɪ], simply raise it to high [ɨ], or both front and raise it to [i], while W-prosody acts to either round non-high /ə/ to [ʊ] or both raise and round it to [ʉ] and [u]. This would also explain the high degree of overlapping allophones and variants within minimal vowel systems, such as in Central Chadic for */a/: [ɛ~a~ɔ], for schwa: [ɪ~ə~ɨ~i], [ʊ~ə~ʉ~u], for */y/ (in syllable nucleus): [i~e], for */w/ (in syllable nucleus): [u~o]. Systematic comparative studies of Chadic vowels have just begun, and such questions as to the high or mid characteristics of "schwa" must currently remain subject to further research.

[6]Note that I do not consider the lexical root-final vowel */a/ to be part of the pattern. It is – and debatably so – reconstructed by default for three reasons. (i) When it is present in modern languages, it would need no explanation and it would be clear that one is not dealing with an added grammatical morpheme of sorts. (In earlier reconstructions of African languages, including Chadic, final vowels were almost automatically subtracted from roots and were considered added material, so that "roots" would aprioristically end in a consonant. Yet, usually no grammatical function could be identified for such final vowel). (ii) When it is not present in modern languages, which is frequently the case, one would be dealing with apocope/deletion, for which, however, conditioning factors have not yet been identified. (iii) In quite a few instances, one finds schwa in word-final position, which allows two options of analysis: Either one is dealing with a likely conditioned (pre-juncture?) allophone of /a/, or the final /a/ has been deleted and epenthetic schwa has subsequently been inserted. This issue remains open for further research on the level of individual languages and/or language groups.

Based on the original number of [-syll] segments in the root (radical consonants or radicals), which alone in many Afroasiatic languages carry basic lexical meaning, PCC distinguished several root types. These root types specified whether and how the inter-radical positions were filled by */a/, in addition to the default presence of lexical-final */a/. In these historically underlying root types, I distinguish a-vocalisation from ∅-vocalisation (first suggested in Wolff 1977). The basic root types are listed in Table 1.

Table 1: Basic root types: ∅- and a-vocalisation patterns

	monoradical	biradical	triradical
∅-vocalisation	√ Ca	√ C Ca	√ C C Ca
a-vocalisation	—	√ CaCa	√ CaC Ca
			√ C CaCa
			√ CaCaCa

When these basic root types left open one or more pre- and interconsonantal slots which could potentially be filled by vowels, additional syllabification processes allowed for epenthetic schwa to be inserted. Insertion had followed the lines of a sonority-based hierarchy pertaining to the consonantal environment, until phonotactically acceptable syllable structures were created. The sonority-based hierarchy would appear to be that which is also found to operate in Tashelhiyt (Berber; see Kossmann 2012: 28ff. and further below in this chapter): *a* > *i/y*, *u/w* > liquids > nasals > voiced fricatives > voiceless fricatives > voiced stops > voiceless stops. These syllabification processes may have left potential vowel slots unfilled by [ə], because root types did not need to follow a requirement to create simple CV.CV.CV syllable structures; see Table 2.

Syllabification in PCC turned the historical root types finally into underlying forms on which the actually occurring surface realisations in modern languages are built. In PCC, consonantal roots underwent multi-step syllabification processes following a sonority-scale hierarchy (see above). At the first step, pre- and interconsonantal positions are filled by */a/ and create first syllable peaks. At the second step, underlying */y/ and */w/, if present in the root, syllabify into their allophones [i] and [u] (Section 1.4.4), which also creates syllable peaks. If necessary, at a third step, epenthetic *ə (see Section 1.4.3) would be inserted between consonants in positions where the sonority sequencing would require the creation of an additional syllable peak. This situation is reconstructed with confidence for PCC. Reconstructed PCC roots are, therefore, given as conflated

Table 2: Synchronically underlying root types showing potential epenthetic vowel insertion. Individual Central Chadic languages may phonetically also require prothetic vowel insertion in cases of word-initial consonant clusters; this is not indicated in the table.

	monoradical	biradical	triradical
∅-vocalisation	√ Ca	√ C(ə)Ca	√ C(ə)C(ə)Ca
a-vocalisation		√ CaCa	√ CaC(ə)Ca
			√ C(ə)CaCa
			√ CaCaCa

formulas, where the potential slots for insertion of */a/ in medial interconsonantal positions are indicated in parentheses. For instance, the reconstructed PCC root for 'girl, young unmarried woman' is given as *d(a)ɣ(a)ra, which allows the following root types to operate in individual languages for this lexical item: *dɣra, *daɣra, *dɣara, and *daɣara. Synchronic word forms in modern Central Chadic languages may reflect any number of such possible root types, but most often reflect only one of them (see 1–2 for synchronic use of two different root types in opposition of contrasting forms; see 3–4 for just one root type being used in the modern languages).

Given current ignorance about PCC morphology and grammar, one does not know whether the choice of the particular root type at the PCC level had any morphological functions. One finds such functions related to the root type choice in present-day languages not only in Chadic, but in other Afroasiatic languages as well. One knows, for example, that the so-called *internal a* may serve morphological functions in Afroasiatic languages, such as indicating plural with nouns and pluractionality with verbs. Therefore, it still remains an open question whether in individual cases the insertion of */a/ was lexical or morphological in nature. Examples (1) and (2) illustrate synchronic instances of both lexical(ised) and morphologically productive *internal a* formations in modern Central Chadic languages.[7]

[7]Note the use of the following conventions in the chapter. Based on the chosen database (Gravina 2015), the suggested 18 language groups within Central Chadic are always given in SMALL CAPITALS, original transcriptions of data are always given in *italics*. Sign ∅ indicates a deletion/loss of a segment. A preceding * signals reconstructed forms. Slanted lines indicate phonemic transcription, square brackets indicate phonetic transcription. Curly brackets identify grammatical morphemes. Sign → indicates synchronic (and often conditioned) change of individual sounds; < ("coming from") and > ("becoming") indicate diachronic changes affecting whole words.

(1) Lexicalised number-sensitive vocalisation patterns
Podoko (Mandara) ‘girl, young unmarried woman’ PCC/areal root *d(a)ɣ(a)ra

sg	*dəhəla* /dxla/	< *dxla	< *dɣra
pl	*dahali* /daxaly/	< *daxal∅-y	< *daɣara-y

Note: The synchronic singular form in Podoko makes use of the diachronic root type CCCa (*dɣra) with common sound changes */ɣ/ ⟶ [x] and */r/ ⟶ [l], plus multiple epenthetic [ə] insertion. The synchronic plural form illustrates lexicalised, i.e. synchronically non-productive, a-vocalisation of the root, i.e. a diachronic root type CaCaCa (Proto-Podoko *daxala), plus lexicalised suffixal *{-y} (IPA *{-j}), which deletes the default lexical-final */a/ of the reconstructed PCC form.

(2) Synchronically productive pluractional verbal stem formation
Lamang (Lamang) ‘to take; to take many (objects)/several times’

simplex	*kəla* /kla/	< *{kla}
pluractional	*kala* /kala/	< *{k-a-la}

Note: For synchronically productive pluractional verbal stem formation, the Lamang CCa (/kla/) monomorphemic verb root, phonetically showing *ə*-epenthesis in surface realisation, allows the infix *{-a-} to turn the simplex stem /kla/ into a bimorphemic pluractional verb stem (/k-a-la/).

(3) Lexicalised root syllabification by “a-vocalisation” (step 1)
Mafa (Mafa) ‘belly’ PCC *x^w(a)ɗa
h^{w}aɗ /x^{w}aɗ/ < *x^{w}aɗ∅ < *x^{w}aɗa
Note: Mafa disregards the option of using the CCa root type (*x^{w}ɗa), but makes use of the CaCa root type (*x^{w}aɗa) by opting for medial interconsonantal insertion of */a/; lexical-final */a/ is deleted. There is no indication of number-sensitivity of the vocalisation pattern.

(4) Lexicalised epenthetic *ə*-insertion (step 3) when there is neither medial /a/ nor an approximant in the root
Sukur (Sukur) ‘belly’ PCC *x^w(a)ɗa
huɗ (x^{w}ə^{w}ɗ) ^{w}/x^{w}ɗ/ < *x^{w}ɗ∅ < *x^{w}ɗa
Note: Sukur makes use of the CCa root type (*x^{w}ɗa) and inserts epenthetic [ə] in the medial interconsonantal position; lexical-final */a/ is deleted. The labialisation feature of the underlying initial consonant /x^w/ gives rise to W-prosody, which “colours” epenthetic *ə* into [u]. There is no indication of number-sensitivity of the vocalisation pattern.

Examples (3–4) illustrate the analytical value of the prosodic approach. A traditional more canonical analysis would treat Mafa *h^{w}aɗ* to be the phonetic realisation of underlying phonemic /x^{w}aɗ/ and Sukur *huɗ* to reflect phonemic /xuɗ/. This involves sound correspondences /x^w/ : /x/ and /a/ : /u/ between the two languages, which, however, would turn out not to be "regular". Prosody-based analysis, on the other hand, allows us:

- to establish the identity of C_1 between the two languages, namely /xʷ/,
- to establish the "vowel correspondence" to be /a/:∅ (or: /a/:/ə/, if schwa is considered to be phonemic in Sukur),
- to generalise the "floating" nature of labialisation in Central Chadic beyond ad hoc instances of local assimilation *ə* ⟶ [u]/xʷ__ and ad hoc assumptions about "delabialisation" /xʷ/ ⟶ /x/.

Example (5) illustrates lexicalised syllabification of a "weak radical" (step 2), i.e. */w/ ⟶ [u].

(5) Podoko (Mandara) 'breast (female), udder, milk (fresh)' PCC *ɗ(a)w(a)xa
uɓa /wɓa/ < *wɓa < *ɓw∅a < *ɗwxa
Note: In Podoko, C_3 */x/ is deleted; */ɗ / diachronically changes into [ɓ] in the environment of */w/, plus there is a metathesis ɓw ⟶ wɓ; */w/ syllabifies in syllable-nucleus position ⟶ [u].

1.4.3 The ambiguous status of schwa (*ə*)

The question of how to handle the vowel schwa (*ə*) in both synchronic and diachronic analyses of (Central) Chadic languages remains important and open to alternative answers. Some authors in their descriptions of modern CC languages treat schwa as epenthetic on the basis of very high or even complete predictability of its occurrence, and therefore non-phonemic, while others in their descriptions of other languages may consider it a phoneme. Phonological arguments can be found to support either analysis. Without wanting to enter a theoretical discussion here about the distinction between epenthetic phonemic and intrusive non-phonemic vowels (cf. Hall 2006), I follow established Chadic linguistic usage to call non-phonemic intrusive vowels "prothetic" and "epenthetic". In my comparative work on Central Chadic languages, *ə is consistently found to be fully or almost fully predictable in its distribution and, therefore, is treated as non-phonemic at the level of the common proto-language (PCC). This, however, does not exclude the possibility that PCC epenthetic schwa became phonologised in individual modern Chadic languages or language groups where /ə/ could and possibly should be considered a synchronic phoneme.

As indicated in Section 1.4.2, pre- and interconsonantal syllable-nucleus positions that were not filled either by */a/ or by vocalic allophones of approximants ([i] or [u]), could be filled by epenthetic *ə in a process of sonority-based syllabification of consonants. Such an underlying sonority hierarchy is not only valid for Chadic languages, but mirrors the principles for Northern Berber Tashelhiyt, as outlined by Kossmann (2012: 28ff.; see Section 1.4.2).

Epenthetic schwa and its prosodically "coloured" variants (see Section 1.4.5) can be of extremely short duration including phonetic [∅], which might depend on speech tempo and idiolectal speech habits, as indicated in field notes and phonological sketches by fieldworkers (e.g. Frick 1977, Wolff 1983b). Occasionally, it is transcribed as an "open phonetic transition" between two consonants. Depending on the degree of voicedness of consonants, schwa is rendered by varying graphic symbolisations, such as CəC ~ CᵊC ~ CC, even by the same author for the same language and even the same word.[8] Schwa usually cannot undergo any lengthening or carry stress. However, there are rare exceptions in modern CC languages where long schwa [əə] occurs in the transcription of surface realisations, which might actually reflect an underlying different long vowel, which would likely be */aa/ (no detailed studies yet available). Epenthetic schwa dissolves consonantal clusters through the processes of consonant syllabification (cf. above). As a syllable peak, schwa can carry tone. Before word-initial consonantal clusters, some languages insert prothetic [ə] (with "uncoloured" variants [a~ɐ~ʌ] under ∅-prosody) and create new syllables by dissolving word-initial consonant clusters and thereby produce vowel-initial words in surface structure, e.g. Margi (Margi) *u'wa* (əʷʔwa) ʷ/ʔwa/ (< *ʔw∅a < PCC *ɗwxa) 'breast (female), udder, milk (fresh)'.

Just like phonemic */a/, non-phonemic schwa comes under the "colouring" effects of prosodies, which create a variety of phonetic surface vowels. Namely, schwa becomes [ɨ~ɪ~i] under Y-prosody, [ʉ~ʊ~u] under W-prosody, and (IPA) [y~ø] under combined Y+W-prosodies.[9] Prosodies colour */a/ to be phonetically realised as [ɛ] and [ɔ] (see Section 1.4.5 below).

A particular challenge of Central Chadic phonological analysis is a distinction between the epenthetic schwa and its coloured variants and the phonemic /a/, which may also have a (likely conditioned pre-juncture?) allophone [ə]. This allophonic schwa undergoes the same prosodic "colouring", as does the epenthetic *ə, see the following example from two Kotoko-North group languages, which incidentally reflect two different underlying root types:

[8] See, for instance, my own fieldnotes containing the Lamang word for 'bull' /lɣŋ/, which shows the following variant transcriptions: *ələɣəŋ ~ əlɣəŋ ~ ləɣəŋ ~ əlɣàŋ ~ alɣəŋ*.

[9] The vowel [ø] is given for Moloko (Mofu) by Friesen et al. (2017) where other Central Chadic languages would show IPA [y].

(6) ‘to blow, breathe’ PCC *v(a)tsa

Afade	*fti* /fty/		< *ft∅-y	< *vtsa-y
Mpade	*fasɨ* ʸ/fasə/	*fasə-∅ʸ	< *fasa-y	< *vatsa-y

Note: PCC *v changes into /f/, PCC *ts changes into /t/ in Afade and into /s/ in Mpade. In Afade, suffixal *{-y} deletes the preceding lexical-final */a/ of the simple root. In Mpade, suffixal *{-y} does not delete the final */a/, but rather desegmentalises and prosodises to Y-prosody, which affects the root-final vowel /a/ in the shape of its allophone [ə]: While the allophone [a] would be palatalised to [ɛ~e], the allophone [ə] is palatalised to [ɨ].
Alternatively, one could assume deletion of /a/ and compensatory insertion of epenthetic schwa, which would explain the identical “colouring” under prosody effects in a more natural way. Examples of this type illustrate the potential over-analysis (see Section 1.4.1) based on the identification of [ɨ] as schwa under Y-prosody. If in this example [ɨ] was meant to indicate a central high vowel (in place of schwa), there would be no Y-prosody effect to be stated and one could render the Mpade example in conventional traditional Chadic transcription with final schwa: *fasə* /fasa/ < *fasa < *vatsa.

While schwa is not considered to be phonemic in my PCC reconstructions, it may be treated as phonemic in modern CC languages. For instance, in modern Kilba (Margi), the word for ‘ashes’ is *pətsəɗu* in phonetic surface realisation as transcribed in the database. Based on my assumptions regarding underlying minimal vowel systems in Central Chadic, for Kilba there are two options regarding the underlying phonemic representation (note that, in a minimal vowel system analysis, surface [u] represents underlying /w/):

- one may analyse schwa as synchronically phonemic: /pətsəɗ-w/;[10]
- one may analyse schwa as epenthetic insertion: /ptsɗ-w/ > [pətsəɗu].

My own historical analysis concerning the reconstruction of PCC is based on the analysis of schwa as being epenthetic in nature and, therefore, it is treated as being non-phonemic. Since surface [u] is identified as a vocalic allophone of the underlying phonemic approximant /w/, one arrives at an ultimate underlying vowel-less representation of the word, namely *ptsɗ-w. A multi-tiered approach allows one to sketch out the linguistic history of the word for ‘ashes’ in Kilba as follows, see Table 3.

[10]Under such an approach, one needs to accept that language-specific evolution allows for epenthetic *ə to become phonologised, meaning that a fair number of modern CC languages are probably best described by attributing a phonemic status also to /ə/. This would automatically change their synchronic vowel system from more to less “minimal” and would also have effects on the identification of their underlying “root types” (see Section 1.4.2).

Table 3: Multi-tiered historical analysis of synchronic *pətsəɗu* 'ashes' in Kilba (Margi)

Data	Status of form	Phonological processes	Process description
pə.tsə.ɗu	Phonetic surface realisation	Syllabification	ə-epenthesis; *w → u (allophonic)
/ptsɗ-w/	Underlying phonemic representation	$^*k^w$ → w	Weakening of suffixal $^*k^w$
*ptsɗa-k^w	PCC reconstructed suffix-augmented root	> *ptsɗ∅-k^w	Deletion of lexical-final */a/

1.4.4 Minimal vowel systems in Central Chadic

In both Northern Berber Tashelhiyt and Central Chadic languages, the two high vowels [i] and [u] can be analysed as allophones of /y/ and /w/ which are in perfect complementary distribution with their consonantal allophones. The vocalic allophones [i] and [u] occur in syllable-nucleus positions, while the consonantal allophones [y] and [w] occur in syllable-margin positions. While the allophones [i] and [u] of underlying /y/ and /w/ are considered vowels in surface phonetic realisations, one still counts /y/ and /w/ among the consonants which form "purely consonantal" roots in the characteristic Afroasiatic root-and-pattern structure (see Section 1.4.2 above). This situation holds for PCC as well as for some synchronic phonological systems.

In an apparently paradoxical manner, such analysis both contradicts and conforms to the claim by Crothers (1978: 115) that "all languages have /i a u/". Chadic languages mostly do have at least a vocalic inventory of [i, a, u] in surface phonetic realisations, and usually they have more than just these three phonetic vowels.[11] Nonetheless, both on a more abstract synchronic level of phonological analysis and in a diachronic perspective, only */a/ is an undisputable vowel phoneme in a sense of exclusively carrying the feature [+syll]. It can be reconstructed as such for at least PCC (and most likely also for PC). Sounds */y~i/ and

[11] In a paper surveying phonological features of Central Chadic languages, Roberts (2001) equates the universal claim that all languages have /a, i, u/ with its Central Chadic equivalents *a*, pal, and lab, i.e. one vowel and two prosodies.

*/w~u/ ([±syll]) are reconstructed for PCC (and PC) as approximant phonemes together with their characteristic allophony in terms of complementary distribution, and as such they are also present in all known modern Central Chadic languages.

For the analysis of Central Chadic languages, in both diachronic and synchronic perspective, it is, therefore, of utmost relevance to keep in mind the different phonological nature of the four basic phonetic surface vowels [a, ə, i, u]:

- /a/ is essentially a vowel and it is reconstructed as such already for the PCC proto-language level;
- [i] and [u] are conditioned allophones of /y/ and /w/, which are also reconstructed as approximants at the PCC proto-language level;[12]
- *ə is epenthetic in nature and is reconstructed as non-phonemic for the PCC proto-language; in modern CC languages, however, some linguists treat schwa as being synchronically phonemic.

A typological survey undertaken in Section 3 below will show the rare but non-unique cross-linguistic distribution of such vowel systems.

An alternative approach in current Chadic linguistics disregards the systemic relationship between the approximants and the high vowels; see, for instance, the description of Moloko below (Friesen et al. 2017) and other synchronic grammars (cf. Schuh 2017). It relates the high vowels unequivocally to schwa in a minimal vertical vowel system. In this system, [i, u] are considered the prosodic "colourings" of schwa (viewed as high central vowel IPA ɨ), irrespective of whether the latter is analysed as being phonemic or simply epenthetic. In this analysis, /y/ and /w/ are automatically treated as purely consonantal ([-syll]), i.e. devoid of the otherwise characteristic complementary distribution of vocalic and consonantal allophones. This is illustrated in Table 4 by Moloko (Mofu), which has 10 conditioned phonetic surface vowel qualities, which are said to stem from underlying /a/ and epenthetic schwa (Friesen et al. 2017: 53).

A surface-oriented phonological analysis of Central Chadic languages may run into serious difficulties if used for historical and comparative analysis, where the identification of source segments in the proto-language becomes crucial.

It is a potentially rare cross-linguistic phenomenon that Chadic synchronic vowel systems with up to 17 or more vowels can be derived historically, and in some languages also synchronically (see Moloko above), from an underlying minimal vowel system which is based on only one phonemic vowel, namely /a/.

[12] For an alternative phonological interpretation of surface [i, u] as conditioned variants of schwa see below.

Table 4: Moloko surface vowels

	∅-prosody	Y-prosody	W-prosody	Y+W-prosody	Adjacent... to /y/	to /w/
/a/	[a]	[ɛ]	[ɔ]	[œ]	[a]	[a]
[ə]	[ə]	[ɪ]	[ʊ]	[ø]	[i]	[u]

1.4.5 Prosodies in Central Chadic: word-level labialisation and palatalisation

Chadic languages have until recently been described and sometimes are still described by field linguists as having "plain" segmental phonological systems, without giving any consideration to the notion of prosodies. Depending on the language and author, series of palatalised, labialised, and prenasalised consonants have been postulated as part of synchronic consonantal inventories. This, however, led to postulating extremely rich inventories for individual Central Chadic languages, e.g. almost 80 consonantal phonemes for Bura (Margi: Hoffmann 1987) and more than 90 for Higi (Higi: Barreteau 1983). The idea of treating labialisation, palatalisation, prenasalisation, and combinations of these as "prosodies" allowed for the considerable reduction of the consonantal inventories. The first modern descriptive monographs describing Central Chadic languages (Hoffmann 1963, Newman 1970, Wolff 1983a) did not yet make reference to prosodies.

The prosody-based approach has since become a powerful descriptive tool in Central Chadic linguistics and, with very few exceptions, is almost a standard practice now. The notion of prosody (a suprasegmental feature applying to a lexical or sublexical domain larger than a segment, such as syllable, morpheme or word) was presumably inspired by the teaching of J. R. Firth and his followers at the School of Oriental and African Languages (SOAS), University of London, in the 1950s, from where it reached the leading linguistics department at the University of Ibadan in Nigeria in the 1960s. There it was introduced into Central Chadic linguistics by the late Carl Hoffmann (1925–2007) in an unpublished yet influential conference paper of 1965 on the phonological analysis of the Higi language (Hoffmann 1965). A mimeographed copy of that paper was circulated among some members of the *West African Linguistic Society (WALS)* including the present author, who eventually passed it on to the late Daniel Barreteau (1950–2007). The latter immediately accepted the approach for his own research on Central Chadic languages in Cameroon (Barreteau 1983). Within Nigeria, it also circulated among the members of the *Summer Institute of Linguistics* (SIL), where Roger Mohrlang and James Hoskison took notice and used the approach for their own work on Higi (Mohrlang 1971, 1972) and Gude (Hoskison 1974, 1975a,b, 1983).

For a long time, prosodies, in particular labialisation and palatalisation, but also prenasalisation, were considered to be highly language-specific and pertaining only to Higi and Gude, as well as to Ga'anda (R. M. Newman 1977b), and to Mafa and Mofu-Gudur (Barreteau 1987). The first Chadicists to explore the comparative potential of the prosodic approach, although restricted to certain groups of fairly closely related Central Chadic languages, were Wolff 1981, 1983b, Wolff et al. 1981 on languages of the then so-called Wandala-Lamang group, and Hoffmann (1987) on languages of the then so-called Bura-Margi group. Inspired by this and other descriptive, typological, and comparative work of the 1980s, the prosodic approach became increasingly applied to a growing number of languages and language groups within Central Chadic, including several studies by linguists of SIL. There is now a general consensus in Chadic linguistics that, for both synchronic descriptions and comparative analyses, a prosodic approach provides adequate analytical and descriptive tools and has high explicative value and, therefore, is preferable over other more traditional approaches. The prosody-based approach takes into account that words in Central Chadic languages may be characterised by a regime of word-level prosodies, predominantly in terms of palatalisation (Y-prosody) and/or labialisation (W-prosody), but also in terms of prenasalisation (N-prosody) and glottalisation (ʔ-prosody) of obstruents. These prosodies, once operational as phonological processes, are conceived as floating suprasegmental features within simple-word boundaries that can affect both vowels and consonants. As developed in a series of publications by the present author (Wolff 1981, 1983b, 2004, 2006, 2017, 2019, 2022a), the prosodies have their origin in the divorce of certain (co-)articulation features of reconstructable consonantal segments (including approximants) in the proto-language. The original carrier segments of these dissociated features could be part of the root (where Chadicists speak of phonological/lexical prosodies) or of petrified affixal augments to synchronic roots (where Chadicists speak of morphological/grammatical prosodies). This means that the proto-language possessed consonants, which were associated with divorceable features such as [+high, -back] (giving rise to palatalisation prosody), [+high, +back, +round] (giving rise to labialisation prosody), [+nas] (giving rise to prenasalisation prosody), and [+glott] (giving rise to glottalisation prosody).

Prior to their prosodification to become floating suprasegmental features, prosodies had no existence as separate phonological units in the system of the proto-language, i.e. they cannot be separately reconstructed for PCC in addition to consonants, approximants, and vowels.[13] At variance with authors such as Roberts

[13]This is a major departure from the approach chosen by Gravina (2014) and Roberts (2001), the latter identifying "prosodies as distinctive building blocks of the phonological system, just like the consonants and vowels, but independent of them."

(2001) and Gravina (2014), I claim that they emerge secondarily from reconstructable segments by two interrelated diachronic processes, namely desegmentalisation and prosodification (Wolff 2022a).

1. The process of *partial desegmentalisation* can be described as "phoneme split", in which the segmental shape of the consonantal segment (or approximant) remains intact and a single or combination of articulatory features divorces from the segment to become a suprasegmental floating word-level prosody. Graphic representations would be /y/ ⟶ /y/+^{y} (Y-prosody), /w, C^{w}/ ⟶ /w, C^{w}/+^{w} (W-prosody), /m, n/ ⟶ /m, n/+^{n} (N-prosody), /C^{ʔ}/ ⟶ /C/+^{ʔ} (ʔ-prosody).
2. The process of *complete desegmentalisation* can be described as a subsequent step, in which the segmental shape of the consonantal segment (or approximant) is segmentally reduced to ∅, but with the characteristic articulatory feature(s) "surviving" as floating prosody. Graphic representations would be /y/ ⟶ ∅^{y} (Y-prosody), /w, C^{w}/ ⟶ ∅^{w} (W-prosody), /m, n/ ⟶ ∅^{n} (N-prosody), /C^{ʔ}/ ⟶ /∅^{ʔ} (ʔ-prosody).

Prosodies, therefore and following my line of argument, can be reconstructed as being of originally segmental nature on the level of the proto-language. They do not exist as phonological units in addition to the reconstructed segments; they are just different, namely suprasegmental, manifestations of reconstructed segments, either coexisting with the original segment or replacing them. As such they can enter 1:1 sound correspondences among themselves or with other segments between pairs of languages. Once having become "floating", prosodies can re-associate with new segments within the boundaries of the same simple word. With Y- and W-prosodies, their effect is the prosodic "colouring" of new carrier segments, be it vowels or consonants, in terms of palatalisation and labialisation. With N- and ʔ-prosodies, their effects are the prenasalisation and glottalisation of obstruents somewhere in the chain of segments. See Figure 1. The PCC reconstructions are those suggested in Wolff (2023). Note that the actual diachronically underlying form (the PCC "augmented root") provides the shape that is actually reflected in the modern language, i.e. reflecting (i) "choice" of root type from the root-type options provided by PCC (as indicated by the conflated formula), and (ii) choice of petrified grammatical markers, like, for instance, *{-k^{w}(a)} and *{-y(a)} that have fused with the simple root.

Prosodies may combine and anchor on the same segment, occasionally giving rise to somewhat rare vowel qualities such as IPA [œ, y]; see Figure 2.

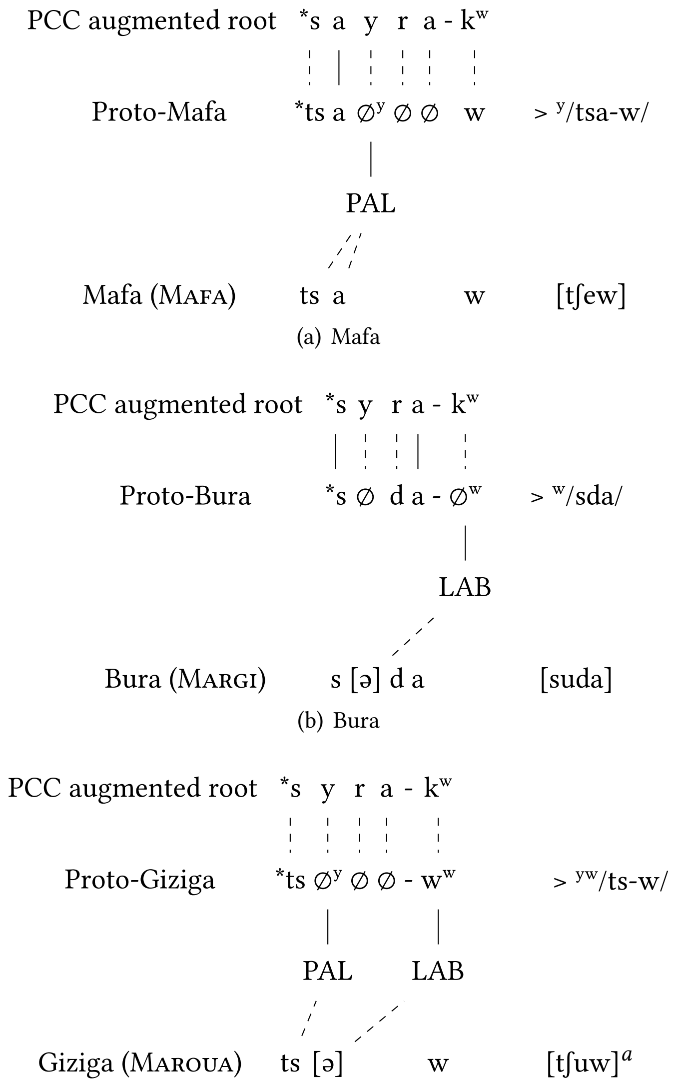

Figure 1: Examples of Y- and W-prosodies in Central Chadic languages: PCC *s(a)y(a)ra 'two'

[a]Note that in the prosodic approach to Central Chadic languages, local assimilations can be captured under "prosodic effects", since fundamentally prosodies govern the whole word as their potential maximal domain. In non-prosodic analysis, the phonetic surface realisation [tʃuw], for instance, would likely be treated as a case of local assimilation of epenthetic [ə] to following /w/, while the palatalisation (*ts ⟶ *tʃ*) cannot be accounted for by local assimilation in a parallel manner.

PCC augmented root *p ɗ a k^{w} a - y

Proto-Mbuko *p ɗ a k ^{w}∅ - y^{y} > ^{wy}/pɗak/

LAB PAL

Mbuko (Hurza) p [ə] ɗ a k^{w} [pəɗœk]

Figure 2: Y- and W-prosodies combined: PCC *p(a)ɗ(a)k^{w}a 'razor'

With regard to vowels, these prosodies create conditioned allophones of reconstructed PCC */a/ as well as variants of *ə. Prosodies "colour" */a/ to be phonetically realised as [ɛ] and [ɔ], and *ə to be realised as [ɪ~ɨ~i] and [ʊ~ʉ~u], and – given the uniform performance of Y- and W-prosodies across the many languages of the database – this is likely to have happened already at the proto-language level. As a matter of orthographic convenience and in the absence of a phonological contrast, these vowel "colourings" are very often transcribed simply as <e, o> and <i, u>.

Hitherto, the only comprehensive approach to a general history of Central Chadic phonology that acknowledges the salient role of prosodies is Gravina (2014), whose pioneer attempt, however, according to the present author, is flawed by certain weaknesses:

1. It does not recognise the essential underlying *root-and-pattern* structure of Central Chadic words and its impact on the distribution of vowels within the word.

2. It aprioristically imposes a rigid syllable-structure constraint on the proto-language. This entails the reconstruction of schwa as a phonemic vowel in fixed syllable-peak positions – only for many schwas to be immediately deleted again.

3. It rests on the assumption of a vowel system /a, ə, i/ (in Gravina's notation /a, ɨ, i/), which is typologically rare if not doubtful in cross-linguistic perspective.

4. It treats Y- and W-prosodies as being of essentially different phonological nature. Y-prosody is treated as an autonomous phonological unit in addi-

tion to vowels and consonants on the PCC level, while W-prosody is considered simply an accompanying feature of reconstructed labialised velar consonants.[14]

5. It does not account for the historical origins of reconstructed phonemic Y-prosody. Rather, Y-prosody is treated as a sort of *deus ex machina* not related to identifiable segments in the segmental chain of the PCC reconstructed word.

6. It misses regular sound correspondences between segments and prosodies.

Gravina (2014: 333) felt, therefore, forced to state regarding schwa that "the status of this vowel is difficult with living languages, and with reconstructed languages it is not possible to reach a reliable conclusion". Such a frustrated conclusion could be avoided by attributing a phonemic status only to */a/ and by treating occurrences of *ə as non-phonemic, i.e. prothetic and epenthetic in PCC, like in many synchronic CC systems. Gravina has proposed an essential CC-internal typological distinction between "vowel prosody systems", "consonant prosody systems", "mixed systems", and "no-prosody systems". This essential distinction is not corroborated by my own more recent studies on lexical reconstruction in PCC (Wolff 2022a, 2023). Rather, it illustrates a significant but later areal clustering of certain typological features within Central Chadic.

1.5 A multi-tiered approach

The phonological analysis of Central Chadic languages trivially profits from approaches on at least three, if not four levels of analysis, related to the Saussurean distinction between diachronic and synchronic perspectives on the one hand, and different levels of theoretical abstraction on the other. Minimally two levels pertain to the synchronic perspective, namely (i) a phonetic surface structure vs (ii) a synchronic underlying phonemic structure. A possible third level is that of "structural" representation indicating phonemes together with active prosodies (following a suggestion by Barreteau 1983). One other level pertains to the deepest diachronic perspective, i.e. it reflects the reconstructed proto-language forms.

[14]It remains a fact, though, that in individual Chadic languages the two prosodies are not employed in the same or parallel fashion. This may be explained by the fact that Y-prosody stems uniquely from diachronically underlying */y/, while W-prosody stems from diachronically underlying */w/ as much as from any labialised velar (*/C^w/) that is reconstructed for the proto-language.

On the shallow "surface" level of data transcription, one identifies the phonetic surface realisations based on distinctive units (Section 2.3.2). This first level is complemented by an analysis on a more abstract level based on the identification of contrastive units and the segmental targets of relevant prosodies.[15] With these two complementary levels of analysis, one remains in the domain of synchronic description and is methodologically safe on one side of the so-called Saussurean Firewall (term adopted from Kiparsky 2015). However, all languages have history, and their synchronic units and structures reflect this history of different diachronic levels. Such proto-languages can be "reconstructed" based on Neogrammarian methodology known as the "comparative method" and a method of "internal reconstruction". One can reconstruct individual proto-language representations, which may coincide in certain cases with the synchronic underlying phonemic representation, and one can reconstruct representations on the level of the ultimate proto-language for the whole language family or one of its branches.

Once there is robust information from both sides of the Firewall, synchronic and diachronic, the challenge is to reconcile the findings to one another and offer historically grounded explanations of how the synchronic phonological systems of modern languages have come into being and how individual words have taken the different shapes they now display. The idea of "evolution" behind the reconciliation of synchronic data and a diachronic perspective rests on the trivial assumption that modern languages, in their synchronic phonology and grammar, show "innovations" as much as "retentions" (or "archaisms"), the latter mirroring various previous stages of language history. In an overall historical perspective, one is thus challenged to link the synchronically underlying abstract phonological units to the reconstructed diachronic units (see Table 3 above). This does not mean to dismantle the Saussurean Firewall, rather it means to take a comprehensive look at the history of the language(s) under focus.

The proto-language level of analysis is phonologically the most abstract one. In Central Chadic, it is based on the identification of reconstructed contrastive phonemes of the proto-language system and of prosodies that can be reconstructed as operating already on the proto-language level. With a few exceptions, these prosodies are no longer operative as productive synchronic phonological processes at the level of modern languages. One may tentatively generalise that with synchronic minimal vowel systems, prosodies are likely to be synchronically operative. With synchronic multi-vowel systems, however, prosodies have become lexicalised and are no longer synchronically productive, so that they may be considered resistant to prosodic analysis.

[15] Using the terminological distinction between "distinctive" and "contrastive", I follow a lead suggested by P. Kiparsky (2015, 2018).

Our multi-tiered approach to Central Chadic and its internal cohesion is made explicit in Table 5.

Table 5: Multi-tiered approach to the synchronic and diachronic analysis of Central Chadic languages

Features	Perspectives	Levels	Units
distinctive	synchronic	SURFACE	"quasi-phonemes": segmental units (including epenthetic vowels)
contrastive	synchronic	UNDERLYING	phonemes & prosody effects
contrastive	diachronic	HISTORICAL	proto-language phonemes & prosodies

Potentially the first Chadicist to explicitly discuss a multi-tiered approach to Central Chadic languages in order to capture the salience of prosodies in addition to the segmental phonemes was the late Daniel Barreteau (1950–2007).

> Nous distinguons entre une analyse structurelle qui fait la part entre les traits phonémiques (paradigmatiques) et les traits prosodiques (syntagmatiques), et une analyse phonémique, qui reste proche de la phonétique, où les traits prosodiques, combinés avec les traits phonémiques, ne sont pas tenus en compte isolément. Les traits phonémiques, segmentaux, sont constitutifs des phonèmes tandis que les traits prosodiques s'appliquent sur l'ensemble du mot. Cette distinction est d'autant plus importante que les langues font un grand usage des traits prosodiques comme le higi et les autres langues tchadiques de la branche centrale (Biu-Mandara). (Barreteau 1983 : 250)
>
> We distinguish between a structural analysis which consists of (paradigmatic) phonological features and (syntagmatic) prosodic features, and a phonological analysis, which remains close to phonetics, where the prosodic features, combined with the phonological features, are not considered in isolation. The segmental phonological features are constituent features of the phonemes whereas the prosodic features apply to the whole word. This distinction is the more important since the languages make ample use of prosodic features like Higi and the other Chadic languages of the Central (Biu-Manara) branch. (Translation by the author H. E. Wolff.)

Barreteau (1983: 251) actually speaks of three levels of synchronic description. He illustrates the suggested levels with examples like the following ones from the Higi (Higi) language, for which he postulates only two underlying vowel phonemes /a/ and /ə/, see Table 6.

Table 6: Multi-tiered analysis of Higi words acc. to Barreteau (1983)

Formes structurelles Structural forms	*Phonémiques* Phonological	*Phonétiques* Phonetic	*Sens* Meaning
^{w}kə	kwə	kwɛ̀	chèvre ‘goat’
^{nw}tə	mtə	mtɛ́	mourir ‘to die’

This can be compared to a similar multi-tiered presentation format for Lamang that was independently suggested by Wolff (1983a: 37), illustrated with some modifications in Table 7 by the derivationally extended verb stem ‘go down(hill)/ westwards’ of the verbal root *dza-* ‘to go’. Note that the levels do not fully match Barreteau’s tiers. The idea was to show that synchronic word forms in Lamang:

(i) can be phonologically analysed on the basis of a 3-monophthong (a, i, u) plus one diphthong (symbolised “E” below) vowel system (tier 1: “structural” representation, to borrow the term from Barreteau 1983);

(ii) could also be transcribed “broadly” in terms of non-contrastive allophonic vowel representations (tier 2: practical-orthographic transcription, disregarding non-contrastive distinction between [ɛ] and [e]);

(iii) could, further, be transcribed in a narrow transcription that would identify vocalic allophones closer to their phonetic realisations (tier 3: phonetic transcription, i.e. maintaining the surface phonetic distinction between [ɛ] and [e]).

(iv) To this could be added tier 4: deep-level diachronic representation (Proto-Lamang) based on the reconstruction of a minimal vowel system.

We must remain clear, however, in keeping historical stages and synchronic levels of analysis strictly apart in the descriptions of individual languages. Already Barreteau (1983: 271) had rightfully warned against confusing synchronic underlying abstract “structural forms” with historical reconstructions even though and quite often they may turn out to be identical.

Table 7: Multi-tiered transcription of verb stem ‘to go down’ in Lamang

Structural representation (using 4 vowels: /a, i, u/ and /E/)	ʸ/dza-´ɗí/
‘Broad’ (practical) transcription (using 6 vowels: *a*, *e*, *o*, *i*, *u*, *ə*)	*dzéɗé*
‘Narrow’ (phonetic) transcription (using 10 vowels: [a, ɛ, ɔ, e, o, ə, ɨ, ʉ, i, u])	[dʒɛ́ɗé]
Diachronic representation (using one vowel: *a)	*dza-´ɗý

Note: The toneless motion-verb root /dza-/ ‘to go’ combines with a locative-directional extension suffix {-ɗi} (carrying Y-prosody and a H-H tone pattern) meaning ‘down(hill), westward’. The root-final vowel /a/ of the verbal root undergoes palatalisation (from Y-prosody associated with the final segment of the suffix, which is diachronically underlying *{ʸ/-´ɗý/} ⟶ surface {-ʸ[-´ɗí]}) and becomes [ɛ], at the same time it lowers the final [i] (⟵ */y/) in the adjacent syllable, which becomes [e]: [dʒɛ́ɗé]. Y-prosody is also responsible for the palatalising of underlying /dz/ ⟶ [dʒ]. Since [ɛ] and [e] do not contrast in the language, they are commonly both transcribed for practical convenience as <e>: *dzéɗé*, graphically suggesting a kind of vowel “harmonisation” (or “levelling”) across the whole word. Reconstructing Proto-Lamang with a minimal one-vowel system entails the analysis of surface [i~e] to be a reflex of diachronically underlying */y/.

2 Central Chadic: the vocalic domain

Section 2 aims to show how only a prosodic approach to Central Chadic phonological systems allows us to identify the contrastive units that enter into regular sound correspondences between the pairs of languages, as required by the comparative method. A first attempt along these lines was presented by Gravina (2014). This was followed by alternative reconstructions based on a different theoretical and methodological approach to the comparative study of prosodies in Central Chadic by Wolff (2022a, 2023). Both studies rely on the same set of language data (Gravina 2015).

A starting point for both studies is a lack of any series of regular sound correspondences in surface vowels between the pairs of languages, as exemplified in Table 8 (cf. also Wolff 1983b) with the words for ‘nose’ and ‘ear’ in a set of closely related Central Chadic languages, in which any vowel would appear to correspond to any other vowel in other languages.

The situation becomes more transparent once the effects of Y- and W-prosodies (or their absence, indicated by ∅) on the vowels has been identified, as in Table 9.

Table 8: Surface vowel correspondences in certain Central Chadic languages: ‘nose’ and ‘ear’

	‘nose’	‘ear’
Dghweɗe	*xtire*	*ɬeme*
Glavda	*xtəra*	*hʸimia*
Gvoko	*xtor*	*ɬuwo*
Guduf	*xtere*	*ɬime*
Podoko	*ftra*	*ɬama*
Wandala	*əktare*	*ɬəma*
Gwara	*akʷcin*	*ɬimi*
Lamang	*xtsini*	*ɬəməŋi*

Table 9: Prosody effects on surface vowels in certain Central Chadic languages: ‘nose’ and ‘ear’

	‘nose’			‘ear’		
	∅	+Y	+W	∅	+Y	+W
Dghweɗe		*xtire*			*ɬeme*	
Glavda	*xtəra*				*hʸimia*	
Gvoko			*xtor*			*ɬuwo*
Guduf		*xtere*			*ɬime*	
Podoko	*ftra*			*ɬama*		
Wandala		*əktare*		*ɬəma*		
Gwara		*akʷcin*			*ɬimi*	
Lamang		*xtsini*		*ɬəməŋi*		

Note: Surface [ə] and [a] reflect ∅-prosody on schwa and /a/, surface [u] and [o] reflect W-prosody on schwa and /a/, surface [i] and [e] reflect Y-prosody on schwa and /a/, unless surface [i] represents syllabification of /y/ in syllable-nucleus position, as in the word-final positions of Lamang *xtsini*, Glavda *hʸimia*, Gwara *ɬimi*, and Lamang *ɬəməŋi*, where underlying /y/ is reconstructed as a manifestation of a very common reconstructed suffixal root augment *{-y}.

A prosodic analysis allows the identification of the underlying phonemic segments which enter regular sound correspondences between the pairs of languages. It is only after the prosodic analysis that the comparative method can be applied. A complete phonological analysis of synchronic Central Chadic words, therefore, requires the identification of both segments and prosodies, as shown in Table 10. These examples also show the variation with regard to the underlying root types: CCCa ~ CCaCa for 'nose' and CCa ~ CaCa for 'ear'.

Table 10: Prosody-based analysis in certain Central Chadic languages for 'nose' and 'ear'

	'nose' PCC *x^{w}(a)ts(a)na		'ear' PCC *ɬ(a)ma	
	CCCa	CCaCa	CCa	CaCa
Dghweɗe	^{y}/xtra/			^{y}/ɬama/
Glavda	/xtra/		^{y}/x^{y}m-ya/	
Gvoko		^{w}/xtar/	^{w}/ɬwa/	
Guduf		^{y}/xtara/	^{y}/ɬma/	
Podoko	/ftra/			/ɬama/
Wandala		^{y}/ktara/	/ɬma/	
Gwara	^{y}/k^{w}tsn/		^{y}/ɬm-y/	
Lamang	^{y}/xtsn-y/		/ɬm-ŋ-y/	

Such a prosody-based analysis reveals that the six surface vowels (*a*, *ə*, *i*, *e*, *o*, *u*) in the examples listed in Table 9 reflect just a single underlying vowel phoneme /a/ (with allophones [a, e, o]), in addition to the pro- and epenthetic schwa ([ə], with an occasional prothetic variant [ɐ] – mostly transcribed as [a] as in Gwara *ak^{w}cin*), and a syllabified /y/, which is realised as [i] in word-final syllable-nucleus positions. Without applying a prosodic analysis to Central Chadic language data it would be hard to reach any meaningful historical-comparative analysis with regard to vowels.

2.1 Proto-Central Chadic: Segmental units

Under the assumption of historically minimal vowel systems in (Central) Chadic languages, PCC phonology is reconstructed with a basic yet non-trivial dichotomy of "consonantal" versus "vocalic" segments. Consonantal segments (Section 2.2) are specified by the feature [-syll] and, as it can be claimed (Wolff 2022a, 2023), they may be affected by a total of four word-level prosodies, namely palatalisation (Y-prosody), labialisation (W-prosody), prenasalisation (N-prosody), and glottalisation (ʔ-prosody). Note that the class of the vocalic segments [+syll], introduced in Section 2.3, only undergo the effects of Y- and W-prosodies. A particular role is played by the approximants ([±syll]), whose structural ambivalence makes them part of both the consonantal and the vocalic domains of PCC segmental phonology. They do not undergo any prosodic effects (see Section 2.2 and Section 2.3), but rather trigger them. Note the absence of a classic "vowel system" in which several phonemic vowels contrast with each other. This apparent deficit of the vocalic domain is compensated, so to speak, by making use of the vocalic allophones of the two approximants. The architecture of the reconstructed PCC phonological units is depicted in Figure 3.

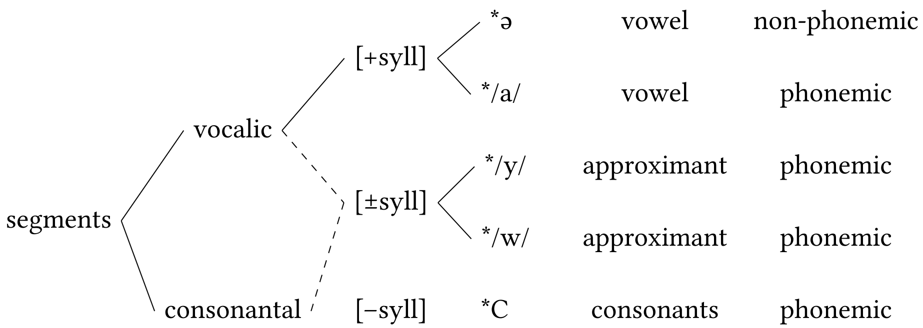

Figure 3: Phonological architecture of PCC vocalic and consonantal units

2.2 Consonants and approximants

A reconstructed consonantal inventory of PCC, which also includes approximants, is given in Table 11.[16]

[16]The inventory in Table 11 is slightly at variance with the one used in Wolff (2022a). The modifications pertain most of all to the phonemic status in PCC of the velar nasals [ŋ, ŋ^{w}] and the series of prenasalised obstruents (see Wolff 2022b). Note that the consonantal chart does not preclude the phonologisation of allophones of consonants that are not reconstructed as phonemes for PCC in Table 11, but which in certain modern CC languages indeed function as synchronic phonemes. These include velar nasals /ŋ/ and /ŋ^{w}/, prenasalised obstruents, and glottal stop. According to established Chadic linguistics conventions, implosives and ejectives are subsumed under a series of "glottal" consonants, the most common being the implosives /ɓ/ and /ɗ/, which are confidently reconstructed for PCC. Note that /ʔy/ of still uncertain phonetic realisation is tentatively reconstructed so far only for the root 'water' (PCC *ʔy(a)ma). Individual modern languages occasionally have other glottal consonants in phonetic surface realisation, such as transcribed by [s'], [ɬ'], [k'], [k^{w}'] etc. whose emergence, however, can be historically accounted for by the notion and effects of ʔ-prosody, see Wolff (2023).

Table 11: PCC consonantal segment inventory

Consonants [−syll]		Labial	Alveolar	Post-alveolar	Labialised velar
Plosive	voiceless	p	t	k	k^w
	voiced	b	d	g	g^w
	glottal	ɓ	ɗ	ʔy	
Affricate	voiceless		ts		
	voiced		dz		
Fricative	voiceless	f	s	x	x^w
	voiced	v	z	ɣ	$ɣ^w$
Lateral	voiceless		ɬ		
Fricative	voiced		ɮ		
Nasal		m	n		
Liquid			r		
Approximants [±syll]				y	w

As my continued comparative investigations into the PCC consonantal system and lexical reconstructions have shown (Wolff 2023), surface representations of [ŋ] and [$ŋ^w$] in present-day CC languages overwhelmingly result from a fusion of a nasal and a velar consonant, which means that one can exclude /ŋ/ and /$ŋ^w$/ as separate PCC consonantal segments.

A distinction, first between prenasalised obstruents and homorganic nasal + obstruent clusters and, second, between glottal(ised) consonants and glottal + obstruent clusters, in modern CC languages is not always clear from the available transcriptions of data. Linguists may treat this issue one way or the other in synchronic descriptions, but internal reconstruction usually suggests nasal + obstruent and glottal + obstruent clusters as the historical source. The opposite also occurs, namely that historical analysis favours prenasalisation by genuine N-prosody, while the synchronic transcription in the database suggests a nasal + obstruent cluster.

PCC is reconstructed without a series of palatalised consonants, even though many modern CC languages have sets of synchronic palatalised consonants /C^y/. These are diachronically stemming from the effects of Y-prosody. On the other hand, PCC is reconstructed with a series of labialised velar consonants (*/C^w/) and */w/, which all may become sources of W-prosody affecting other units in a chain of segments. The symbol C^w, therefore, is ambivalent in the transcriptions used here: With velars, it represents a reconstructed phonemic labialised velar */C^w/. With non-velars, it represents any other consonant that has been labialised under a W-prosody effect. This will be illustrated in a set of examples below (see Section 2.3.4).

It may be interesting to note that the two prosodies are different with regard to their segmental sources, at least as far as PCC is concerned. W-prosody has a segmental basis both in the series of labialised velars and in the approximant */w/. Y-prosody has a segmental basis only in the approximant */y/. This opens a more far-reaching question: Are PCC reconstructed labialised velars themselves retentions from PC or PAA, or have they come about in PCC by the effects of W-prosody already operating in PC? This question must remain open for the time being.[17]

2.3 Vocalic segments and approximants

2.3.1 The proto-language system

In the reconstruction of PCC, vowels, approximants, and consonants represent three distinct classes of segments. Vowels are a class of segments that are specified as [+syll], while approximants are specified as [±syll], and consonants are unequivocally specified as [-syll]. This means that both vowels and approximants can fill syllable-nucleus positions, which require a [+syll] specification. The structure behind the allophony of the only vowel */a/ and the approximants, as well as of the conditioned variants of non-phonemic schwa in CC languages in terms of the transcription conventions used in synchronic sources is illustrated in Figure 4.

Despite the frequent appearance of basic surface vowels *a*, *i*, *u* in modern languages, therefore, on the level of the proto-language they do not all qualify as vowels of the same phonological status: */a/ is the only true vowel phoneme, while [i] and [u] represent */y/ and */w/ or, occasionally, an epenthetic schwa (depending on transcription conventions, see Section 1.4.1). The approximants /y/ and /w/, for whatever reasons, do not come under the effect of prosodies, but

[17] Note that Newman (1977a: 9) reconstructs a PC phonemic inventory with a series of palatals and of palatalised velars as well as labialised velars. This still authoritative publication, however, was written before the prosodic analysis of (Central) Chadic languages became more widely accepted.

Phonemic	Allophonic			
	[+syll]		[-syll]	
*/y/	i		y	
*/w/	u		w	
	[+syll]			
*/a/	∅-prosody a ~ ɐ ~ ə	Y-prosody e ~ ɛ ~ æ	W-prosody o ~ ɔ	Y+W-prosodies œ
Non-phonemic *ə	ɐ ~ ə ~ ɨ	ɨ ~ ɪ ~ i	ʉ ~ ʊ ~ u	IPA y ~ ø

Figure 4: Allophony and transcription variants of PCC vowels */a/, *[ə], and approximants */y/ and */w/

rather qualify as sources for palatalisation and labialisation prosodies themselves. In contrast to the approximants, the phonemic vowel */a/, pro- and epenthetic vowels, and all the remaining consonants do tend to come under the effect of the major prosodies of palatalisation (Y-prosody) and labialisation (W-prosody). Y-prosody triggers changes */a/ ⟶ [ɛ] and [ə] ⟶ [ɨ, ɪ], often being transcribed as [e] and [i]. W-prosody triggers changes */a/ ⟶ [ɔ] and [ə] ⟶ [ʉ, ʊ], often being transcribed as [o] and [u]).[18]

In addition to its 26 consonants and in the absence of a "vowel system" in the narrow and most common sense, PCC operated a system of distinctive yet only partially contrastive phonetic surface vowels resulting from the approximants */y, w/, the single phonemic vowel */a/, and a non-phonemic vowel *ə.

2.3.2 From PCC to the modern languages

Regarding phonetic surface realisations, many modern CC languages give an impression of operating either a basic three-vowel or a four-vowel system, depending on whether schwa is considered to represent a synchronic phoneme or not. The other recurring issue is whether high vowels [i] and [u] are considered to be independent phonemes or conditioned allophones of underlying /y/ and /w/. Depending on the choices made by a linguist describing a particular language, many

[18]Note that central(ised) varieties of high vowels and fronted and rounded varieties of central vowels are at times indiscriminately transcribed in Chadic data as both *ɨ/ɪ* and *ʉ/ʊ*. For the present chapter, I will read barred-*i* (*ɨ*) and barred-*u* (*ʉ*) to indicate, slightly at variance with IPA, raised (and impressionistically slightly fronted) and raised back-rounded varieties of mid-central IPA schwa (*ə*).

CC languages are synchronically described as operating either a two-vowel system (/a, ə/), or only one vowel phoneme (/a/), or three- (/a, i, u/) or four-vowel (/a, ə, i, u/) systems. As later diachronic developments saw the phonologisation of (tense and lax) mid-vowel allophones into independent vowel phonemes in individual modern languages, some of them are also described as having five-, six-, seven-, or eight-vowel systems (see below). I disregard here the issue of vowel length, which has historically developed in certain Chadic languages but not in others (see Wolff 2022a, 2023).

The decision to accept schwa as a synchronic phoneme or to treat it as a predictable prothetic/epenthetic vowel is often a matter of theoretical perspective and/or of personal preferences of a descriptive linguist, as phonological arguments can be found to support either analysis for the synchronic descriptions of modern Central Chadic languages. This does not invalidate the suggested treatment of *ə as fully predictable and non-phonemic in PCC. Doing so further allows the unequivocal identification of different underlying root types with fixed positions for medial interconsonantal */a/, which in turn allows a retrospect identification of the underlying vocalic segments (*/a/, *ə, */y/, */w/) for phonetic surface vowels.

In the absence of and disregarding diachronic insights as now available (Wolff 2022a, 2023), synchronic descriptions of modern Chadic languages had no reason to question the phonological status of the basic surface vowels that were usually transcribed as [a, i, u, ə, e, o]. By shallow phonological analysis, they were identified as phonemic – possibly with the exception of schwa. Accepting such analyses as synchronically correct would mean accepting that synchronic /i, u, e, o/ and possibly /ə/ had become "phonologised" from their diachronic origins as conditioned allophones and variants of */a, y, w/ and *ə. The impression conveyed by modern synchronic grammars of Central Chadic languages is that of synchronic three- or four-vowel systems, as depicted in Table 12 and as considered most likely for PC reconstruction by Newman 1977a, 2006, disregarding length. The diachronic scenario for such phonologisation would be that via quasi-phonemes:

> The concept of a quasi-phoneme originated in the literature on sound change and phonologization, as part of the effort to solve the problem why allophonic distinctions sometimes remain unaffected when their conditioning environments disappear, and become phonemic instead (Ebeling 1960, Korhonen 1969, Janda 2003). The idea was that this happens when they for some reason have acquired "quasi-phonemic" status before the environment changes (Kiparsky 2018: 66).

Table 12: After apparent phonologisation I: Surface-level vowel inventories in modern CC languages

(a) Three vowels

/i/		/u/
	/a/	

(b) Four vowels

/i/		/u/
	/ə/	
	/a/	

Along the same lines of shallow surface-oriented phonological analysis, further post-PCC historical developments could then be viewed as potentially phonologising the conditioned allophones of underlying */a/ under Y- and W-prosodies, which usually yield the surface representations [ɛ] and [ɔ]. Occasionally, the high surface vowels [i] and [u] would undergo lowering assimilation [i] ⟶ [e] and [u] ⟶ [o], triggered by the occurrence of a low vowel /a/ in apparently any adjacent syllable. Simplified transcriptions and "practical" orthographic conventions would lead to the descriptive acceptance of rather common synchronic five- and six-vowel systems which contain non-contrasting [ɛ, æ, e] and [ɔ, o] and which one finds in many modern Chadic languages, usually transcribed as <e, o>. This can be captured by postulating the following historical sound changes, which apparently have fed phonologisation towards the postulated synchronic systems:

(1) /y, w/ ⟶ /i, u/;

(2) under Y-prosody: ^{y}/a/ ⟶ /ɛ/, often symbolised graphically as <e>;

(3) under W-prosody: ^{w}/a/ ⟶ /ɔ/, often symbolised graphically as <o>.

See Tables 13 and 14.

Table 13: After apparent phonologisation II: Prosody-induced tense mid vowels in modern CC languages

(a) Five vowels

/i/		/u/
/e/		/o/
	/a/	

(b) Six vowels

/i/		/u/
/e/	/ə/	/o/
	/a/	

When synchronic [e, o] can be diachronically identified with originally lowered allophones of /i, u/, the fronted and rounded allophones of /a/ (originally, Y- and W-prosody effects) may receive quasi-phonemic status as /ɛ, ɔ/ in individual modern languages. This then results in synchronic seven- or eight-vowel systems:

Table 14: After phonologisation III: Prosody-induced lax mid vowels in modern CC languages

(a) Seven vowels

/i/		/u/
/e/		/o/
/ɛ/		/ɔ/
	/a/	

(b) Eight vowels

/i/		/u/
/e/	/ə/	/o/
/ɛ/		/ɔ/
	/a/	

The result of such phonologisation processes is that most modern Central Chadic languages no longer appear to base their underlying vowel phonemes on the inherited minimal vowel system of the common proto-language, but function with synchronic multi-vowel systems. The original minimal-vowel system only survives in a few languages – one of the most spectacular and therefore most frequently cited case is that of Moloko (Mofu group, see Friesen et al. 2017). In other CC languages, this deep underlying system can be detected only on a highly abstract level of phonological analysis, which already comes close to the internally reconstructed system of the postulated proto-system for an individual language.

A case to illustrate the point is Lamang (Lamang group; Wolff 1983a, 2015). The language has 10 phonetic vowels in more or less narrow transcription: [i, ɪ, ʊ, u, e, ə, o, ɛ, ɔ, a]. In terms of a classic Prague-school structural analysis, it has four vowel phonemes, namely three monophthongs /a, i, u/ plus distinctive word-final /E/, plus epenthetic schwa. The exclusively word-final /E/ historically reflects a final diphthong *-ay containing a reconstructable PCC suffix *{-y}; it is phonetically realised as [o] under W-prosody and as [e] elsewhere. See the following examples from the Lamang group languages Lamang and Hdi.

Lamang also shows an allophony [w~u], which is still operational synchronically as can be seen in the confrontation of simplex and pluractional verb stems.

A sound [ə] operates as epenthetic vowel, and both /a/ and [ə] undergo predictable prosody-induced colouring (see Wolff 2015, Vol. 1. 64-82).

On a deeper level and by historically informed analysis, which is supported by recent insights in Central Chadic historical phonology, Lamang, too, could now be described as still and even synchronically operating an underlying minimal vowel system of the type reconstructed for PCC, despite its appearance of

Table 15: 'mouth' PCC *m(a)ya, Proto-Lamang group internal reconstruction *(a-)wy. Lamang and Hdi differ in terms of reflexes of a PCC prefixal root-augment *{ma-}. While Lamang shows the reflex *{a-} in *ma-mya > *∅a-my∅ > *a-wy, Hdi shows no reflex at all: *mya > *my∅ > *wy.

	Lamang	Hdi
transcription/surface realisation	*ewe* [ɛwe]	*wi*
underlying prosodic+phonemic representation	^{y}/awy/	/wy/

Note: PCC */m/ ⟶ *w*; syllabification */y/ ⟶ *i*; Y-prosody */a/ ⟶ *ɛ* (Lamang); vowel lowering *i* ⟶ *e/a*.C__ (triggered by /a/ in preceding syllable; Lamang), practical/semi-orthographic transcription convention [ɛwe] > *ewe* (Lamang).

Table 16: 'to marry' : 'to marry many times'
Proto-Lamang internal reconstruction *wma [uma] : *wama [wama]

	simplex	Pluractional formation by infix {-a-}:
transcription/surface realisation	*uma* [uma]	*wama* {w-a-ma}
underlying phonemic representation	/wma/	/wama/

Note: Underlying root type CC*a* /wma/ allows {-a-} infixation > C-*a*-C*a* /wama/. The initial vowel [u] of the simplex is a conditioned allophone of /w/ in syllable-nucleus position; in syllable-margin positions the conditioned allophone is [w].

Table 17: 'hut, bedroom' PCC *v(a)na
Proto-Lamang-group internal reconstruction: *vn-y-k^{w}

	Lamang	Hdi
transcription/surface realisation	*ivəŋ ~ ivŋ*	*viŋ*
underlying prosodic+phonemic representation	^{y}/vŋ/	^{y}/vŋ/

Note: Reconstructed suffixal root-augment *{-y} desegmentalises completely and prosodises into ∅^{y}; root-final /n/ and suffixal root-augment *{-k^{w}} fuse to yield delabialised surface [ŋ]; Lamang inserts prothetic [ə] before initial CC, which Y-prosody "colours" to be realised [i] (*ivŋ*); Hdi does not insert prothetic schwa but rather inserts epenthetic schwa between the two consonants, which Y-prosody "colours" to be realised [i] (*viŋ*); Lamang allows for two phonetic realisations (*ivŋ ~ ivəŋ*), by also inserting epenthetic schwa between the two consonants, but not subjecting it to Y-prosody. This epenthetic schwa tends to be heard in slow and deliberate speech.

operating a shallow 3+1-vowel system on the surface. A parallel case can also be postulated for a historically informed reanalysis of the Wandala vowel system (see Wolff & Naumann 2004).

2.3.3 Modern CC languages

In a typological survey of modern Central Chadic languages one can generalise that surface appearances of words are characterised by quite a number of different vowels, mostly short and only occasionally long. The most frequent short vowels are [a] and schwa [ə], followed by [i] and [u], and much less frequent are [e] and [o]. Occasionally, other vowels result from the influence of either Y- or W-prosodies on /a/ and epenthetic schwa, yielding phonetic surface vowels such as [ɐ, ʌ, ɛ, æ, ɔ, ɪ, ʊ], or as a result of combined Y- and W-prosody effects on these, yielding [œ] and IPA [y] (given as [ø] for Moloko (Mofu) by Friesen et al. 2017). In the literature covering synchronic descriptions of these languages, therefore, one finds more or less rich vowel systems which are very much comparable to those of any other world's languages.

However, taking a more abstract approach or, especially, looking at these languages in diachronic perspective, one needs to reconsider the situation. This verdict does not invalidate purely synchronically-based analyses, which have a high scientific and practical value in themselves. However, they leave open interesting questions such as where the present phonological systems come from and how they have evolved from their reconstructable origins.

Continuing the overview of modern Central Chadic languages, one finds that in synchronic surface-structure oriented descriptions, high vowels [i, u] are claimed for all these languages, but are almost everywhere treated as separate phonemes rather than complementary vocalic allophones of /y/ and /w/ or as prosody-conditioned variants of non-phonemic *ə. The reconstructed PCC word forms usually unequivocally allow us to identify the proto-language source segments of surface [i] and [u] as either approximants */y/ and */w/ or epenthetic *ə.

2.3.4 Illustrative examples

The following examples show how a historical phonological analysis of PCC works, demonstrating prosodic effects and sound changes operating over a few thousand years in modern CC languages. The historical *input* contains the sequences of reconstructed PCC phonemes which include only one phonemic vowel */a/ and active Y- and W-prosodies (i.e. palatalisation and labialisation according to Wolff 2022a, 2023). The *output* contains the transcribed data from a freely available database (Gravina 2015). These data, when associated with a synchronic multi-vowel system, are characterised by the lexicalised effects of prosodies which have created, via quasi-phonemes, a larger number of synchronic vowel phonemes as part of enriched vowel systems that have evolved over time. In the rather few cases where synchronic language systems operate with minimal vowel systems akin to the PCC reconstructed system, prosodies can be seen to be still synchronically operational. Note that the current state of Central Chadic linguistics allows one to identify with a high level of credibility only the input and the output data. The phonological details of language change between input and output would need qualified classical phonological analysis of the individual languages in order to identify the underlying phonemes, which for most languages in the database is not available.

In Table 18, the initial consonant of a root *sbta is affected by Y-prosody (*/s/ ⟶ s^y [ʃ]) stemming from the influence of a petrified prosodising suffix (*/-y/ ⟶*y^y). The segmental part of the approximant /y/ syllabifies into [i] in the nucleus position of the final syllable:

Table 18: ‘hair’ PCC *sbta

Bana (Hɪɢɪ)	*sbta-y	> *s∅t∅-y^y	> *s^yt-y	s^yty > *ʃti*

In example Table 19, an original C_2 consonant of the root *$ɣ^w$va is affected by W-prosody (*/v/ ⟶ [v^w]) stemming from a diachronic labial cluster (*/wv/) subsequent to the weakening and prosodification of the original labialised velar C_1 */$ɣ^w$/ ⟶ *w^w ⟶ $∅^w$.[19]

In Table 20, the final nasal /n/ of a root *x^wtsna fuses with the delabialised suffix consonant (*/k/ ⟵ *{-k^w}), to yield [ŋ] in synchronic surface representation:

In Table 21, the labialisation feature of the suffix *{-k^w} to the root *dzvna is retained, including its W-prosody effect, so that the fusion with the preceding nasal /n/ yields surface [$ŋ^w$].[20] Here, an originally tri-morphemic PCC word form

[19]While in Table 18 Y-prosody illustrates the frequent case of a right-to-left feature anticipation, in Table 19 there is a less frequent left-to-right feature spreading of W-prosody, unless one assumes a preceding metathesis *wv ⟶ *vw*.

[20]There remains an intriguing question why and under which conditions labialised velars become delabialised in some examples, like in Table 20, but not in others, like in Table 21. Delabialisation is a highly frequent diachronic process across CC languages. Confronting PCC historical input and synchronic output in modern languages does not provide answers in terms of governing principles or diachronic rules. Answers must obviously be sought in individual language histories and/or in individual word histories. Both are currently not available.

Table 19: ‘faeces’ PCC *ɣʷva

Jimi (Bata)	Input	*ɣʷva-y-n
	*a → ∅; weakening *ɣʷ → w	*wv∅-y-n
	Prosodification *w → ∅ʷ	*∅ʷv-y-n
	W-prosody v → vʷ	vʷyn
	syllabification y → i	vʷin
	Output	*vʷin*

Note: An originally tri-morphemic PCC word form *ɣʷva-y-n underwent segment deletion and sound changes which included the prosodification of *y. This yielded a proto-Jimi form *ʷ/vyn/ which also corresponds to the synchronic underlying form in modern Jimi. This form is realised phonetically as *vʷin* ‘faeces’. The high front vowel [i] is a conditioned allophone of /y/ in syllable-nucleus position.

Table 20: ‘nose’ PCC *xʷtsna

Mbazla (Maroua)	Input	*xʷtsna-y-kʷ
	*xʷ → k; *ts → t; *a → ∅; delabialisation: *kʷ → k	*ktn∅-y-k
	Prosodification: *y → ∅ʸ; fusion: nk → ŋ	*ktŋ-∅ʸ
	ə-epenthesis; Y-prosody:	kəʸtəʸŋ
	əʸ → i	kitiŋ
	Output	*kitiŋ*

Note: An originally tri-morphemic PCC word form *xʷtsna-y-kʷ underwent segment deletion and sound changes which included the prosodification of *y. This yielded a proto-Mbazla and underlying form *ʸ/ktŋ/, which modern Mbazla realises phonetically as *kitiŋ* ‘nose’. The high front vowel [i] are the phonetic realisations of epenthetic schwa under Y-prosody.

*dzvna-y-kʷ underwent segment deletion and sound changes, including prosodifications, yielding a proto-Mbazla and underlying form *ʸʷ/tsfŋ/, which modern Mbazla realises phonetically as *tʃufuŋ* ‘guineafowl’. Under the chosen transcription conventions in the source, the high back vowel [u] represents the phonetic realisations of epenthetic schwa under W-prosody, which other sources often transcribe as [ʉ, ʊ].

As said above, surface representations of prenasalised obstruents [ᵐb, ⁿd, ᵑg] etc. in present-day CC languages, apart from rare instances of possibly spontaneous phonetic prenasalisation, usually emerged from nasal+obstruent clusters and nasalisation prosody (N-prosody). The latter diachronically stems from the desegmentalisation and prosodification of petrified and fused root-augmental affixes, which originally included a nasal consonant. Most often one is dealing with

Table 21: ‘guineafowl’ PCC *dzvna

Mbazla (Maroua)	Input	*dzvna-y-k^{w}
	*dz → ts; *v → f; *a → ∅	*tsfn∅-y-k^{w}
	Fusion: nk^{w} → ŋ^{w}; prosodifications: *y → ∅^{y}; ŋ^{w} → ŋ+^{w}	*tsfŋ^{w}-∅^{y}
	ə-epenthesis; Y-prosody: ts^{y} → tʃ; W-prosody: ə^{w} → u	tʃufuŋ
	Output	*tʃufuŋ*

reflexes of a reconstructed prefixal marker *{ma-} of a deep Afroasiatic heritage.

In Table 22, which demonstrates the root *ba, data transcription *^{m}ba* marks a prenasalised obstruent in a root-initial position, which comparative evidence is able to explain as a diachronic nasal+obstruent cluster. However, alternative analyses are feasible. An originally bi-morphemic PCC word form *ma-ba underwent segment deletion and, thereby, created an initial nasal+obstruent cluster yielding a proto-Mbuko and underlying form */mba/, which modern Mbuko realises phonetically as [mba] ‘to be able’. This analysis, however, does not underlie the transcription of the database, which obviously follows another analysis: An originally bi-morphemic PCC word form *ma-ba underwent segment deletion and, thereby, created an initial nasal+obstruent cluster. The initial nasal of the cluster desegmentalised, prosodified, and created N-prosody yielding a proto-Mbuko and underlying form *^{n}/ba/, which modern Mbuko realises phonetically as *^{m}ba* ‘to be able’.

Table 22: ‘to be able’ PCC *ba

Mbuko (Hurza)	Input	*ma-ba
	*a → ∅; nasal cluster	*m∅-ba > *m-ba
	Prosodification *m → ∅^{n}	*m^{n}-ba > ∅^{n}-ba
	Output	mba *^{m}ba*

A few CC languages show non-reconstructed and synchronically rare initial glottal consonants in synchronic transcriptions. Comparative evidence allows one to explain them as synchronic ʔ-prosodies originating from glottal+obstruent clusters. In Table 23, a C_2 /r/ of a simple root *sra undergoes a sound change *r → *ɗ* → *ʔ*, which creates a root-initial cluster *sʔ* which is synchronically interpreted as a surface glottalisation of /s/ → [s’] by ʔ-prosody.

An internally reconstructed proto-Mser and underlying form *^{y}/msʔka/ is realised phonetically in modern Mser as *ms'ɨkɨ* 'foot, leg'. The front central vowels [ɨ] are the phonetic realisations of both epenthetic schwa and the centralised (pre-juncture?) allophone [ə] of lexical-final /a/ under Y-prosody.

Table 23: 'foot, leg' PCC *sra

Mser (Kotoko-Central)	Input	*ma-sra-y-k^{w}a
	*a → ∅; *r → *ɗ* → *ʔ*; *k^{w} → *k*	*m∅-sʔ∅-y-ka
	Prosodification *y → ∅^{y}; */a/ → [ə]	*m-sʔ-∅^{y}-kə
	ə-epenthesis	msʔə^{y}kə^{y}
	ə^{y} → *ɨ*	ms'ɨkɨ
	Output	*ms'ɨkɨ*

2.4 Summary: the system of prosodies in Central Chadic languages

Prosodies are an essential feature of Central Chadic linguistic history and typology because they are instrumental in making underlying minimal vowel systems operational. They stem from segments in the common proto-language, and they characteristically contribute to shaping the phonetic appearance of words in modern languages. In order to account for the synchronic shapes of words, it is not important whether the prosodies have a lexical (phonological) or a grammatical (morphological) origin. This distinction goes back to Schuh (2002). Morphological prosodies stem from mostly defunct and semantically bleached petrified affixal grammatical markers. In a number of modern languages, however, these markers are still synchronically operational. Phonological prosodies stem from the segments of a lexical root itself. In individual cases, the analytical choice between phonological and morphological prosodies is not obvious. There are a small number of examples, in which both phonological and morphological sources could be held accountable for certain prosodic effects. This can be neatly illustrated with a reconstruction of the word for 'tooth' (PCC *ɬ(a)ɗ(a)na). This root is reconstructed as allowing both prefixal and suffixal root augments, like most reconstructed lexical items. Among the suffixal augments one finds a highly frequent grammatical marker *{-y}, which characteristically tends to serve as a source for palatalisation (*{-y} → *y^{y}/∅^{y} → Y-prosody). One might be tempted, therefore, to relate all palatalisation effects to this suffixal root augment historically. However, one must take into account that a root-internal *ɗ may undergo a sound change *ɗ ⟶ /y/, quite common in CC languages, cf. the following examples:

(7) ‘night’ PCC *rvaɗa

Sukur (Sukur) *r v a ɗ a

∅ v a y ∅ > *vay*

(8) ‘fly’ PCC *dzkʷaɗa

Mbara (Musgum) *dz kʷ a ɗ a

t wʷ a y ∅

LAB

t [ə] w a y > *tuway*

(9) ‘five$_2$’ PCC *ɬɗma

Malgwa (Mandara)[21] *ɬ ɗ m a

ɮ y b a

y ɮ b a

PAL

[ə]y y ɮ b a

[i] i ɮ [ə]b e > *iidhləɓe*

Accepting a sound change *ɗ ⟶ /y/ and returning to the root *ɬ(a)ɗ(a)na ‘tooth’, it remains to be acknowledged that the C_2 of the root itself may be a source of Y-prosody after a change *ɗ ⟶ /y/. As data show, C_2 *ɗ and *{-y} may co-occur and can have different reflexes in modern CC languages, cf. examples from languages other than Malgwa (Mandara):

- Daba group: Buwal ʸ/ɮɗaŋ/ *ɮəɗeŋ*, Gavar ʸ/ɮɗaŋ/ *ɮiɗeŋ*,
- Mandara group: Matal ʸ/ɬɗ/ *ɬɪɗ*,
- Lamang group: Lamang ʸ/ɬɗŋ/ *ɬɗiŋ*, Hdi ʸ/ɬɗŋ/ *ɬi'iŋ*.

These examples show that *ɗ can be maintained, while the vowels still undergo palatalisation (*ə → [i~ɪ], *a → [e~ɛ]), which must be an effect of suffixal *{-y} here.

There is both right-to-left and left-to-right directionality in the spreading of prosodies, although the former is less frequent than the latter.

3 Cross-linguistic contextualisation of Central Chadic vowel-system typology

For this section, the author was guided by the valuable literature survey on minimal vowel systems in Anderson (2016: 59-117).

3.1 Consonant-to-vowel ratio

Languages with minimal vowel systems are often claimed to "show inflated consonant inventories. For instance, among the Northwest Caucasian languages Kabardian has 47 consonant phonemes, Abkhaz 59, Ubykh over 80 – as opposed to three vowel phonemes" (Anderson 2016: 66). PCC is reconstructed with only 26 consonants plus two approximants, as opposed to one phonemic vowel. However, modern CC languages may possess much richer inventories of consonants, since a number of prenasalised, labialised and palatalised obstruents, as well as nasal velars *ŋ* and *ŋʷ* and additional glottal consonants have emerged from prosodic effects and segmental fusions (see Wolff 2023). For illustrative synchronic treatment, see Barreteau's (1983: 262) reanalysis of Central Chadic Higi, in which 26 plain consonants are inflated to 93 consonants by the effect of various prosodies. See also Hoffmann (1987: 465-468) for rich synchronic consonant inventories in the Margi group (Bura: 79, Margi: 75; versus Kyibaku: 39, Həba: 40 consonants). Bura and Margi display many complex consonantal phonemes historically reflecting bi- if not triconsonantal sequences, which have fused or undergone prosodic effects such as labialisation, palatalisation, and prenasalisation. Newman & Ma (1966: 228) and Newman (1977a: 17) view these as segmental fusions which accompanied the loss of interconsonantal vowels. This diachronic explanation is considered insufficient by Barreteau (1983: 271) at least for the

Higi language. Anderson (p.c. 2022) suggests that systems with contrastive secondary articulation which conditions vowel quality can inflate the consonant system. Contrasts like front vs back that play out in different ways on the vowels in most languages may do so also on a domain extending over both vowel and adjacent consonant(s) in many of the minimal vowel systems. This would also apply to the effect of prosodies in Central Chadic.

3.2 Ultimate origin: vowelless systems?

A typological parallel links historical hypotheses concerning PCC to the Sepik-Ramu languages of Papua New Guinea. The latter having "vowel systems, in which many instances of phonetic vowels can be shown to reflect more abstract representations without vowels" (Anderson 2016: 79).

Central Chadic may lend support to this insofar as vowelless analyses are feasible for underlying structures, at least for some languages. The PCC minimal vowel system with only one phonemic member, namely */a/, may in itself be the result of vocalogenesis from a historically even deeper zero-vowel system, tentatively linked up to Proto-Chadic or even Proto-Afroasiatic. While synchronic /i/ and /u/ are derived from reconstructed palatal and labiovelar approximants */y/ and */w/, reconstructed */a/ could tentatively be derived from a pharyngeal approximant */ʕ/ (this hypothesis remains speculative at the present time and largely based on analogy to */y/ and */w/, but would appear to merit closer investigation in future research). This would result in a historical system with three basic approximants *ʕ, *y, *w, which together would be the source of a later triangular *a, *i, *u vowel system which many experts (cf. overviews in, for instance, Frajzyngier & Shay 2012, Meyer & Wolff 2019) would be willing to postulate for (Proto-) Afroasiatic. This, however, remains a hypothetical and also a prospective line at the current state of comparative Afroasiatic research (see Section 3.6).

Such assumptions come typologically close to the abstract scenarios in both Modern Pekingese in Asia and the Upland Yuman languages in North America. Pulleyblank (1983: 57) suggests an analysis of Modern Pekingese without any vowels whatsoever by relating syllable peaks (including high vowels *i*, *u*, *y*, and also the low vowel *a*), to underlying approximants/glides (cf. also Anderson 2016: 74).

Anderson (2016: 83, 85) points out further parallels in Papua-New Guinea and in descriptions pertaining to the Upland Yuman languages like Walapai and Yavapai. For Yavapai, Shaterian (1975: 130) argues "that [i] and [u] are the syllabic copies of /j/ and /w/ respectively, that [a] is the syllabic realisation of /h/, and that syllabic /ʔ/ is realised as [ə], harmonising with the following syllable in careful speech". Anderson (2016: 85ff.), citing also Langdon (1976: 146, 1996: 97) comments on this that a minimal vowel system might have existed at least at the level of Proto-Yuman.

Both Pulleyblank for Pekingese and Shaterian for Yavapai evoke at least a diachronic allophony of /y~i/, /w~u/, similar to PCC, but also imagine a diachronic non-vowel origin of */a/, for which one could speculatively envisage a pharyngeal approximant *ʕ in PCC. Syllabification of these three approximants would have yielded allophonic *a, *i and *u also in the history of the Afroasiatic languages, not only Central Chadic. Later these conditioned vocalic allophones were phonologised, which gave vowel phonemes /a, i, u/ in the modern languages. For Proto-Chadic and Proto-Afroasiatic, such historical scenarios remain to be seriously investigated beyond the tentative hypothesising proposed in early works by the present author (Wolff 1981, 1983b).

3.3 Asymmetrical allophonic variation of vowels

The evolution from PCC to modern CC languages suggests that the non-phonemic *ə might have been more susceptible to the phonetic colouring effects by surrounding consonants (or, in the Chadic context, prosodies) than the phonemic */a/. This is similar to the situation referred by Anderson (2016: 76, 106) for the Arandic languages of Australia, the Ndu languages, as well as Chinese and Irish. The reason could be the longer duration of /a/ than that of /ə/.

This, again, could be supported by the data from Central Chadic languages, where schwa impressionistically tends to be shorter in duration than /a/.

3.4 Direction of prosodic impact and the overlap of allophones

PCC shares two typological features with Anindilyakwa, an Arnhem language in Australia, and also with Irish (Anderson 2016):

(1) there is a strong tendency to favour the regressive over the progressive conditioning of vowels;

(2) there is massive overlapping of vowel allophones, which also involves the neutralisation of contrasts among vowels.

Indeed, in the Central Chadic languages, a right-to-left anticipation is much more common than the left-to-right spreading of prosodic effects. Both, however, occur.

The overlap of vocalic allophones and variants in terms of varying transcription conventions can be depicted for Lamang as follows (cf. Wolff 1983a: 37, 2017: 17, slightly modified in Figure 5).

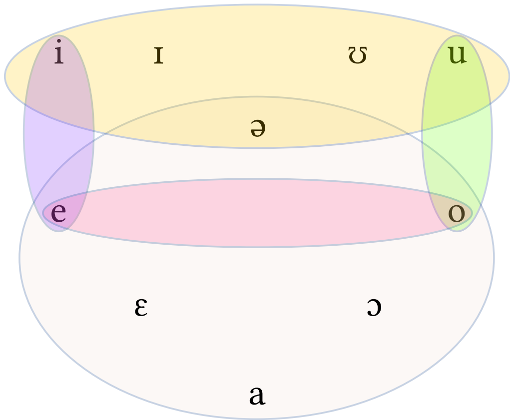

Figure 5: Allophonic and graphic overlap of vowels in Lamang

Figure 5 shows the following overlaps of allophones (in terms of both impressionistic transcriptions rather than based on phonetic studies, and for "practical" orthography purposes), where in particular mid vowels are candidates for neutralising underlying phonemic contrasts:

- [i, ɪ, ə, ʊ, u] may represent non-phonemic schwa;
- [i, e] may represent phonemic /i/;
- [u, o] may represent phonemic /u/;
- [ə, ɛ, e, ɔ, o, a] may represent phonemic /a/;
- [e, o] may represent /E/ (< */a-y/, only in word-final position).

3.5 Minimal one-vowel systems

Comparing the PCC one-phonemic-vowel minimal system with that of Haruai of the Piawi family in Papua New Guinea, one notes at least four points of typological similarity. First, in both languages one is dealing with phonemic one-member minimal vowel systems, namely /ə/ in Haruai (according to Comrie (1991) and */a/ in PCC). Second, [i] and [u] are the predictable syllabic variants of */y/ and */w/, respectively. Third, there is a non-phonemic/epenthetic non-low vowel, namely [ɨ] in Haruai and *ə in PCC. Fourth, mid vowels [e] and [o] tend to reflect underlying sequences vowel-glide-vowel, namely /əyə/ and /əwə/ in Haruai, which correspond to */aya/ and */awa/ in PCC.

The situation in the Salishan language Nuxálk, also known as Bella Coola, is also typologically close. The language is described as having a minimal vowel system /i, a, u/, reminiscent of broad assumptions concerning Afroasiatic languages. According to Nater (1984: 3ff.), there is only one vowel in the language, /a/. The other vowels, [i] and [u], are claimed to be in near-complementary distribution with /j/ and /w/, respectively.

3.6 Outlook on Afroasiatic

Given the findings of the survey of Central Chadic and other similar languages, one might wonder whether there exists a correlation between minimal vowel systems, in particular those with only one or two underlying vowels, and the presence of contrastive secondary articulations of consonants which condition vowel quality (and Y-and W-prosodies, similar to those). Both such articulations and "coloured" vocalic allophones might first be phonetic and later phonologise adding new segmental phonemes, both vowels and consonants, to the phonemic inventories.

Chadic is the largest and possibly most diverse language family within the Afroasiatic phylum. In the light of my recent comparative research on the Central Chadic languages (Wolff 2022a, 2023), one could possibly expect to find that Chadic as a whole, as well as the Afroasiatic languages from other families within the phylum (Ancient Egyptian, Berber, Cushitic, Semitic, possibly Omotic), might also possess, or have possessed historically, comparable minimal vowel systems and prosodies. This, to the best of the author's knowledge, has not (yet) been widely researched or documented. Nonetheless, there are promising leads in this direction from disparate traces in the literature.

First, there is scattered evidence from the three other branches of Chadic (West- and East-Chadic, and Masa). Schuh (2002) reports the operation of morphological Y-prosody in West Chadic-A Bole and West Chadic-B Miya, Duwai, Bade, and Ngizim. Roberts (2007) reports prosodies in East Chadic-A Somrai, Gabri, Kabalai, and East Chadic-B Mawa, as well as from the Masa branch (He'de). Given the heavy evidence from the Central Chadic languages, this leads Roberts (2009: 139) to conclude "that the prosodies may have been characteristic of Proto-Chadic from its early days", but have "seriously eroded" in the branches other than Central Chadic. In this regard, this would make Central Chadic the phonologically most archaic of the four branches of Chadic.

Second, one Berber language, namely Tashelhiyt, has explicitly been described along the lines of a PCC-type minimal vowel system. Indeed, Tashelhiyt and the Central Chadic languages share a number of typological features in this regard. There is, however, a methodological problem in this comparison. For Central Chadic, there is fairly robust comparative evidence regarding the diachronic evolution of these languages, while for Tashelhiyt one would be dealing just with a synchronic system of one modern language (Dell & Elmedlaoui 1985). In order to overcome this methodological hurdle, I will here confront modern Tashelhiyt (based on Kossmann 2012: 28ff., who follows Dell & Elmedlaoui 1985) with two modern CC languages with minimal vertical vowel systems, namely Lamang (see Wolff 2015) and Mandara (Mirt 1969, Fluckiger & Whaley 1981, Wolff & Naumann 2004; see also Frajzyngier 2012 for a non-prosodic approach to the language).

Tashelhiyt (Northern Berber) has a three-member vowel system /a, i, u/ plus an epenthetic central vowel [ə], the latter being considered a controversial segment, both phonetically and phonologically (Kossmann 2012). The insertion of schwa is determined by the need to syllabify a sequence of consonants according to their relative sonority. The latter is built on a hierarchy that rests on the inherent sonority of segments (for Tashelhiyt: *a* > *i/y*, *u/w* > liquids > nasals > voiced fricatives > voiceless fricatives > voiced stops > voiceless stops). As in Central Chadic languages, the high vowels [i, u] are allophones of the approximants /y/ and /w/ rather than independent phonemes. Kossmann (2012: 30) reports that the "vocalic realizations are found when the phoneme is in a syllabic position, while the semivowels are found when the phoneme is in non-syllabic position. This correctly describes most instances of *y*, *w*, *i*, and *u* in Tashelhiyt. Given a complementary distribution of the allophones [y, i] and [w, u] as a function of a syllable nucleus versus a syllable margin, the vowel system of Tashelhiyt would be reduced to a one-member system with only /a/ plus epenthetic schwa.[22]

This situation is nearly identical to that in Lamang (Wolff 2015, Vol. 1: 64ff.) and other Central Chadic languages, such as Mandara of a neighbouring language group. In Lamang (LAMANG), an apparent synchronic four-vowel system /a, i, u, E/ plus an epenthetic [ə] can be reduced, historically and by observing a complementary allophonic distribution of /y~i/ and /w~u/, to a one-vowel system with the only vowel /a/. This succeeds if one accepts a historical analysis in which word-final /E/ (with conditioned allophones [e, o]) reflects an original bi-morphemic diphthong *aY (< *a{-y}). This diphthong surfaces by default as

[22] Actually, modern Tashelhiyt appears to have undergone a phoneme split which has created phonemic high vowels besides the semivowels /y/ and /w/ (see Kossmann 2012: 31, based on van den Boogert 1997: 247–249, 253). Such phoneme splits have been proposed for the (Central) Chadic languages in the process of vocalogenesis as well (Wolff 2017).

[e] under an automatic palatalisation prosody, and as [o] under a labialisation prosody. Pro- and epenthetic schwa plays a sonority-based role for surface syllabification, similar to Tashelhiyt.

Mandara's (MANDARA; Mirt 1969, Fluckiger & Whaley 1981) native words, i.e. excluding loans and phonetically long synchronic vowels, appear to have two short vowels /a, ə/. The latter has a highly intriguing synchronic allophony: apparently, /ə/ → [e] in word-final position. Wolff & Naumann (2004) identify final [e] as a result of monophthongisation of an underlying historically bi-morphemic sequence /a-y/ and consider [ə] to be epenthetic and inserted in a sonority-based fashion. All this is parallel to neighbouring Lamang. Such a reanalysis ascribes to Mandara a minimal vowel system with only one short vowel /a/, parallel to Lamang and Tashelhiyt (Berber).[23]

This parallel in vowel system typology between Tashelhiyt (Berber) and the Chadic languages, in particular those of the Central Chadic branch, may indicate a somewhat closer relationship between Proto-Berber and Proto-Chadic (maybe a shared "Libyco-Chadic" node in the Afroasiatic family tree model). This link is nowadays obscured by a strong typological impact of Arabic phonology on other Berber languages. Possibly, Tashelhiyt has preserved an archaism from a very distant common past, just as the Central Chadic languages have done. This very tentative hypothesis, however, needs thorough investigation in future research (see Wolff 2022c).

Third, as exciting as the Tashelhiyt case, there is challenging typological evidence coming from modern Semitic languages, for instance, Arabic dialects and Ethiosemitic Chaha.[24] Bellem (2008, 2007) studied what she calls "consonant resonance" in Arabic dialects. Bellem's consonant "resonance characteristics" and "resonance domains", in particular her "resonance elements A, I, U", stunningly resemble the ideas tentatively discussed in this paper regarding the ultimate origin of "vocalogenesis" and prosodies in Chadic. Namely her "I element" corresponds to my Y-prosody, and her "U element" to my W-prosody. Her "A element" involves some back resonance like pharyngealisation. This is parallel to tentative assumptions about the pharyngeal-approximant origins of */a/ which, however, in PCC reconstructions is no longer operational. Rather, one can pos-

[23]Note that this analysis for Mandara is at variance with that presented by Frajzyngier (2012), who postulates three phonemic vowels /a, i, u/ plus an epenthetic vowel and "harmony" processes. This reflects Frajzyngier's preference for a non-prosodic approach to Central Chadic phonology and his disregard of the */y~i/ and */w~u/ allophony. Such an analysis was already pursued in his Gidar monograph (Frajzyngier 2008), which was promptly refuted by Schuh (2010).

[24]These studies were pointed out to me by Cormac Anderson (p.c. 2022).

tulate ∅-prosody, which, however, is no more than the absence of the other two prosodies.

Banksira (2000) described the complex morphophonology of Chaha, an Ethiosemitic language belonging to the "Gurage" cluster, based on the analysis of a minimal /a, ə/ vowel system plus epenthetic [ɨ]. Interestingly in this context he notes:

> There is no glide vs vowel contrast, so [i] and [y] represent /I/ while [u] and [w] represent /U/. In most cases, the mid peripheral vowels [o, e, ɔ, ɛ] are biphonemic, i.e. [o] is the fusion of /ə/ and /U/, [e] of /ə/ and /I/, [ɔ] of /a/ and /U/ and [ɛ] of /a/ and /I/ (Banksira 2000: 3).

His high "vocoids" /U/ and /I/ behave a lot like W- and Y-prosodies in CC languages. Not only do they account for the emergence of mid vowels, but they also affect the consonantal inventory. According to Banksira (2000: xxix ff.), the consonant inventory of most Gurage languages is highly enriched by the creation of non-phonemic sounds such as the labialized labials (p^w, f^w, b^w, m^w) and palatalized velars (k'^y, k^y, g^y, *ç*), which are not found in Proto-Ethio-Semitic. The enrichment of the consonant system appears to relate to a simultaneous impoverishment of the vowel system. The frequency of the front vowels *i*, *e*, *ɛ* is much lower than that of the central vowels *a*, *ə*, *ɨ*, and the frequency of the back vowels *u*, *o*, *ɔ* is much lower than that of the central vowels but much the same as that of front vowels. Banksira proposes the features /U/ (a phonemic element found in all back vowels) and /I/ (a phonemic element found in all front vowels), which always abandon their articulators and float to dock on preceding targets. So /U, I/ are not pronounced independently, which makes them similar to Central Chadic W- and Y-prosodies.

Arguably, in Chaha, one may not be dealing with the "impoverishment of the vowel system" (Banksira 2000) but with an original minimal vowel system plus, in my own terms, a prosodification of the [+high] feature shared by palatal and labiovelar (co-)articulation. Despite the differences in detail, studies like those of Bellem and Banksira open an inroad for promising comparative and typological research in a broader Afroasiatic perspective by including evidence from living Semitic languages into the comparison to the Chadic and Berber evidence. Currently, the author is not aware of any related research on Coptic, Cushitic, or Omotic languages.

Another interesting aspect regarding modern Semitic vowel systems is a widely reported "collapse" of short *i and *u into schwa in many dialects of

Arabic.[25] In Arabic dialects, the resulting (sub-)systems with two short vowels /a, ə/ obviously do not mirror any archaic minimal-vowel-system situation like that reconstructed for PCC. On the contrary, they have begun to obscure the original triangular nature of a short-vowel /a, i, u/ system, which still survives in a number of Arabic dialects. According to Watson 2002: 21, in certain dialects of Arabic today, *i and *u have collapsed to schwa and are only rarely distinctive. This merger leaves these dialects with a two-short-vowel system: open /a/ versus semi-closed /ə/. For a number of other dialects, an opposition between /i/ and /u/ exists in certain contexts, but has been reduced greatly.

As it arises from the present chapter, synchronic two-vowel systems of the /a, ə/ type in modern Afroasiatic languages may have different historical origins. On the one hand, they may represent an early stage in the unfolding of vocalogenesis (possibly from a "vowelless" proto-system that one might wish to equate with Proto-Afroasiatic) towards a minimal vowel system as one finds in (Central) Chadic languages. On the other hand, they may represent a much later "collapse" of a preceding richer vowel system, as one finds in Arabic dialects and possibly other modern Semitic languages through a general path of vowel reduction. It remains to be shown by further research whether and how the triangular short-vowel-system /a, i, u/ in Semitic links up with a still hypothetical vowelless system in Proto-Afroasiatic. In the latter, the syllabified approximants *ʕ, *y and *w might have operated almost exclusively in the vocalic space (i.e. as syllable-nuclei allophones [a, i, u]), possibly allowing also a central epenthetic vowel schwa to play a distinctive yet non-contrastive role for forming syllabic nuclei.

4 Conclusion

Minimal vowel systems, as the ones discussed in this chapter and as can now be considered characteristic for the Central Chadic languages, may be viewed as phonological rarities, but they are by no means unique in cross-linguistic perspective.

Central to the analysis and description of such minimal vowel systems is the recognition of the complementary allophonic distribution of /y~i/ and /w~u/. In Afroasiatic including Chadic languages, the approximants /y/ and /w/ count as

[25] This may have motivated Newman (2006: 193) to suggest a similar scenario for Central Chadic. In order to explain the distribution of minimal /a, ə/ vowel systems there, he suggested its origins as "collapsed" from a system of short and long */a, aa, i, ii, u, uu/, which he reconstructed for Proto-Chadic.

consonants when they form part of the "consonantal root", but function as vowels in the vocalic domain when their position is that of a syllable nucleus or peak. This has the effect of creating vowel systems without phonemic high vowels, which leaves low /a/ and non-low schwa (ə), whether the latter is considered to be phonemic or not, to constitute vertical minimal vowel systems.

In Central Chadic languages, minimal vowel systems associate with a regime of prosodies, i.e. most of all palatalisation and labialisation, which create rich surface vowel inventories in terms of prosodically "coloured" allophones and variants, but reflect maximally two underlying vowel phonemes, /a/ and /ə/, or only one (/a/) in systems in which schwa is best considered to be a non-phonemic intrusive vowel that becomes inserted in processes of consonant syllabification.

Minimal vowel systems are not easily to discover simply by looking at synchronic descriptive data. They may require sophisticated and highly abstract phonological analysis to be conducted for the underlying representations in synchronic perspective, as well as for the reconstruction of the proto-language system in diachronic perspective. As in the case of Proto-Central Chadic, methodologically sound analyses on both sides of the Saussurean Firewall can then be considered together and thereby add a historical dimension as the following step after the abstract synchronic analyses.

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Chapter 8

A model of non-modal phonation: Ballisticity in Otomanguean languages

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Ballistic versus controlled syllables have long been posited in Amuzgo and Chinantec languages (Otomanguean). They have been treated as a feature specific only to these languages. Given phonetic and articulatory correlates of ballistic syllables, more recent studies have instead characterized the trait as laryngeal in nature and better understood as a realization of [spread glottis]. In this study, the trait is understood in relation to the distribution of other laryngeal contrasts, and in the context of morphophonological patterns showing that [spread glottis] is also morphemic. A [spread glottis] autosegment is proposed. This autosegment forms part of a three-way phonation contrast (spread glottis, constricted glottis, and modal voice) observed in these languages. A review of available data in light of Hyman's (2006) parameter-based approach to prosodic typology shows that previous assertions that 'ballisticity' is a form of stress or a separate tone system should be abandoned.

1 Introduction

A syllabic level contrast commonly referred to as "ballistic" vs "controlled" has been observed in a number of Otomanguean languages, namely in the varieties of two language groups: Amuzgo (ISO 639-3, Glottocode amuz1254; hereafter Am) and Chinantec (ISO 639-3, Glottocode chin1484; hereafter Ch). The term encompasses a number of stress-like acoustic and articulatory markers that can co-occur with every other lexical prosodic trait (contrastive tone, nasalization, laryngealization, also vowel length in the case of Ch). While ballisticity has been

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largely described instrumentally, phonological accounts are incomplete as they typically lack insight from other parts of the grammar.

The argument presented in this chapter takes into account language-specific syllable economy and morphological phenomena. Both language groups allow only a limited number of monosyllabic structural frames coupled with high prosodic complexity and a large number of morphological combinatory possibilities. All this results in complex morphophonological alternations of these prosodic inventories. Data presented from Am and Ch show that ballisticity is involved in morphological marking, with widest functionality in Am. Ballisticity contrastively marks both functional and lexical morphemes, and is morphologically motivated across different inflectional paradigms and, to a lesser degree, in word formation. In the Ch languages where the feature is attested, ballisticity is mostly restricted to lexical morphemes, though in some it also marks lexical verb classes and verbal agreement.

This chapter follows Silverman (1994) and Herrera Zendejas (2000) in their initial characterization of ballisticity as a phonological feature [spread glottis] (hereafter [sp]) and further discusses the following arguments. First, ballisticity is a phonologically independent phenomenon: it is not dependent on other features as it is cross-distributed with every other lexical prosodic feature. It is contrastive, unpredictable, and found in lexical minimal pairs. Second, the feature is morphologically bound: it marks certain morphological contrasts separately or in combination with other prosodic contrasts (tone, nasalization, vowel length in Ch). Third, coherency within prosodic typology is addressed using Hyman's (2006) prototypical treatment of stress versus tone. This stricter definition of stress and tone allows us to dismiss ballisticity as an archetypal form of both categories while understanding how it is exploited in different languages. And finally, ballisticity is put into perspective with other laryngeal features in the discussed languages. The feature [sp] can be understood as entering the existing paradigm of laryngeal features to form a fully exploited set. In other words, phonation fully contrasts three types: modal voice, [constricted glottis], and [spread glottis], and ballisticity or [sp] is but one realization of this contrast. In order to theoretically interpret multiple and sometimes conflicting laryngeal features realized in one syllable, the laryngeal phenomena are interpreted as having different phonological statuses. In particular [sp] is a syllable-level autosegment rather than a segmentally attached feature as proposed in Silverman (1994) and Herrera Zendejas (2000).

Data used in this study are from first- and second-hand sources. Two different first-hand corpora of the Amuzgo variety spoken in Xochistlahuaca (hereafter AMU) are used. One corpus was recorded in 2010–2013 with JS, a male speaker born in the 1970s, by the author and other members of the Endangered Language Alliance (hereafter ELA), a non-profit documenting language diversity in New York City. This corpus constitutes about 20 hours of elicited paradigms and prompted speech using stimuli like the *Picture series on topological relations* by Bowerman & Pederson (1992). The second corpus of two hours was recorded by the author in 2016, 2017 and 2021 with JP, a male speaker born in 1985. These corpora will be referred to using the initials of the speakers and the year of collection. Second-hand sources for the Amuzgo variety from San Pedro Amuzgos (SPA) and the different varieties of Chinantec are noted in full citation. The Chinantec corpus was compiled by Rensch (1968) and consists of Rensch's own fieldwork and the previous work of other linguists from the Summer Institute of Linguistics. The corpus was digitized in 2012 for the Meso-American MorphoPhonology (MAmP) project funded by the Institut Universitaire de France from 2009-2014.[1]

The study is organized as follows. In Section 2, the feature known as ballisticity is described in detail. I discuss both how it manifests in Am and Ch and in other languages of the world and how it has been treated in the literature. Then, Section 3 addresses the prosodic and morphological status of ballisticity in the Am and Ch languages for which the feature has been phonetically studied. In Section 4, different possible statuses of the feature are considered from a typological perspective, followed by a discussion of other laryngeal features in Am and Ch. At the end of Section 4, all the laryngeal features are briefly considered in an effort to model this contrastive system. Some remaining questions are also touched on. Finally, in Section 5, a short conclusion closes the study.

2 What is ballisticity?

2.1 Introduction

Ballistic syllables have been described in Otomanguean studies by multiple authors (Skinner 1962; Merrifield 1963, 1968; Bauernschmidt 1965; Westley 1971; Foris 1973, Mugele 1982). Ballisticity has been characterized as a syllable level stress-like feature where an initial rapid surge over the nucleus then rapidly decays, followed by devoicing and a breathy release. Other observations include higher energy, fortis onset consonants, shorter duration and diverging tonal realizations, as compared to "controlled" syllables. All these features are also listed in DiCanio & Bennett (2020). Across the different Otomanguean languages in which ballisticity has been attested, descriptive accounts vary only slightly,

[1] Cf. http://jll.smallcodes.com/home.page

mostly in relation to the distribution of ballistic and controlled syllables rather than to their phonetic characteristics.

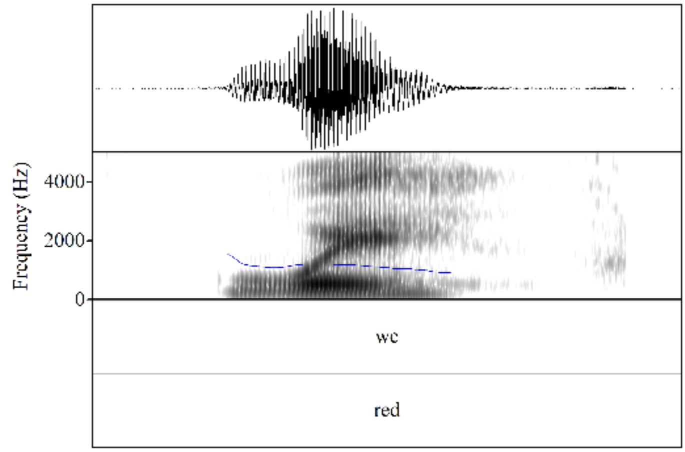
Phonetic correlates of ballisticity have been analyzed for the Ch languages of Lalana (Mugele 1982), Palantla (Merrifield & Edmondson 1999) and Comaltepec (Silverman 1994, 1997a), and the Am languages AMU (Herrera Zendejas 2000) and SPA (Kim 2011). Figure 1 presents spectrograms of controlled and ballistic syllables /we/ (M) 'red' and /we·/ (L) 'two' (from ELA, 2011). Ballisticity is noted as a syllable-final dot: /CV·/.

Figure 2 presents the same contrast in a more complex environment with /tsa̤ʔ/ 'plant fibers; ash' (top) and /tsa̤ʔ·/ 'sponge' (bottom) (from JP 2021). Here the vowel is aspirated and the syllable ends in a glottal stop, which illustrates the prosodic complexity that ballisticity is part of. The annotation reflects the multiple realizations of laryngealization through two vowel slots, but this is not to indicate vowel length.

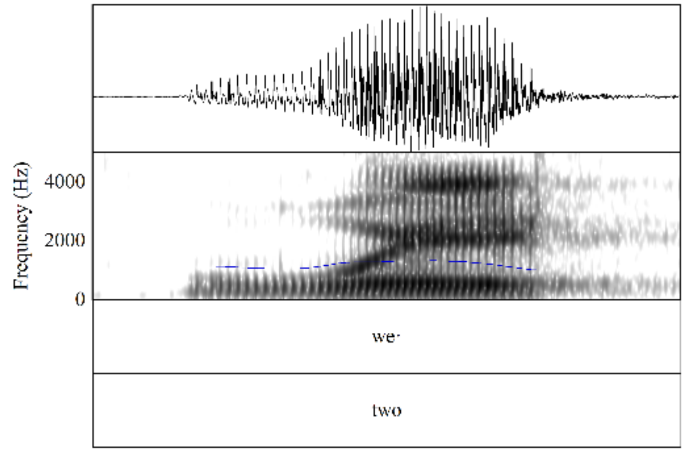
Taken as a whole, results from these different studies affirm the impressionistic descriptions of the feature in the literature. Counterpart "controlled" syllables show steady initial surge, sustained voicing, stable formants throughout the syllable, and no final aperiodicity, which is typical of modal voicing. Articulatory studies of Lalana and Palantla Ch (respectively, Mugele 1984 and Merrifield & Edmondson 1999) point to subglottal pressure as the major articulatory enhancer of ballistic syllables. This is contrary to Silverman (1994) for whom laryngeal abduction is the major articulator.

In all the languages in question, ballisticity occurs widely across different structural syllable types. Depending on the language, these can be oral or nasal, open or closed syllables, with laryngealized or modal onsets, with long or short vowels. Ballisticity is realized with only a partial or a different inventory of lexical tones, as compared to the controlled pronunciation. Depending on the language, ballisticity is contrastive only in the stressed position or on any syllable of a word; it can be found in both free and bound morphemes.

Phonological accounts for Chinantec (Silverman 1994) and Amuzgo (Herrera Zendejas 2000) combine acoustic and articulatory evidence to interpret final frication and loss of voice on ballistic syllables as breathy vowels [Vh], phonologically represented as [spread glottis]. For both authors, other phonetic correlates are considered non-phonological, possibly serving to enhance the saliency of the trait in question. In SPA, Kim (2011) finds differing tone sandhi patterns between ballistic tones and controlled tones as tentative evidence for the phonological reality of this contrast. However, she also calls into question the legitimacy of proposing entirely separate tone inventories.

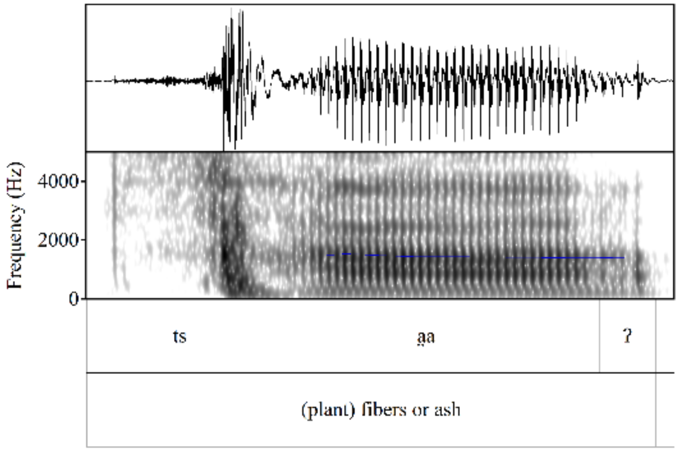


(a) /we/ (M) ‘red’

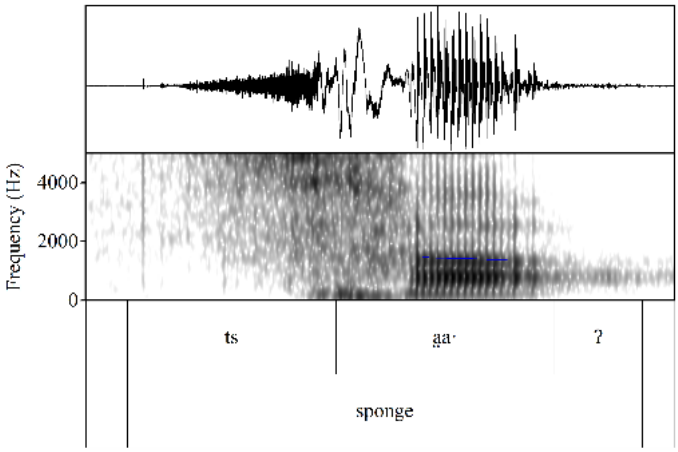


(b) /we·/ (L) ‘two’

Figure 1: Controlled /we/ (M) ‘red’ (top) and ballistic /we·/ (L) ‘two’ (bottom) (from ELA, 2011)



(a) /tsa̤ʔ/ ‘plant fibers; ash’



(b) /tsa̤ʔ·/ ‘sponge’

Figure 2: Controlled /tsa̤ʔ/ ‘plant fibers; ash’ (top) and /tsa̤ʔ·/ ‘sponge’ (bottom) (from JP 2021)

In morphology, ballistic syllables can mark lexical distinctions, morphological derivations, and serve as markers for animacy agreement and tense-aspect-modality. For example in Lealao Ch, Palancar (2015) shows that ballistic syllables in the first personal plural future serve as a marker of verb class I. Dobui (2018) notes that ballisticity marks animacy agreement in a class of adjectives in AMU. For the most part, ballisticity does not map one-to-one with derivational or inflectional values. Ballisticity often combines with other alternations (tone, nasality, laryngealization, length) in what Palancar (2015) calls "prosodic inflection", although this also holds for word formation processes.

The examples below illustrate the ballisticity contrast in a variety of syllabic and morphological environments.[2]

(1) Lexical contrast in AMU (Bauernschmidt 2010: 8–9)

a. Controlled
ka-ʔnãʔ (H-M)
CLASS-funny
'funny'

b. Ballistic
ka-**ʔnã·** (H-M)
CLASS-be.tasty
'be tasty'

(2) Word formation in AMU (Bauernschmidt 2010: 314)

a. Controlled
səiʔ (M)
'flesh, muscle, body'

b. Ballistic
səiʔ· (M)
'meat'

[2]When possible, tones are represented with letters to avoid confusion between different traditions in Otomanguean glossing styles: H is high, M is mid, L is low. Sequential tones are noted with the same divisions as the gloss, and contour tones are noted together, e.g. *ka-hndá* (H-MH) 'CLASS-frog' (AMU). In the examples using unverifiable data from second-hand sources, notation used by the respective authors is reproduced. Where relevant, stress is marked with an acute accent. Transcriptions of examples conform to IPA standards with the exception of breathy and creaky segments, which are written using the orthographic standard, i.e. *ka-ʔnãʔ* (H-M) 'funny' rather than [ka-n̰ãʔ].

(3) Morphological agreement in AMU (JP 2017)

a. Controlled
ka-hã (H-M=H)
CLASS-yellow.AN
'yellow' (AN)

b. Ballistic
ka-**hã·** (H-M=H)
CLASS-yellow.INAN
'yellow' (INAN)

(4) Lexical contrast in Usila Ch (Skinner & Skinner 2000: 269)

a. Controlled
pei^{1}
'extremity, tip'

b. Ballistic
pei^{1}·
'small, little'

(5) Word formation in Usila Ch (Skinner & Skinner 2000: 192)

a. Controlled
lia^{4}
'like' (ADV)

b. Ballistic
lia^{4}·
'as well' (CONJ)

(6) Morphological contrast in Usila Ch (Skinner & Skinner 2000: 474)

a. Controlled
a^{2}-kwan^{3}-i^{3}
CLASS-dress-3SGPOSS
'her dress'

b. Ballistic
a^{2}-**kwan$^{3-3}$·**
CLASS-dress.2SGPOSS
'your dress'

These different accounts clarify observed acoustic and articulatory features, effects in tonal allophony, and distributions across morphosyntactic systems in the Otomanguean languages that display the feature. In yet other languages, both Otomanguean and not, the term "ballisticity" has been used to describe similar but ultimately different phenomena. A discussion of this literature helps to clarify the feature addressed in this study.

2.2 Ballisticity in other languages

The terms "ballistic" versus "controlled" have also been employed for other Otomanguean languages and also for the Finno-Ugric and Scandinavian languages of Northern Europe. This section discusses these phenomena and why they ultimately differ from the ballistic feature found in Am and Ch.

For the Otomanguean Mezquital Otomi, Wallis (1968) used the terms "ballistic" and "controlled" in order to "describe [other] distinctive features of the syllable" rather than the "contrastive syllable types" of Am and Ch (p. 78). The author described the feature as non-contrastive but active in word-level and sentence-level tone sandhi, where predictable combinations of tones result in final aspiration and tone allophony (higher high tones, lower low tones). Palancar's (2013) account treats this same phenomenon as aspiration conditioned by intersyllabic environments. This chapter does not follow Wallis in employing the term "ballisticity".

For Jalapa Mazatec, Silverman et al. (1995) conducted phonetic studies on a set of minimal pairs suspected of contrasting ballisticity. They showed that these do not exhibit phonetic cues typical of ballisticity. Three phonetic correlates typical of ballisticity were examined: fortis consonants, surge and decay in intensity, and post-vocalic aspiration. All three showed no systematic differences between ballistic and controlled syllables. However, fundamental frequency was slightly higher and duration notably shorter in ballistic syllables. It was also noted that length is contrastive, but only in morphologically complex environments. This would leave a gap in simplex forms, which presumably do not contrast length. The authors tentatively proposed that ballistic/controlled forms fill this gap in simplex forms, contrasting "ballistic", or monomoraic, syllables with "controlled", or bimoraic, syllables. Correlates of what initially appear to be ballistic contrasts in Jalapa Mazatec are thus remapped onto the concept of length.

Neither Otomi nor Jalapa Mazatec seems to display the phonetic correlates or phonological structures corresponding to those linked to ballisticity in Am and Ch. Nevertheless, some correlates are similar, which might indicate different evolutionary paths of reconstructed final aspiration.

The terms "ballistic"/"controlled" have also been used in literature on unrelated languages of Northern Europe, notably in Sámi (Harms 1975), Estonian and Danish (Kuznetsova 2018 and the references therein). The terms are used to describe prosodic contrasts with accent-like functions and varying phonetic realizations that form a set of contrasts referred to as "balanced/controlled" versus "unbalanced/ballistic". In a general sense, this is much like in Otomanguean languages: in both language phyla, 'ballisticity' involves perceived spikes in articulatory energy and non-prototypical prosodic functions (which are neither canonical tone nor stress, but something in between).

Some phonetic indicators from these and other European languages find parallels with ballisticity in Otomanguean languages (as described in Morrison 2019): tone (in Swedish, Norwegian, Franconian), duration (Estonian), and laryngealization (Standard Danish), or all of the above (varieties of Scottish Gaelic). However, phonetic indicators of laryngealization in these languages are those typical of constricted glottis (vocal fold stiffening) rather than spread glottis, as is the case for ballisticity in Otomanguean languages. Additionally, the aforementioned contrasts in these languages functionally interact with stress and, in the Finno-Ugric languages, with duration, while in Otomanguean languages ballisticity is independent of both, as shown in Section 3.

3 Phonological and morphological status of ballisticity

This section looks at the phonological and morphological status of ballisticity in AMU and Ch, the languages for which the trait has been clearly identified phonetically.

3.1 Xochistlahuaca Amuzgo

Ballisticity has the widest functionality in AMU. It can occur in all syllable types and can co-occur with all types of word-prosodic inventories, in both cases unpredictably. It can appear more than once in a morphosyntactic word, not only in the stressed position. It also regularly marks animacy agreement in a large class of adjectives, and irregularly marks operations of word formation. Before addressing the distribution of the feature, basic information on AMU phonology (based on Dobui 2018) will be provided.

Segmental inventories for AMU are given in Table 1 and Figure 3. Consonants contrast across five places of articulation. Marginal segments are in parentheses, allophones are in square brackets. All voiced segments (except /β/) can be breathy or creaky. In both tables, the phonemes conform to IPA, but in transcribed examples, I also employ the practical orthography used by some Amuzgo speaking communities, e.g. /m̤/ is written <hm>, and /ɲ̰/ is <ʔɲ>.

Table 1: Consonant inventory of AMU

	Bilabial	Apico-dental	Postalveolar	Velar	Glottal
Stop	(p)	t	t^{j}	k k^{w}	ʔ
Affricate		ts	ʧ		
Fricative	(β)	s	ʃ		
Nasal	m m̤ m̰	n [n ȵ ŋ n^{d}] n̤ n̰	ɲ [ɲ^{dj}] ɲ̤ ɲ̰		
Trill		r			
Tap		ɾ			
Lateral		l l̤ l̰			
Glide	w w̤ w̰		j j̤ j̰		

Figure 3 shows the seven contrastive oral vowels and five nasal vowels. All vowels can also be breathy or creaky, substantially increasing the number of contrastive values possible. As for voiced consonants, non-modal phonation found in examples will be transcribed using the orthographic conventions mentioned above, e.g. /e̤/ is <he> and /õ̰ / is <ʔõ>[3].

i i̤ ḭ		u ṳ ṵ
e e̤ ḛ ẽ ẽ̤ ḛ̃		o o̤ o̰ õ õ̤ õ̰
ɛ ɛ̤ ɛ̰ ɛ ɛ̤ ɛ̰		ɔ ɔ ɔ̤ ɔ̰
	a a̤ a̰ ã ã̤ ã̰	

Figure 3: Vowel inventory of AMU

There are three register tones: H, M, L. The first two phonetically descend slightly, while the last one phonetically rises slightly. The contour tones are HL,

[3]Note that the realization of the nasal vowel /õ/ is accompanied by an unreleased and voiceless labial closure and is phonetically transcribed as [ãwm̥].

which may rise slightly upward at the end, LM, and MH. The latter two both rise, as expected. A near-minimal tonal sextuple is given in Table 2 (all data from Bauernschmidt (2010) with page numbers given in the table).

Table 2: Minimal sextuple of tones in AMU

hnda (H)	'river' (p. 121)
hnda· (M) child.3SG.POSS	'his/her child' (p. 121)
ka-hnda· (L-L) CLASS-expensive	'expensive' (p. 5)
hndaʔ (HL)	'ordered, organized' (p. 123)
ka-hnda (H-MH) ANIM-frog	'frog' (p. 5)
hnda (LM)	'moment, time' (p. 121)

On ballistic syllables, the same tones are realized over a compressed duration, given the devoicing of the final portion of the vowel. Low ballistic tone does not show a final rise, and no ballistic equivalent to LM exists.

The maximal syllable structure in AMU is CCGVʔ where G is a glide and the final glottal stop is segmental. Minimal (V) and maximal (CCGVʔ) syllables are uncommon, while CV(ʔ) and CCV(ʔ) are most common.

3.1.1 Distribution of ballisticity in AMU

In (7–18), four syllable structures, V, Vʔ, CV, CVʔ, with lexically oral and nasal (or morphologically nasalized, see Dobui 2021 and on SPA Cortéz Vázquez 2016) nuclei are crossed with the prosodic inventories of ballisticity and non-modal phonation, represented by *h/ʔ* to the left of the vowel (all data from Bauernschmidt 2010).[4] Ballisticity exists for every type of syllabic structure, including underpopulated types (V and Vʔ) and crosses with each prosodic feature. Where possible, minimal pairs are given to illustrate the contrastive reach of ballisticity.

[4]For better visibility, data sources in (7–18) are given with initials followed by page numbers: B for Bauernschmidt (2010), AP for Apóstol Polanco (2014), and JG for De Jesús García (2004). For example, "AP6" should be understood as Apóstol Polanco (2014: 6).

Most are monomorphemic, but in some cases it was not possible to find simplex examples. For example, in contrast to a ballistic and breathy nasal syllable with an initial stop onset *thõ·* (H) 'bent thread/wire' and 'as well as', I included a controlled counterpart *t-hõ* (n.d. for tone) 's/he put', the past marked form of *ma-hõ* 'to put' (M-H).

(7) V	oral	nasal
controlled	a (M) 'well, good' (adv) (B1)	–
ballistic	ma-kwaʔ=**a·** (M-M=M) prog.sg-eat.1sg=1sg 'I am eating' (AP6)	ma-k^{w}ãʔ~**ã·** (M-M~M) prog.sg-eat.3sg~3sg 's/he is eating' (AP7)

(8) ʔV	oral	nasal
controlled	ʔa (H) 'thick, viscous' (B134)	**ʔɛ·** (L) 'because' (B134)
ballistic		

(9) hV	oral	nasal
controlled	ho (H) 'place' (B131)	k^{w}i-laʔ-hõ=ɲ^{dj}e (M-H-MH=H) prog.pl-caus.pl-compare=et.pl 'they are comparing' (JG737)
ballistic	**ho·** (H) 'for, towards' (used with motion verbs) (B131)	**hõ·** (H) 3sghum 's/he' (B131)

(10) Vʔ —

(11) ʔVʔ	oral	nasal
controlled	—	—
ballistic	**ʔɛʔ·** (L) 'ew' (sound of disgust) (B134)	—

(12) hVʔ	oral	nasal
controlled	haʔ (M) 'heavy' (B119)	hãʔ=ɲe (H=H) dark=TE 'dark, obscure' (B119)
ballistic	**haʔ·** ʧiu (L L) 'of course' (B119)	tueʔ-**hãʔ·**~ã· (M-H~M) PST.become-dark.3SG ~3SG 's/he fainted' (B244)

(13) CV	oral	nasal
controlled	to (H) 'girdle' (B349)	tõ (H) 'knot (in thread, rope, hair)' (B349)
ballistic	kwi-**to·** (M-L) 'if by chance' (B97)	**tõ·** (H) 'exactly' (B349)

(14) CʔV	oral	nasal
controlled	k^wi-tʔɔ (M-LM) PROG.PL-PL.answer 'they answer' (JG494)	tʔõ (H) PST.sprout.3SG 's/he sprouted'(B78)
ballistic	ka-**tʔo·** (H-M) 'truncated, stumpy' (B31)	k^wi-**tʔõ·** (M-L) 'to spread out' (B96)

(15) ChV	oral	nasal
controlled	t-ha-kwã (L-M) PST-go.call.someone.3SG 's/he went to call someone' (AP208)	t-hõ (MH) PST-reach.into.something.3SG 's/he reached into something' (JG185)
ballistic	**thɔ·** (L) PST.go.1SG 'I went' (JG186)	**thõ·** (H) 'bent thread/wire', 'as well as' (B345)

(16)

CVʔ	oral	nasal
controlled	toʔ (H) ‘be full, busy’ (B349)	tõʔ (H) ‘head of garlic; main rib of a leaf; bundle (of leaves, fruit, etc.)’ (B350)
ballistic	**toʔ·** (M) ‘garbage, waste (noun); rotten, decayed’ (adjective) (B349)	**ntõʔ·** (HL) ‘oven’ (B290)

(17)

CʔVʔ	oral	nasal
controlled	k^wi-wi-tʔaʔ (M-H-HL) PROG-become-full ‘to accumulate’ (B114)	k^wi-tʔõʔ (M-L) PROG-scatter ‘to scatter, to disperse’ (B96)
ballistic	ma-**wʔɔʔ·** (M-M) PROG.SG-answer.2SG.2SG ‘you answer’ (JG494)	**mʔãʔ·** (L) PL.DET (B254)

(18)

ChVʔ	oral	nasal
controlled	thoʔ (HL) ‘measurement unit from thumb to little finger’ (B345)	thõʔ (MH) ‘together, unified, in agreement’ (B346)
ballistic	**thɔʔ·**+su (M+H) ‘grinding stone’ (B346)	**tha^{n}ʔ·+ɲ^{dj}o** (M+H) ‘lip’ (B344)

Table 3 summarizes the contrasts seen in examples (7–18), where empty cells correspond to forms that were not found. Wide distribution across syllable types and combinations with different prosodic inventories show that ballisticity is independent of other prosodic contrasts Still, minimal pairs rarely contrast solely in ballisticity; rather lexical contrast is often enhanced by other described prosodic contrasts.

As also seen in (7–18), ballisticity marks both functional and lexical, and bound and free morphemes. It is also involved in morphological marking across different inflectional classes and, to a lesser degree, in word formation.

Table 3: A summary of ballisticity distribution across syllable and phonation types in AMU

	controlled		ballistic	
Syllable structure and phonation types	oral	nasal	oral	nasal
V	+	−	+	+
ʔV	+	−	+	−
hV	+	+	+	+
Vʔ	−	−	−	−
ʔVʔ	−	−	+	−
hVʔ	+	+	+	+
CV	+	+	+	+
CʔV	+	+	+	+
ChV	+	+	+	+
CVʔ	+	+	+	+
CʔVʔ	+	+	+	+
ChVʔ	+	+	+	+

All morphemes are monosyllabic.[5] Phonological words are often multisyllabic with multiple class markers or tense-aspect-mood markers in pre-stem position, possibly multimorphemic stems, and multiple suffixes and/or enclitics in postposition. In the prosodic word, stress is fixed on the stem-final syllable, which is "redundantly marked by differences of pitch allophones and of duration of voicing in the syllable nuclei" (Bauernschmidt 1965: 472). Syllables preceding and following the stem have reduced vocalic and tonal inventories. The examples in (19–22) show ballisticity on root syllables, as seen in (19) which contains free lexical roots and (21) with lexically derived stems. It can also occur in the bound morphemes in pre- and postposition of the stem, as seen in the bound morphemes in (20) and (22) where it marks agreement.

Morphologically, contrastive ballisticity is observed both as lexical and inflectional word prosody. In (19), ballisticity differentiates two lexical roots. In (20), ballisticity in combination with tone differentiates between grammatical morphemes like 1pl inclusive versus 1pl exclusive. In (21), ballisticity distinguishes

[5]Although a monomorphemic "sesquisyllable" (literally one-and-a-half syllables, i.e. a major syllable and a minor dependent syllable) consisting of a syllabic sonorant before an occlusive onset of a following major syllable (e.g. n̩.CV: *n̩təĩʔ· (HL)* 'adobe') is frequently found.

between ‘flesh’ and ‘meat’, and between ‘well’ and ‘geyser’. However, semantically related minimal pairs like these are rare and the form-to-function derivational value of ballisticity is inconsistent. In (22), ballisticity marks an adjectival stem to accord with an inanimate noun. Contrary to the examples in (21), inanimacy marking with ballisticity is productive in a large class of adjectives consistently marked for animacy agreement. In (22), subject agreement for the second person singular is also regularly marked in a verb class. In this same example, ballisticity marks only the syllable of the stem, with no spreading to adjacent syllables. Similarly, in (22), syllables mismatch for ballisticity within the same prosodic word domain, which shows that no ballistic spread or harmony occurs.

(19) Free morphemes

a. controlled
   wɛ (M)
   ‘red’

b. ballistic
   wɛ· (L)
   ‘two’

(20) Bound morphemes

a. controlled
   =ja (L)
   1PL.INCL

b. ballistic
   =ja· (LH)
   1PL.EXCL

(21) Derivation

a. i. controlled
      seiʔ (M)
      ‘flesh, muscle, body’

   ii. ballistic
      seiʔ· (M)
      ‘meat’

b. i. controlled
      tsuiʔ (M)
      ‘(water) well’

ii. ballistic
tsuiʔ· (M)
'geyser'

(22) Agreement

a. i. controlled
ka-ʧi· (H-H) ka-hã (H-M)
ANIM-eagle CLASS$_{\text{ADJ}}$-yellow.AN>
'the eagle is yellow'

ii. ballistic
lja (H) ka-**hã·** (H-M)
dress CLASS$_{\text{ADJ}}$-yellow.INAN
'the dress is yellow'

b. i. controlled
ma-k^{w}ãʔ~ã (M-M~M)
PROG.SG-eat.3SG.HUM~3SG.HUM
's/he is eating'

ii. ballistic
ma-**k^{w}aʔ·** (M-HM)
PROG.SG-eat.2SG
'you are eating'

Ballisticity can occur once, more than once, or not at all at the word level. In examples (23–24), stress co-occurs with both ballistic and controlled syllables. In the compound word for 'ball' in (23), the root for 'fruit' is ballistic while the root for 'rubber' remains controlled. The Spanish loan for 'chair' ends in a ballistic syllable, which might correspond to the word-final stress in the original language. The root for 'warm' appears independently in (24a) and derived as a reflexive verb in (24b), with no change in ballisticity. The data elicited by the ELA (2012) come from the *Picture series on topological relations* by Bowerman & Pederson (1992).

(23) ELA (2012)

nti (HM)	**tɛ·**+hn^{dj}oʔ (L+LM)	na (M)	khɛ (L)	su**lɛ·** (H M)
nti	**tɛ·**+hn^{dj}óʔ	na	khɛ	su**lɛ·** (HM L+LM M L H M)
EXIST.inside	fruit-rubber	COMP	under	chair

'The ball is under the chair.'

(24) a. Bauernschmidt (2010: 270)
nda-tio (H-M) **wi·** (L)
nda-tió **wi·** (H-M L)
water warm
'warm water'

b. ELA (2012)
tio-ʧó (M-HM) ma-tsəi-**wi·**=ne (M-M-L=M)
tio-ʧó ma-tsəi-**wí·**=ne (M-HM M-M-L=M)
CLASS$_{\text{HUM}}$-boy PROG.SG-CAUS-warm=ET
'A boy is warming himself.'

In general, words where all syllables are controlled are common while words with ballistic syllables are a minority, although multisyllabic words where all syllables are ballistic do exist, as in (25). This distribution stems from the fact that multisyllabic words are more likely to have class markers or preverbs. Such morphological units were once fully lexical but have become grammaticalized and have lost the prosodic contrast of ballisticity. The latter process indicates that controlled syllables are in general default, or unmarked, in the language. Compare the word for 'fruit', as it appears as a full content word containing a ballistic syllable in (26a), to its function as a class marker in (26b), where it is no longer ballistic. In (23) above, given the ballisticity of the root for 'fruit' the whole word is considered a compound with two full content lexical roots. Ballisticity loss through grammaticalization is not consistent for all noun class markers, which are often still analyzable as content words. For example, the root *ju·* (M) 'person' is ballistic both as an independent word and as a noun class marker, as in (25). Inverse cases where morphemes become ballistic through grammaticalization have not been attested.

(25) ELA (2012)
ju·=sʔa· (L=L) ma-ʔma (M-MH) **hnõ·** (L)
ju·=sʔa· ma-ʔma **hnõ·** (L=L M-MH L)
CLASS$_{\text{HUM}}$=man PROG.SG-smoke.3SG cigarette
'The man is smoking a cigarette.'

(26) ELA (2012)

a. **tɛ·** (L) ntʲha=na (ML=M) ʃkẽ (L) tsʔõ (LM)
tɛ· ntʲha=na ʃkẽ tsʔõ (L ML=M L LM)
fruit hang=INAN head.3SGPOSS tree
'A piece of fruit hangs from the tree.'

b. tɛ-mansana (L-HLM) nti (H) lansa (HB)
tɛ-mansana nti lansa (L-HLM H HB)
CLASS$_{\text{FRUIT}}$-apple inside arrow
'Inside of the apple there is an arrow.'

To summarize the characteristics of ballisticity in AMU, this feature:

(1) is unpredictably distributed across different syllable structures;

(2) co-occurs with all types of laryngeal specifications and all other types of word-prosodic inventories;

(3) can occur in stressed or unstressed syllables;

(4) is found on bound and free morphemes;

(5) can occur more than once in a word;

(6) can contrast lexical or grammatical minimal pairs (and contexts) alone or in combination with tone, nasality, or phonation;

(7) and, regular form-to-function morphemic value is only found in animacy marking in a class of adjectives.

3.2 Chinantec languages

Of the 23 Chinantec varieties present in the corpus by Rensch (1968), ballisticity is attested in lexical roots in nine varieties across all five language groups: I-Northern highlands (in the town of Sochiapan), II-Transition zone (Palantla and Tepetotutla), III-Lowlands (Ozumacín), IV-Southern Lowlands (Latani, Lalana, Lealao), and V-Mountain highlands (Quiotepec and Comaltepec). For the remaining 14 varieties (which are part of language groups I, III and V) further data and study is needed to establish whether the ballisticity contrast is active.

The consonantal inventory for Proto-Chinantec is given below in Table 4. For vowels, Rensch (1989: 11) reconstructed the following: *i, *e, *a, *u, * ɨ, and *ə, in addition to several diphthongs in Chinantec. The tonal inventory includes *H, *L, *HL, *LH, and *HLH. Vowel length, ballisticity and vowel nasalization are also reconstructed.

In those modern Ch languages where the feature is attested, ballisticity is also widely and unpredictably distributed across syllable structures and co-occurs with other prosodic inventories, such as tone, nasalization and laryngealization

Table 4: . Reconstructed consonants in Proto-Chinantec (adapted from Rensch 1989: 11)

	Bilabial	Alveolar	Velar	Glottal
Stop	*p *b	*t *d	*k *kʷ *g *gʷ	*ʔ
Fricative		*s		*h
Nasal	*m	*n	*ŋ	
Approximant	*w	*l	*j	

of sonorants and vowels, and vowel length. Syllable shapes in almost all Ch languages are usually CV or CGV, where G is a glide or a vocalic element of a diphthong. In simplex morphemes, across the different languages codas may always have a glottal stop, sometimes a glide, and a "post-syllabic nasal" consonant in Lalana, Temextitlán, Yolox, Ozumacín (Rensch 1968).[6]

3.3 Distribution of ballisticity in Ch languages

Examples (27–38) show the distribution of the ballistic vs. controlled contrast across different syllable structures with short vowels in Comaltepec Ch (all data from Andersen et al. 2021).[7] The syllable structures given for this variety parallel those found in AMU as much as possible, but structures like CʔV or ChV are not attested for this variety.

(27)

V	oral	nasal
controlled	a (LH) INAN 'to contain (liquid)' (p. 2)	ĩ (L) AN definite article (p. 58)
ballistic	**a·** (L) 'to fill' (p. 2)	**ã·** (H) 'worm' (p. 2)

[6]In some Ch languages, a final glottal fricative is cited in coda position in the literature. For these same languages, ballisticity is not mentioned (see Rensch 1968). This may serve as an indication of potentially undetermined ballisticity.

[7]In the data below, verbs should not be considered as infinitives, e.g. examples like *hee·* (LM) *kiaʔr·* (M) INAN 'to accompany' are given with a final rhotic, which is a verbal formant. Verbal stems can be specific to plural subjects and distinguish for inanimate vs. animate, which is noted as INAN/AN, e.g., *hiʉʔ·* (L) INAN PL 'to fall off'.

(28)

ʔV	oral	nasal
controlled	ʔuɨ (H) ‘black widow spider’ (p. 56)	—
ballistic	—	—

(29)

hV	oral	nasal
controlled	hi (L) ‘book’ (p. 73)	hã (LM) ‘foam’ (p. 68)
ballistic	**ha·** (H) interrogative (p. 68)	—

(30)

Vʔ	oral	nasal
controlled	aʔ (LM) heart.2SG.POSS ‘your heart’ (p. 3)	—
ballistic	—	—

(31)

ʔVʔ	oral	nasal
controlled	ʔuiʔ (H) ‘flake’ (p. 56)	—
ballistic	**ʔiʔ·** (L) INAN ‘to liquify’ (p. 56)	**ʔuĩʔ·** (L) INAN ‘to get ground (specific to maize)’ (p. 56)

(32)

hVʔ	oral	nasal
controlled	hɨʔ (L) ‘light’ (p. 77)	hĩʔ (L) ‘orange (fruit)’ (p. 76)
ballistic	**hiʉʔ·** (L) INAN PL ‘to fall off’ (p. 76)	**hĩʔr·** (L) ‘to be alive’ (p. 77)

(33) ʔLV	oral	nasal
controlled	ʔla (LM) INAN ‘to bounce, pull’ (p. 118)	—
ballistic	**ʔli·** (H) ‘arch’ (p. 120)	—

(34) hLV	oral	nasal
controlled	hlɨ (HL) INAN ‘to be covered’ (p. 79)	hmi (LH) ‘skunk’ (p. 82)
ballistic	**hlʉ·** (L) INAN ‘welt’ (p. 80)	**hma·** (L) INAN ‘to be wide’ (p. 80)

(35) hLVʔ	oral	nasal
controlled	hleʔr (L) AN ‘to tremble’ (p. 79)	hmangʔ (M) ‘pure’ (p. 80)
ballistic	**hloʔ·** (H) INAN ‘to be good, precious, beautiful’ (p. 79)	**hmaʔ·** (M) ‘things or animals distributed’ (ADV) (p. 80)

(36) ʔLVʔ	oral	nasal
controlled	ʔleʔ (L) INAN ‘to decompose’ (p. 119)	ʔleiñʔ (LM) AN ‘to push’ (p. 119)
ballistic	**ʔleʔ·** (LM) ‘group’ (p. 120)	**ʔnaʔ·** (H) ‘disgusting, evil’ (p. 143)

(37) CV	oral	nasal
controlled	tu (L) ‘chicken’ (p. 184)	tũ (LM) ‘guitar’ (p. 184)
ballistic	**tʉr·** (L) INAN ‘to abandon, leave’ (p. 186)	**tũ·** (M) ‘two’ (p. 184)

(38)

CVʔ	oral	nasal
controlled	toʔ (L) 'shrimp' (p. 183)	tõʔr (LM) 'to mend something' (p. 183)
ballistic	**toʔ·** (L) INAN SG 'to fall' (p. 183)	**tõʔ·** (L) 'type of parakeet' (p. 183)

Examples (39–50) show the distribution of the ballistic vs. controlled contrast across different syllable structures with long vowels in Comaltepec Ch (Andersen et al. 2021).

(39)

V	oral	nasal
controlled	ee (L) 'early (in the morning)' (p. 35)	—
ballistic	**ee·** (LH) 'girdle, tape' (p. 35)	**ãã·** (LM) 'bridge' (p. 2)

(40)

ʔV	oral	nasal
controlled	—	ʔuɨɨ (L) koo (L) 'strip, thread' (p. 56)
ballistic	**ʔuɨɨ·** (H) INAN 'to ache' (p. 56)	**ʔuɨ̃ɨ̃·** (M) 'far' (p. 56)

(41)

hV	oral	nasal
controlled	hee (LH) 'between, in' (p. 70) hii (LH) 'tuber' (p. 74)	haaiñ (L) EXIST (p. 68) hĩĩ (L) 'year, season' (p. 74)
ballistic	**hee·** (LM) kiaʔr· (M) INAN 'to accompany' (p. 70)	**haaiñ·** (L) AN 'to break a limb' (p. 68) **hĩĩ·** (L) 'mud' (p. 74)

(42) Vʔ —

(43) ʔVʔ —

(44)

hVʔ	oral	nasal
controlled	—	—
ballistic	**hɨɨʔ·** (LH) INAN ‘to be unfertile’ (p. 78)	**hĩĩʔ·** (LH) ‘only’ (p. 74)

(45)

ʔLV	oral	nasal
controlled	ʔlee (L) ‘powder’ (p. 119)	—
ballistic	**ʔlee·** (M) ‘soldier’ (p. 119)	—

(46)

hLV	oral	nasal
controlled	hlɨɨ (M) AN ‘larva’ (p. 79)	hmee (L) INAN ‘to stink’ (p. 81)
ballistic	**hlee·** (L) INAN ‘to tremble’ (p. 78)	**hliiñ·** (L) INAN ‘to shuck, husk’ (p. 79)

(47)

ʔLVʔ	oral	nasal
controlled	—	ʔlɨiñʔ (H) AN ‘to be evil’ (p. 120)
ballistic	**ʔlooʔ·** (LH) ‘cockroach’ (p. 121)	**ʔleeiñʔ·** (LH) AN ‘to earn salary/pay’ (p. 119)

(48)

hLVʔ	oral	nasal
controlled	—	hmɨiñʔ (LM) AN ‘to urinate’ (p. 88)
ballistic	**hlɨɨʔ·** (LH) ‘stick, slit of firewood’ (p. 79)	**hlúuiñʔ·** (LH) AN ‘to be lame’ (p. 80)

(49) CV	oral	nasal
controlled	too (L) 'hole' (p. 182)	tõõ (LH) INAN. 'to stand vertically' (p. 182)
ballistic	**too·** (L) 'grinding stone' (p. 182)	**tõõ·** (ML) 'thorn' (p. 182)

(50) **CVʔ**	oral	nasal
controlled	–	tuiñʔ (L) AN 'to be hunchbacked' (p. 185)
ballistic	**tooʔ·** (LH) NOUN 'drop' (p. 183)	**tɨɨ ngʔ·** (LH) 'edge, shore' (p. 181)

For the two sets of examples (27–38) and (39–50), true minimal pairs and monomorphemic words are given where possible. Table 5 summarizes these contrasts, where empty cells correspond to forms that were not found. Some syllable types are underpopulated or unpopulated. For example, ʔVʔ only exists with short vowels, and inversely ʔV is more commonly found with long vowels. For the Vʔ type, only one (multimorphemic) form was found.

Tonal inventories and their relation to ballisticity vary across Ch languages. In general, these languages have between three and five level tones, and three or more contour tones (Rensch 1968; Suárez 1983). For some languages, equivalent tonal inventories are attested both in ballistic and controlled syllables, e.g. in Palantla (Merrifield 1968). In others, e.g. in Ozumacín (Rupp 2012), fewer tones combine with ballistic syllables. The latter case appears to be more common. This is also the case for AMU ballistic syllables, which have one contour tone (LM) less than controlled syllables. On the other hand, in a Ch language Quiotepec, the LM contour occurs *only* on ballistic syllables (Gardner & Merrifield 1990). While a reduced set of tonal contrasts in most other Ch languages and in AMU lend ballisticity a marked quality, in Quiotepec the inverse might be the case. A comparison of tone and ballistic interaction across these two language groups is given in Section 3.4.

Ballisticity is largely restricted to lexical morphemes, but it can also mark lexical verbal classes and verbal agreement. In Table 6, a review of data from existing

Table 5: A summary of ballisticity distribution across syllable and phonation types in Comaltepec Ch

	controlled				ballistic			
Syllable structure and phonation types	V	Ṽ	VV	ṼṼ	V	Ṽ	VV	ṼṼ
V	+	+	+	−	+	+	+	+
ʔV	+	−	−	+	−	−	+	+
hV	+	+	+	+	+	−	+	+
Vʔ	+	−	−	−	−	-	−	−
ʔVʔ	+	−	−	−	+	+	+	+
hVʔ	+	+	−	−	+	+	+	+
ʔLV	+	−	+	−	+	−	+	−
ʔLVʔ	+	+	−	+	+	+	+	+
hLV	+	+	+	+	+	+	+	+
hLVʔ	+	+	−	+	+	+	+	+
CV	+	+	+	+	+	+	+	+
CVʔ	+	+	−	+	+	+	+	+

literature[8] shows that in every group of Ch, ballistic lexical roots are found (see the first column). As in AMU, morphological functions of ballisticity are also observed in Ch, but word formation (in the second column) is rare. In the third column, ballisticity marks verbal subject, nominal possession, or animacy agreement, alone or in combination with other prosodic contrasts, e.g. tone. In this column, the example for Quiotepec shows an independent first person singular subject pronoun following the volitive mood marker, which is controlled. In the absence of an independent subject pronoun, first person singular is marked on the mood marker with ballisticity and tonal alternation. As seen from the final column, TAM marking with ballisticity is attested in Palantla, Ozumacín, and Quiotepec, though in combination with a tonal change or a segmental change, as is the case for AMU (see the stem for 'castrate' *kw̰a̰·* (L) and its plural marked form *tw̰a̰* (LM)). Ballisticity in Lealao also occurs on verb stems marked for the 1pl.fut at a rate of 1.4% in Palancar's (2015: 14) quantitative review, meaning presence of ballisticity indicates the verb most likely does not belong to class I verbs, acting as a sort of negative identifier.

[8]The data in Table 6 is reproduced from a variety of sources with varying annotation conventions. Superscript numbers represent tones, where 1 is a high tone. Data from Rupp (2012) reports tones as a system of diacritics.

Table 6: Distribution of ballisticity within the prosodic word in Chinantec varieties

	Free morphemes	Word formation	Agreement	TAM
´I – Usila (Skinner & Skinner 2000: 269, 192, 474)	pei^1 ‘extremity, tip’ **pei^1·** ‘small, little’	lia^4 ‘like’ **lia^4·** ‘as well’	a^2-kwan^3-i^3 CLASS-dress-3SG.POSS ‘her dress’ a^2-**kwan$^{3-3}$·** CLASS-dress.2SG.POSS ‘your dress’	
II – Palantla (Merrifield 1963, 1968)	li^3 ‘tepejilote (type of palm tree)’ **li^3·** ‘flower’			ka^2 gwe^2-dʒa ‘he slept’ **gwe^1·**-dʒa ‘he will sleep’
III – Ozumacín (Rupp 2012: 32-33, 235, 246)	d͡soo (mid) ‘fault, disease’ **d̉soo·** (mid) ‘right’		lle-y (mid) head-3.POSS ‘his/her/their head’ **lle-n·** (low) head-1SG.POSS ‘my head’	jɛɛy (mid-rising) PROG.look ‘be looking’ **jɛɛy·** (high) PST.look ‘looked’

	Free morphemes	Word formation	Agreement	TAM
IV – Lalana (Rensch 1989: 35)	tu^{2} 'belly button' **tu·^{3}** **'tube'**			
IV – Lealao (Rensch 1968; Rupp & Rupp 1996)	ta^{3} 'ladder' **ta^{3}·** 'banana'		ma^{3}-tiaʔ^{3} PERF-fall.INAN '(it) has fallen' ma^{3}-**tiaʔ^{3}·** <PERF-fall.3SG.AN '(s/he) has fallen'	
V – Quiotepec (Rensch 1989: 35; Robbins 1968: 91; Gardner & Merrifield 1990)	tu^{2} 'belly button' **tu^{23}·** 'tube'		nĩ·^{3} duʔ^{3} hnã^{2} go.1SG VOL 1SG 'I intend to go' nĩ·^{3} **du^{12}·** go.1SG VOL.1SG 'I intend to go'	ni^{3}-ʔlaʔ^{1} PST-push 'pushed' ni^{3} **ʔlaa^{1}·** ʔa 'you will push'

In Ch, stems are usually monomorphemic and monosyllabic, although pre- and post-positional functional morphemes may attach to create multimorphemic and multisyllabic words. Only one stem morpheme can be stressed (as marked with an acute accent). On this structure, ballisticity is described as contrastive only in stressed syllables, meaning only one syllable may be ballistic in the prosodic word (Merrifield 1963; Rensch 1968; Rupp & Rupp 1996; Silverman 2006). However, functional morphemes (which do not carry stress) with lexically specified ballisticity do exist, e.g. in Lealao: *-a*^{2}*·* 1sg (Rupp & Rupp 1996) and in Ozumacín: *ta·* (L) 'by' (Rupp 2012). The former morpheme remains unchanged when attached to a lexically ballistic verbal stem, as in (51). On the other hand, some other lexically ballistic verbal stems may become controlled if this morpheme is attached to them; compare (52a) with (52b).

(51) Palancar (2015: 10)
Ballisticity can occur more than once in a prosodic word
ʔi^{2}-***hee***^{2}***·-a***^{4}***·***
fut-run.over.something/one-1sg
'I will run over something/one (animate).'

(52) Palancar (2015: 3)

a. Lexically ballistic verbal stem
ʔi^{4}-***la yʔ***^{4}***·***
fut-get.an.entity.down
'will get an (animate) entity down'

b. Lexically ballistic verbal stem with 1sg marking
ʔi^{2}*-la ʔ*^{42}-***a***^{2}***·***
fut-get.an.entity.down-1sg
'I will get an (animate) entity down.'

Additionally, in compounds, more than one lexical stem can be ballistic, as shown in (53). Theoretically only one syllable can carry stress even in multimorphemic words (Gardner & Merrifield 1990), but in the examples below, stress is not marked in the sources.

(53) a. Ozumacín Ch (Rupp 2012: 89, 40)
la·+hʊʊ· (L+L) 'all'
gyi·+hwʉʉ· (M+H) 'hell'

b. Lealao Ch (Rupp & Rupp 1996: 208)
la·+ɲu· (H+M) 'house with a grass roof'

These examples seem to contest the descriptions of ballisticity as necessarily related to stress both because ballisticity can occur more than once in a prosodic word (as in 51 and 53), and because it is possible for a ballistic syllable to occur outside a stressed position (as in 59). Further study of the distribution of ballisticity in Ch is needed to clarify the trait's possible domains and whether secondary stress could be postulated.

To summarize, in Chinantec, the ballistic contrast:

(1) is found mostly on the stressed syllable, but in some languages grammatical morphemes maintain lexical ballisticity in an unstressed position;

(2) occurs unpredictably on all syllable types;

(3) co-occurs with all types of laryngeal specifications and all other types of word-prosodic inventories;

(4) is lexically contrastive;

(5) irregularly marks animacy and subject agreement on verbs;

(6) is an index marker for at least one lexical verb class in Lealao.

3.4 Comparative summary of ballisticity in Amuzgo and Chinantec

This section reviews and compares the properties of ballisticity in Am and Ch.

A synthesis of the data from AMU and Ch is given in Table 7.

Table 7: Properties of ballisticity in AMU and Ch

	AMU	Ch
Widely distributed across syllable structures	✓	✓
Co-occurs with other word-prosodic inventories	✓	✓
Occurs on stressed and unstressed syllables	✓	(✓)
Lexically contrastive on bound and lexical morphemes	✓	(✓)
Occurs more than once in a word	✓	(✓)
Morphologically active	✓	✓

Table 7 shows that the trait has very similar functional properties in both language groups, despite some deviations (indicated by check marks in parentheses) in those Ch languages where the feature is restricted to lexical morphemes or occurs only once in the prosodic word. Such examples that contradict the mainstream tendencies have been found in Lealao (Group IV) and Ozumacín (Group III). On the other hand, no ballistic syllables have been observed outside the stressed position and more than once in the prosodic word in Palantla (Group II). For now, I will continue to consider that in general, the two language groups differ in the distribution of ballisticity across the prosodic word. While ballisticity is generally not contrastive outside of stressed positions in the word in Ch, its distribution in AMU is freer, and the trait can occur outside of stressed positions and more than once.

Other differences between Ch and AMU involve cross-distributions of the contrast with tonal inventories, although these vary from language to language rather than between the two language groups. As observed in the introduction, ballisticity has been considered in the literature both a syllabic level contrast and a sub-feature of tone: two separate tonal inventories, one controlled and one ballistic, have been proposed. In Table 8, level and contour tones in controlled and ballistic syllables are given for the Amuzgo varieties of San Pedro Amuzgos (SPA) and Xochistlahuaca (AMU) and in all five language groups of Chinantec. To facilitate comparison, I map the original notation found in the literature (given in parentheses) to the H, M, L convention. Tones that do not occur in both ballistic and controlled syllables are italicized.

For almost all the reviewed languages, tones are equally contrastive in ballistic and controlled syllables, although there are some notable distributional differences. In SPA, high tone does not occur with ballistic syllables. Elsewhere, all level tone inventories are found in both controlled and ballistic syllables. Contour tones vary slightly more, at times co-occurring more often with controlled syllables than with ballistic syllables. For example, the LM contour tone in AMU is not found in ballistic syllables. More striking examples are Lealao and Ozumacín, where no contour tones co-occur with ballistic syllables. The inverse, where more contour tones co-occur with ballistic syllables than with the controlled ones, can also be true, as in SPA and Quiotepec. In Sochiapan, MH and HL are noted as being perceived by speakers as ballistic in CV syllable structures, but as controlled in CVʔ. The remaining contour tone LM is perceived by speakers as both controlled and ballistic in free variation for both CV and CVʔ syllables (Foris 1973).

Table 8: Tonal inventories of selected Am and Ch varieties

	Controlled		Ballistic	
	Level	Contour	Level	Contour
Amuzgo varieties				
SPA (Smith-Stark & Tapia García 1984)				
	H, M, L (5, 34, 12)	*MH* (35)	M, L (3, 1)	*HM, HL* (53, 31)
AMU (Bauernschmidt 1965)				
	H, M, L (1, 2, 3)	HL, MH, *LM* (13, 21, 32)	H, M, L (1, 2, 3)	HL, MH (13, 21)
Chinantec varieties				
Group I: Tlacoatzintepec (Thelin 1980)				
	H, MH, M, L (1, 2, 3, 4)	ML, LMH (34, 42)	H, MH, M, L (1, 2, 3, 4)	ML, LMH (34, 42)
Group II: Palantla (Merrifield 1963)				
	H, M, L (3, 2, 1)	LH, LM, HL (13, 12, 31)	H, M, L (3, 2, 1)	LH, LM, HL (13, 12, 31)
Group III: Ozumacín (Rupp 2012)				
	H, M, L (alto, medio, bajo)	*HH, MH, LH (alto ascendente, medio asc., bajo asc.)*	H, M, L (alto, medio, bajo)	
Group IV: Lealao (Rupp 1990)				
	High H, H, M, L (1, 2, 3, 4)	*MH, LH* (32, 42)	High H, H, M, L (1, 2, 3, 4)	
Group V: Quiotepec (Gardner & Merrifield 1990)				
	H, M, L	LH, ML, MH	H, M, L	*LM*, LH, ML, MH

4 Discussion

In this section, a typological account of ballisticity as word prosody is first presented. Then other realizations of laryngeal features in AMU and Ch are analyzed in order to reach a wider understanding of laryngeals as a system in these languages.

4.1 Prosodic typology

Traditionally ballisticity has been referred to as a form of stress, thus syllabically anchored, and with separate sets of tone inventories. However, Silverman (1994) and Herrera Zendejas (2000) analyze ballisticity as a segmentally anchored floating feature “spread glottis” [sp]. Consequently, I will address the question of whether or not [sp] as an autosegment is a form of stress, and why it cannot be understood as a different set of tones.

In word-prosodic typology, a number of types of word prosody from the world’s languages are “analytically indeterminate”, leading Hyman (2006) to rule out the tripartite division of tone, pitch accent, and stress. Instead, the author recommends a parameter-based approach for analyzing prosodic systems over a fixed word-prosodic taxonomy. Under this approach, stress and tone are at opposing ends of a privative scale of characteristics by which word prosodic systems can be compared (p. 229–231):

(1) stress is syntagmatic while tone is paradigmatic;

(2) stress is both obligatory (i.e. every lexical word has at least one stressed syllable) and culminative (i.e. every lexical word has at most one main stressed syllable);

(3) tone is primarily defined by pitch movement, can be non-obligatory e.g. in inventories with few tonal contrasts, and can attach to a number of tone-bearing units.

Despite phonetic correlates similar to stress, this approach allows us to rule out [sp] as an archetypal form of stress, given that in both Ch and AMU, [sp] is not obligatory. On the other hand, in some Chinantec languages [sp] appears culminative because it is restricted to the stressed position of the prosodic word. The Ch word most often consists of one lexical root surrounded by prefixes and suffixes, with stress hosted by one syllable of the lexical root. It is then unsurprising that [sp] most often appears in stress position, but not exclusively. Still, the distribution of the feature in the two language groups indicates differences in the dependency domains. In AMU and some Ch languages, [sp] is morpheme-dependent, occurring multiple times in the word domain.

While [sp] is clearly not stress in AMU and in at least some Ch languages, whether or not it is a form of tone is less clear. In both languages, the sets of tone have also traditionally included the ballistic parameter with so-called ballistic syllable tones usually mirroring the controlled syllable tones. Kim (2011) suggests considering ballisticity as a "high" register of tones versus a "low" register (the latter corresponding to "controlled"), wherein ballisticity is realized as a result of conditioned tone alternations. This is an interesting idea that only captures part of the picture. Considering ballisticity to be uniquely tone-based leaves out any understanding of final devoicing in relation to other laryngeal features, and does not address the morphological functions observed in both languages. However, if tone and [sp] are taken as independent of one another, as I have done here, then effects on tone realization, e.g. shortening of modal voicing, can be attributed to [sp] rather than the other way around.

Still, if taken as altogether different tonemes, the tones with ballisticity could be thought to engage [sp] or final devoicing as a means for perceptual enhancement, as an articulatory consequence, or even as an inherent feature of tone in these languages. This configuration is not without precedent in the languages of the world. In White Hmong (Hmong-Mien), breathy and creaky voice co-occur with one lexical tone each. Garellek et al. (2013) find that while creaky voice is unnecessary for speakers to identify the "low-falling" tone, breathy voice is necessary for the perception of "mid-to-high" tone. This indicates that breathiness is an inherent phonetic feature of this second tone. The authors point out that in other laryngeally complex languages, where phonation and tone combine, the perception of some tones can be dependent on phonation (like breathiness in White Hmong), while for other tones pitch is the main cue (as with the low-falling tone and its optional creakiness in White Hmong). Other combinations of tones and phonations exist as well, where two-way or three-way phonation contrasts can be exploited in different ways in tone realization.

The case of White Hmong and the other languages discussed in Garellek et al. (2013) differ, however, from Am and Ch. The former languages exploit phonation in only a restricted set of tones and contours. There are no full or nearly full sets of tonal melodies contrasting only in phonation, as is clearly the case with Am and Ch, which have tonal inventories that can be both accompanied and unaccompanied by [sp]. The two sets of tones are either equivalent or near equivalent in number. This helps to clarify that [sp] would not be better understood as tone, or as a property of tone. The feature [sp] acts as a privative and additional parameter applied in parallel to the tonal set.

This view of [sp] and tone interaction is only in line with the part of Kim's (2011) proposal that "ballistic tones" should not be considered as a separate set of tones. Following the proposal put forward in the present study, what Kim calls "register" can be understood as the co-occurrence of separate features [sp] and (most) tones, rather than as an interdependent property.

More similarities can be found between [sp] and independent word-prosodic features like the Danish stød or Udihe (Tungusic) glottalization. As described in Kuznetsova (2022: 42–44), the features are independent of pitch accent, although some phonetic effects like pitch dip can occur. The features are widely distributed across vowel and syllable types, are lexicalized and unpredictable, and also have morphemic expression. All these are also true for [sp]. Contrary to [sp], however, these laryngeal word-prosodic features are realizations of [constricted glottis]. Also, the distribution of glottalization in Udihe is restricted to long vowels, and the frequency of occurrence for the respective features in Danish and Udihe differ.

Turning back to Hyman's approach to prosodic typology, let us note that tone is defined as paradigmatic and featural, and a language with tone is "one in which an indication of pitch enters into the lexical realization of at least some morphemes" (2006: 229). Under this definition, ballisticity in Am approaches prototypical tone in that it is paradigmatically applicable to every syllable. On the other hand, Ch appears to present ballisticity syntagmatically as 'word tone' where the word is a major tone-bearing unit. Hyman's typology characterizes this latter type under tone systems with a syntagmatic quality typical of stress, rather than of prototypical tone.

Under Hyman's (2006) approach, [sp] has prototypical characteristics of neither stress nor tone, though in Am it displays tone-like properties, while in Ch it displays stress-like properties. Ballisticity is thus prosodic by its functional properties but it is not really stress or tone. From here, I tentatively follow the autosegmental interpretation. As intended by the author, Hyman's parameter-based approach to prototypical definitions of stress and tone allows for a detailed discussion of possible properties of the feature leading to a more nuanced understanding.

4.2 Laryngeal prosodies and phonemes

The previous typological discussion of ballisticity shows that this feature is independent of tone and stress. Given that its major indicator is glottal abduction typical of aspiration or breathy voice, this section looks at other realizations of laryngeal features found in Am and Ch that co-occur with ballisticity.

4.2.1 Laryngeal features in AMU

For the inventories of the described languages, I have asserted that vowels can be breathy or creaky and sonorants aspirated or glottalized (cf. Section 3.1). This is a departure from previous accounts of /h/ and /ʔ/ as full phonemes (Bauernschmidt 1965, Apóstol Polanco 2014). I analyze these instead as non-segmental instances of non-modal phonation realized on voiced segments, except for /ʔ/ when it is found in coda position. For example, a form noted as *ɳhã* (L) 'here' (Bauernschmidt 2010: 302) is phonologically represented in this chapter as /ɳã̤/. Similarly, aspirated sonorants noted as e.g. *hɲ^{dj}a* M) 'chest, thorax' (Bauernschmidt 2010: 127) are phonologically represented as /ɲ̤a/.[9] The reasons for such an interpretation are outlined below.

First, both /h/ and /ʔ/ are always found before voiced consonants (sonorants) and vowels and never before stops. Upon observation of this same distribution in Jalapa Mazatec (another Otomanguean language), Golston & Kehrein (1998) propose that this distribution shows a dependence on voicing, one better understood as non-modal phonation (laryngealization/aspiration) on vowels and sonorants. This distribution also coincides with what Silverman (1997b) calls "phasing". Languages that display phasing have complex prosodic inventories that combine contrastive tone, nasalization, and non-modal phonation. Given the high load of articulatory targets and sometimes contradictory demands on articulation, targets are often sequenced in time, or "phased". In these languages, non-modal phonation is at least partially asynchronous of voicing, occurring to the left of vowels before modal voice, which is needed for production of contrastive tone.

Second, there is language specific evidence in the phonology and morphology of Am for the non-segmental interpretation of laryngeals that are found before voiced segments. For example, in Am phonology, both laryngeals are unable to block an automatic alternation where high front /i/ undergoes diphthongization after front consonants. For instance, *ti* (L) 'bud' is realized as [təi]. This same effect is illustrated in (54), where the lexical verb stem in (54a) is marked for past tense by an alveolar stop prefix /t/ in (54b), also triggering initial consonant loss. The high front /i/ in (54a) is diphthongized in (54b) after prefixation of /t/ rather than surfacing as *[ti̤ʔ]. Under a phonemic analysis of the laryngeal in (54a) as *kʷhiʔ* rather than *kʷi̤ʔ*, it would be difficult to explain why *h* is unable to block diphthongization in (54b). The inability of laryngeals to block this automatic alternation supports an interpretation of laryngeals as non-phonemic.

9 Forms like this are represented as /ɲ̤a/ (and not */ɲ̤^{dj}a/) given that post-nasal occlusion is an allophonic alternation that blocks nasal assimilation of oral vowels, a process called "nasal shielding" (see Dobui 2021).

(54) De Jesús García (2004: 565)

a. /kʷi̤ʔ/ (M) ‘choose’
[kʷi̤ʔ]

b. /ti̤ʔ/ (M)
[tə̤i̤ʔ]
PST-choose

More evidence is found in the morphophonology of nominal plurals. When the plural prefix /n/ attaches to a nominal stem with two consonants in the onset, a language-internal rule against $C_1C_2C_3$ initial syllables (unless C_3 is a glide) triggers deletion of C_1, as in the morpheme for ‘knee’ in (55).

(55) JP (2021)

a. **ʃ**tʲoʔ· (M)
‘knee’

b. ka-**ɲ**tʲoʔ· (M-M)
ANIM-PL-knee
‘knees’

This is not the case in Cʔ/h initial stems. After prefixation, the sequences CCʔV and CChV are permitted, as in (56), which again indicates that neither laryngeal is segmental and thus does not comport a violation of $*C_1C_2C_3$.

(56) JP (2021)

a. **s**tʔəĩ (H)
‘vulture’

b. ka²-**n**tʔəĩ (H)
ANIM-PL.vulture
‘vultures’

c. shã· (HL)
‘lark’

d. n-shã· (HL)
PL-lark
‘larks’

From the above evidence, these laryngeals cannot be analyzed as full consonantal segments contrary to how they have been treated in previous literature.

However, other possible analyses remain. Laryngeals could be (i) part of the nucleus, i.e. *CV̤*, *CV̰* or (ii) part of the consonant, i.e. as unisegmental *Cˀ*, *Cʰ*. In other words, is *shã· (HL)* ‘lark’ underlyingly /sã̤/ or /sʰã/?

Again, alternations seen in the morphophonology show these laryngeal features to be dependent on adjacent voiced segments, as described in (i), and not secondary articulations of consonants, as in (ii). In (54b) above, when the past tense marker /t/ is prefixed to this class of stems, the initial consonant elides but aspiration remains. The same behavior is found across all stems of this class (i.e. where elision occurs) that have laryngeal features. *CʔV* and *ChV* always become *t-ʔV* and *t-hV* when marked by the past prefix and never **t-V*. This means that Cʔ and Ch do not act unisegmentally. Moreover, the laryngeals realized after prefixation are indeed those of the stem and not of the aspect marker itself, which is /t/ and not i.e. **tˀ* or **tʰ*. This can be seen when *ku+tʲe·* (M+M) ‘distribute’ becomes *tu+tʲe·* after past tense marking, and not e.g. **tˀu+tʲe·*. The morphophonology of plural nominals also provides more evidence that *Cʔ* and *Ch* are not unisegmental. For example, *tsʔã* (H) ‘tail’ becomes *nʔã* ‘tails’ and not **nã* (see also 55 and 56). These patterns hold across both paradigms.

There remains the question of whether in laryngeal-initial syllable shapes (i.e. *h(L)V* and *ʔ(L)V*, where L is a sonorant) glottals are segmental or voice-dependent features. In the morphophonology of past prefixation, another inflectional class of these syllable shapes is marked by t-prefixation without any change to the stem (as opposed to 54). Thus in (57a), the laryngeal features are maintained after prefixation of the past marker, much like in other stems of different shapes. Examples of this kind are rare but indicate that laryngeals are a dependent part of the adjacent voiced segment. In (57b), however, the laryngeal feature is not realized when the nominal plural marker /n/ is prefixed.

(57) a. De Jesús García (2004: 476, 491)
t-huʔ·(L) t-ʔma
PST-expel; throw away PST-smoke

b. Bauernschmidt (2010: 6)
ka^2-hnõ (M-H)
CLASS-owl
ka^2-nõ (M-H)
CLASS-PL.owl

There are multiple interpretations for the alternation in (57b). One is that the plural prefix /n/ triggers elision of initial unisegmental /n̤/, leaving behind only the nasal prefix: *n-n̤V* → *n-V*. A second interpretation of (57b) is that a phonetic effect resulting from concatenation of /n-n̤V/ or /n-hnV/ results in loss of [spread glottis] or *h* in an intervocalic environment, followed by elision. A third alternative is that the ban against CCC triggers loss of *h* as in: *n-hnV* ⟶ *n-nV* ⟶ *n-V*, as above in (56).

All cases appear to call upon resolution of two identical consonants surfacing. This effect is seen with other prefixes in the language. For example, the verbal stem *mẽĩʔ·* (L) hit.3sg takes the plural verb prefix /t/ and surfaces as ***t****-mẽĩʔ* (LM) **pl**-hit.3pl (De Jesús García 2004: 505). But t-initial stems like *tãʔ* (L) leave.3sg surface unchanged after t-prefixation as *tãʔ* (L) <**pl**.leave.3pl> (De Jesús García 2004: 498).

The first interpretation would support the argument that *hn* is underlyingly /n̤/. The laryngeal feature does not surface because it is dependent on the stem-initial nasal sonorant that itself is elided to avoid homorganic CC. The second and third interpretations require a number of steps to derive surface forms. These do not rule out *h* as phonemic given that this segment could have been deleted as an initial C, an effect that is found elsewhere in nominal plurals. In this particular environment, the status of initial laryngeals is unclear. Still the most succinct interpretation (i.e. implicating fewer rules) is the first one. It is also the one supporting the analysis of laryngeals proposed here. Other alternatives would require more study. In any case, they also demand a more elaborate analysis that assumes that initial and non-initial laryngeals should be treated differently.

When found to the left of voicing, laryngeals are taken not as phonemes but rather as realizations of [spread glottis] and [constricted glottis], meaning instances of non-modal phonation. Still, for ease of exposition this chapter notes [h] and [ʔ] in transcription throughout the text. However, when either of them is found to the left of a sonorant or vowel, they respectively indicate aspiration and laryngealization, or breathiness and creakiness.

The final type of laryngeal feature is [ʔ] in the stem coda position, i.e. to the right of voicing. I analyze this final /ʔ/ as a phoneme in AMU, although one with a highly restricted distribution, i.e. occurring uniquely in the coda. Evidence of its status as segmental can be found in verbal subject marking. The first person singular is realized as *=a·* after stems with *ʔ* in final position like (58). After stems without *ʔ* in final position like (58b), the realization of the first person singular is *=ja·*. In (59), the glottal-final stem is marked by the second person plural marker *=joʔ·*.

(58) Apóstol Polanco (2014: 6, 56)

a. ma-kʷa**ʔ**·=a· (M-H=M)
PROG.SG-eat.1SG=1SG
'I am eating.'

b. ma-tʲhɛ·=**j**a· (M-H=M)
PROG.SG-cut.1SG=1SG
'I am cutting.'

(59) Apóstol Polanco (2014: 7)
kʷi-kʷa**ʔ**·=joʔ· (M-L=M)
PROG.PL-eat.2PL=2PL
'You (pl.) are eating.'

These data can be taken to show that a final glottal is indeed phonemic, rather than a laryngeal feature dependent on the preceding vowel. This interpretation depends on the underlying representation of the first person singular as /a·/ and not e.g. as /ja·/. If /ja·/ were the underlying representation, one might assume a rule against CVC.CV words that triggers alternation of /ja·/ to /a·/ in favor of CVC.V. However, forms like the one in (59) show that there is no problem for glottal final stems to be followed by another consonant word-internally, i.e. in CVC.CV. Therefore, the first person singular marker is interpreted as /a·/. In turn, this indicates a word-level well-formedness rule preventing CV.V from surfacing in (58b) (e.g. **ma-tʲhɛ·=a·*). The form [ja·] is realized instead, forming CV.CV. This means that the final glottal is phonemic, as any other interpretation, i.e. *CV̰* or *CVˀ* instead of *CVʔ*, means that (58a) would be an illicit word form: *CV̰.V (**kʷa̰·=a·*) or *CVˀ.V (**kʷaˀ·=a·*) rather than a case of CVC.V (*kʷa**ʔ**·=a·*), as interpreted here.

4.2.2 Laryngeal features in Ch

In Chinantec, glottal fricatives and stops are also transcribed in the literature as consonants preceding sonorants or vowels. Glottal stops are also transcribed in coda position. Earlier accounts (Andersen 1989; Westley 1991; Macaulay 1999) have contrasted three types of word-initial sonorants: "the plain series, the voiceless series, and the glottalized series" (Macaulay 1999: 76). These resemble non-modal phonations described above for AMU and their phasing before the modal voicing period. They can be phonologically represented as in (60). Additionally, this voicing-dependent distribution of laryngeals is reconstructed for Proto-Chinantec (Rensch 1968, 1989).

(60) Italicized forms from Ojitlán (Macaulay 1999: 76)
ʔmĩ¹ã² → /m̰ĩ¹ã²/
'to sew'

(61) ʔja² → /ja̰²/
'to griddle'

No other onsets with *h* and *ʔ* (i.e. *CʔV* or *ChV*) are attested in e.g. Ozumacín (Rupp 2012), Lealao (Rupp & Rupp 1996), or Comaltepec (Andersen et al. 2021). Additionally, all other prevocalic positions are either single consonants or consonants and glides. The latter are considered by Rupp (2012: 10) to be part of diphthongs. Considering *h* and *ʔ* as voicing-dependent in Ch rather than as full segments also has the advantage of eliminating the only apparent initial consonant clusters in Ch, like those in (60).

As for glottal stops found in coda position, observations from noun possession and verb subject inflection point to their phonemic status. In the variety from Ozumacín, possession of unalienable nouns is marked by segmental and prosodic suffixes (in bold in 62). First person possession is marked by *-n,* [sp], and low tone. Second person is marked by a final glottal stop, and third person is marked by *-y* [i]. Unalienable nouns are body parts or nouns considered close to humans. They do not surface without possession, meaning no unmarked forms exist. In (63), subject is marked on the verbs 'to fry (inanimate things)' and 'to collect (inanimate things)' with similar forms. First person subject is *n-*, second person is the glottal stop, and third person is *-y.*

(62) Rupp (2012: 235–236)

a. lle**n·** **(L)** 'my head'
lle**ʔ** (M) 'your (sg/pl) head'
lle**y** (M) 'his/her/their head'

b. tuʔ**n·** **(L)** 'my stomach'
tu**ʔ**· (H) 'your (sg/pl) stomach'
tu**y**ʔ· (H) 'his/her/their stomach'

(63) Rupp (2012: 248)

a. tʃɪɪ**n** (MH) 'I fry (inanimate) things.'
tʃɪɪ**ʔ**· (M) 'You (sg/pl) fry (inanimate) things.'
tʃɪɪ**y** (MH) 'S/he/they fry (inanimate) things.'

b. hɪɪʔ**n** (M) 'I collect (inanimate) things.'
hɪɪ**ʔ** (M) 'You (sg/pl) collect (inanimate) things.'
hɪɪ**y**ʔ (MH) 'S/he/they collect (inanimate) things.'

Rupp (2012: 236) observes that while the third person possessive suffix attaches stem-finally in coda-less stems (62a and 63a), in a lexically glottal final stem (62b and 63b), *-y* attaches to the left of the glottal stop. One way to account for this is to look at the syllable shapes that are realized. In (62b) and (63b), *-y*, which is realized as [i], cannot attach in final position, as this would result in multiple syllables: * *hɪɪʔy* i.e. CVCV. By maintaining the righthand alignment of the glottal stop, a licit CVVC surfaces instead. This points to the phonemic status of the glottal stop.

However, in the first person examples in (62b) and (63b), the final glottals are treated differently than in the third person. In the first person examples, the *-n* suffix attaches without further segmental change to the stem instead of the glottal stop staying right-aligned. Under the understanding that Ozumacín has post-syllabic nasals (Rensch 1968: 30), the morpheme *-n* is not homosyllabic when attaching to glottal-final stems. While these forms do not trouble the analysis of /ʔ/ as phonemic, neither do they bolster the argument.

At the very least, glottal stops in coda position are treated as phonemes in third person possession in unalienable nouns and subject marking on verbs. Similarly to AMU, the non-segmental laryngeals to the left of voiced segments are still transcribed below as *h* and *ʔ*, following tradition.

4.3 Phonological status of ballisticity

This section addresses how ballisticity fits in with the realizations of laryngeal features discussed in Section 4.2 and outlines possible directions for further research.

It is clear that ballisticity, or [sp], acts differently than the laryngeal features explored in Section 4.2, despite all these traits being laryngeally-based. First, [sp] is realized voicing-finally, while the laryngeal features described in Section 4.2 are realized pre-vocalically as *hV/L* and *ʔV/L* in Ch, and as *(C)hV/L* and *(C)ʔV/L* in Am. Both sets are dependent on voiced segments, and the prevocalic laryngeal features are treated as voicing features.

Contrary to Silverman and Herrera Zendejas, however, [sp] should be treated as attaching to the syllable rather than to a vowel segment. The difference in its status from that of other laryngeal features is seen in how it is realized. Contrary to the other features, ballisticity combines with tonal realization. As previously noted, it is also linked with fortis consonants, which indicates a syllabic level of application. Importantly, ballisticity co-occurs with the other laryngeal features. Under a segmental understanding of ballisticity, it should not be able to attach to the same segment which already carries a contradictory laryngeal value. A syllabic understanding of ballisticity resolves this problem.

By generalizing the different distributions and statuses of laryngeal features into an abstract model, their entire inventory can be thought of as a three-way phonation contrast somewhat symmetrically distributed to the left and the right of voicing. For both language groups, laryngeal features that attach to the left of voicing are left-aligned. For AMU, this is an alignment either to a sonorant or a vowel position, but never to both at the same time. For Ch, laryngeal features are truly left-aligned, given that *Ch/ʔV* never occur. For both languages, non-modal phonation on the left edge is privative and paradigmatic: only one realization can occur at a time.

On the right-edge in both language groups, [sp] and glottal stop are right-aligned, with the specification that [sp] is voicing-dependent and syllabic and the glottal stop is segmental. Contrary to the other laryngeal features, these two types can co-occur in both languages. Analyzing their individual statuses as non-segmental for [sp], and segmental for [ʔ] accounts for this non-privative distribution.

The modeling of the laryngeal features as two sets, one realized on the left edge and another on the right edge, accounts for their co-occurrence in one syllable and syntagmatic distribution. And finally, the absence of any laryngeal feature constitutes modal phonation, the third value in the three-way contrast.

Some open questions remain, in particular how to reach a full theoretical understanding of laryngeals in these languages, where prosodic inventories are so rich. An area of inquiry that remains to be further explored is the relation of ballisticity to contrastive length suggested for Jalapa Mazatec in Silverman et al. (1995) and explored acoustically for AMU in Apóstol Polanco (forthcoming). Contrastive length is found in Ch, but not in Am, according to the literature. This raises the question for Ch of how ballisticity interacts with short and long syllables, and whether in Am ballisticity also bears some special relation to duration.

5 Conclusion

The study brings together a wide set of data across a number of Chinantec and Amuzgo languages to establish the phonological and morphological properties of 'ballisticity,' a trait thought to be specific to these Otomanguean languages. Previous phonetic characterizations of the feature give acoustic aperiodicity and articulatory abduction as its primary correlates, which makes it better understood as a laryngeal feature [sp]. This study combines this insight together with an interpretation of other language-specific laryngeal features. It tentatively suggests that both languages have a three-way modal-breathy-creaky contrast. Under this contrast, laryngeal features are fully contrasted in the positions to the left and to the right of voicing, although the features have different phonological statuses. The "ballistic" feature is but one expression of a richly exploited set of laryngeal features in these languages.

6 Abbreviations

=	clitic	FRUIT	fruit noun class marker
~	reduplicated morpheme	FUT	future
ADV	adverbe	G	glide
Am	Amuzgo language group	H	high tone
AMU	Amuzgo variety from Xochistlahuaca, Guerrero	HUM	human
		INAN	inanimate
		INCL	inclusive
AN	animate	L	low tone
ANIM	animate class marker	M	mid tone
C	consonant	PERF	perfective
CAUS	causative	PL	plural
Ch	Chinantec language group	POSS	possessive
		PROG	progressive
CLASS	class marker	PST	past
COMP	complementizer	SG	singular
CONJ	conjunction	[sp]	spread glottis
ELA	Endangered Language Alliance	SPA	Amuzgo variety from San Pedro Amuzgos
ET	extended theme	V	vowel
EXCL	exclusive	VOL	volitive mood
EXIST	existential pronoun		

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Chapter 9

A tonological rarity: Tone-driven epenthesis in Ghomala’

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This chapter focuses on a rarely mentioned tonological rarity – tone-driven vowel epenthesis – and argues that it is attested in the Cameroonian language Ghomala’. Specifically, an epenthetic vowel is inserted to avoid a rising tone on a syllable closed by an obstruent (e.g. /gɔ̌p/ ⟶ [gɔ̀pə́] ‘hen’), but is never triggered in other tonal contexts (e.g. /bɔ̂p/ ⟶ [bɔ̂p] ‘thorax’, *[bɔ́pə̀]). Morpho-phonological alternations show that when this rising tone is modified and lost, the epenthetic vowel is also lost, demonstrating strict co-variation between tone and segment. Unlike most cases of vowel epenthesis in the literature, epenthesis cannot be attributed solely to segmental or syllabic well-formedness. This chapter catalogues all supporting evidence for tone-driven epenthesis in Ghomala’, including instrumental analysis of recordings made approximately forty years apart. We show that while the motivation for this process is quite common typologically (avoiding a contour tone on a sub-optimal host), the repair itself (i.e. epenthesis) is virtually unprecedented in the literature.

1 Introduction

What kinds of tones, tone systems, and tonological operations are common in the world’s tonal languages, and which are rare? There has been considerable focus on common versus rare phenomena in non-tonal phonology – e.g. with regard to consonants (Butskhrikidze 2010, Tuttle 2010) or stress/accent (Helmbrecht 2010) – but less consideration has been given to tone.

Despite its scarce literature, certain tonological rarities are still known at this point. Languages with three to four pitch heights are common enough (e.g. low,

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mid, and high) but systems with five heights are rare and six virtually unattested (Yip 2002: 20, Odden 2020). Moreover, tonal operations like downstepping are quite common, while 'upstep' is attested but much rarer (Snider 1990). And various asymmetries have been established with respect to the frequency of anticipatory vs. regressive tone assimilation (see Hyman 2007 for an extensive survey). Certain tonal patterns are rare and contentious enough to generate a literature themselves, e.g. the famous Xiamen [nan] tone circle within its tone sandhi system (Dong 1960, Chen 2000: 42ff, Zhang et al. 2006, *inter alia*).

For this chapter, our specific focus is on rarities in tone/segment interaction. Some interactions are well-known and quite common such as consonant depression by voiced consonants, while others are exceedingly rare such as cases when the tone height/type is dependent on vowel height (Jiang-King 1999, Yip 2002: 31). In general, most interactions happen in the direction from segments to tone, and rarely from tone to segments (Wee 2019: 208). What we show here is an even rarer case: the insertion of a vowel itself in order to host tone, i.e. a 'tone-driven epenthesis'. While little attention has been given to the possibility of tone-driven epenthesis and it remains controversial (Gleim 2019, Rolle & Merrill 2022), we demonstrate its existence in the Cameroonian language Ghomala' based on a variety of arguments from both root structure and morpho-phonological alternations.

This chapter is organized as follows. Section 2 provides essential background information on the Ghomala' language, Section 3 presents the evidence for tone-driven epenthesis, Section 4 situates the rarity of tone-driven epenthesis in a typological perspective, and Section 5 concludes this chapter.

2 Background on Ghomala'

2.1 The language setting

Ghomala' (pronounced [ɣɔ̀máláʔ], ISO 639-3: bbj) is a Bamileke language of the Grassfields family spoken in Western Cameroon, part of the larger Bantoid subgroup within the Niger-Congo phylum. In this chapter, we examine data from the Bandjoun and Baham varieties. These are closely-related varieties of the Central dialect of Ghomala' (Domche-Teko & Hatfield 1991: 3, Mba 1997), as opposed to the North and South dialects. In fact, Ghomala' has been called simply Bandjoun in the literature (a.k.a. Banjun or simply Jo), so-named because it is the main Ghomala-speaking *chefferie* (Mba 1997: 77).

Ghomala' has at least 350,000 speakers (Kamdem 2020: 2, citing Simons & Fennig 2018). Its speaker community is likely much higher than that. For example, religious organizations like the Joshua Project claim 1.145 million speakers.[1] Ghomala’ is relatively healthy, widely spoken as the community language (Domche-Teko & Hatfield 1991), with most children being at least Ghomala’-French bilingual today (Kamdem 2020: 3, fn4). Ghomala’ (especially of Bandjoun, the *de facto* standard) is often used in print, taught in local schools, and used regularly on local radio. There have been various literacy and standardization efforts underway for several decades now (Domche-Teko & Hatfield 1991: 8). Domche-Teko & Hatfield (as well as Bomda 2005: 45ff.) provide a comprehensive timeline of the earliest descriptions of Ghomala’, dating back to the colonial period.

Data in this chapter come primarily from the grammatical description in Nissim (1972, 1981) and recordings made around the time of these publications, as well as from a modern dictionary of Ghomala’ (Eichholzer 2010). The data relevant to tone-driven epenthesis are also confirmed by other publications on Ghomala’ (Ntagne & Sop 1975, Piron 1997), as well as YouTube recordings made by Ghomala’ language advocates (these play a role in Section 3.3). These latter recordings are made some forty years after Nissim’s, thereby demonstrating the stability of these Ghomala’ epenthesis patterns.

2.2 Phonological profile

Ghomala’ has a rich set of consonantal and vocalic contrasts (Nissim 1981, Bomda 2005), summarized in Table 1. Among consonants, there are five manners of articulation: stops, affricates, fricatives, nasals, and approximants. The consonants in parentheses may be derived from the other consonants at an abstract level of analysis (Nissim 1981: 121–130), but for practical purposes they are transcribed as separate units. Among vowels, there are four heights and three degrees of backness.

Ghomala’ transcriptions follow the IPA except for *c*=[tʃ] and *j*=[dʒ] (Nissim actually describes them as both palatal and affricated), *š*=[ʃ], *ž*=[ʒ], *y*=[j], *ẅ*=[ɥ], *ʉ̯*=[ɰ], *ʉ*=[ʉ]~[ɯ], and *α*=[ɐ]; see Nissim (1981: 45–71) for phonetic details. Some marginal phones not included in this table are [z] and a series of aspirated stops [t^h, d^h, p^h, b^h, k^h], as well as various nasal+stop sequences and consonant+glide sequences.

Two final phonological details are relevant for our later discussion. First, only the consonants /m, ŋ, p, k, ʔ/ may appear in coda position. Second, both lexical morphemes (i.e. roots) and functional morphemes are prototypically monosyllabic. This fact is important for our analysis of final epenthetic vowels, which expand a monosyllabic form into a disyllabic one.

[1]See https://joshuaproject.net/languages/bbj.

Table 1: Segmental inventory of Ghomala’

LABIAL	DENTAL	PALATAL	VELAR	GLOTTAL	FRONT	CENTRAL	BACK
p b	t d		k g	ʔ	i	ʉ	u
pf bv	ts dz	c j			e	ə	o
f (v)	s	(š) (ž)	(ɣ)	h	ɛ	ɑ	ɔ
m	n		ŋ			a	
	(l)	y	ʉ̯				
		ẅ	w				

2.3 Morphological and syntactic profile

Ghomala’ nouns belong to one of six noun classes (three singular and three plural). Noun classification is often only reflected in noun phrase concord rather than through marking on the noun itself (e.g. the demonstrative ‘this’ has forms *yaŋ*, *tsɔ*, *pɔ*, and *mɔ*, depending on the class of the noun).

Canonical word order is [SUBJECT PARTICLE(S) VERB OBJECT (OTHER)] (where ‘other’ includes *inter alia* adverbs or prepositional phrases). A typical sentence structure is illustrated in (1). We will explain the tone marks shortly.

(1) [gā ê də̄ má ǎ gɔ̄ m̄ lɔ́ʔtà]
gā ê N-lə̄ má ǎ N-ɣɔ̄ m̄ lɔ́ʔtà
1S H_PST INFL-take mother my INFL-go to hospital
‘I took my mother and went to the hospital (today)’ (Kamdem 2020: 100)

Verbal affixation is highly limited, and inflection is primarily marked via a series of pre-verbal particles (Kamdem 2020: 97–98), such as *ê* H_PST (hodiernal past) in (1). Several inflectional patterns contain a general inflectional prefix *N-* INFL (also seen in 1), which is realized phonetically either as pre-nasalization or some other consonantal change. Suffixation is restricted to a small set of multi-functional derivational markers indicating meanings such as repetition of action, plurality on arguments, valency changes, *inter alia* (Mba 1997). These facts will become important as we develop our arguments in Section 3.

2.4 Tone system

At a basic level of analysis, Ghomala’ makes a central distinction between high (H) and low (L) tone. In reality, there are numerous surface tone heights and several contour tones as well. To illustrate the tone system, consider monosyllabic roots with open syllables in Table 2. Here, a six-way tone contrast can be discerned, based on the pronunciations of nouns in isolation compared to their pronunciations when they appear in object position after a verb.

This table shows that there are two types of high tones. One is consistently realized as high, and transcribed simply as H (row a). The other is realized as high in isolation but as a downstepped high in object environment, transcribed as ꜜH (b). Likewise, there are two types of low tones. One is realized as a level low tone which does not fall to the lowest part of the pitch range (c), and is transcribed as L° with a degree symbol (following Africanist conventions – e.g. Bird 1999). The other low tone is one which *does* fall to the lowest part of the pitch range (d), and is transcribed simply as L. Finally, there are two contour tones. One is a LH tone which is realized as rising in isolation but may also be realized as a downstepped high in certain contexts (e). The other is a HL tone, consistently realized as a falling tone. Note that the tone numbers provided are schematic approximations of pitch height (where 1 is the lowest and 5 the highest).

Table 2: Six-way tone contrast (Nissim 1981: 150, 153)

	Tone	Isolation			Context		
a.	H	fɑ́	55	'parent'	ǒ ꜜyɔ́ fɑ́	55	'you saw the parent'
b.	ꜜH	dhə́	55	'spouse'	ǒ ꜜyɔ́ ꜜdhə́	44	'you saw the spouse'
c.	L°	tsə̀°	22	'cola nut'	ǒ ꜜyɔ́ tsə̀°	22	'you saw the cola nut'
d.	L	tà	21	'pot'	ǒ ꜜyɔ́ tà	21	'you saw the pot'
e.	LH	bvʉ̌	25	'dog'	ǒ ꜜyɔ́ ꜜbvʉ́	44	'you saw the dog'
f.	HL	bʉə̂	51	'madman'	ǒ ꜜyɔ́ bʉə̂	51	'you saw the madman'

Regarding the level low tone (row c), several sources on Ghomala' transcribe it simply as a mid tone (Bomda 2005, Bessala & Moguo 2017, Kamdem 2020, Moguo 2021). Nissim (1981: 72) refers to it as *le ton central* which is typographically indicated by the lack of a diacritic, and explicitly contrasts this tone against a mid tone (*ton moyen*) found in related languages but not Ghomala' (we refer the interested reader to Nissim for the exact arguments). In this work, we shall exclusively use the L° convention. At a descriptive level, all the aforementioned variants are acceptable, demonstrated in Table 3. This additionally shows the uniformity across all sources in marking high and low tone.

Table 3: Notational equivalence of L°, unmarked, and M across sources

	Tone	This work	Nissim 1981		Bomda 2005		Meaning
a.	H	só	só	(p. 72)	só	(p. 56)	‘friend’
b.	L°	bàp°	bap	(p. 50)	bāp	(p. 53)	‘meat’
c.	L	fò	fò	(p. 50)	fò	(p. 51)	‘chief’

3 Tone-driven epenthesis in Ghomala’

Out of this six-way tone contrast, the most important for this chapter is the rising tone (LH, row e from Table 2). Building on the original description of Nissim (1981), we defend the thesis that this tone (and this tone alone) conditions tone-driven epenthesis, defined as the phonological insertion of a vowel in order to realize a pitch target. Specifically, words like /gɔ̌p/ ‘chicken’ are realized as [gɔ̀pə́] where the final [ə] is epenthetic.

3.1 Segment-tone co-variation

The first thing to establish is co-variation between a final vowel segment and a rising tone. In Table 2, we showed the contrastive tone patterns on monosyllabic roots with open syllables. These same patterns are found on syllables closed with a sonorant coda /m, ŋ/ (the only sonorants allowed in this position), demonstrated in Table 4. Note that the distinction between lexically contrastive H and downstepped ꜜH is not always apparent (e.g. in dictionary entries), since they are pronounced identically in isolation. We, therefore, do not make this distinction in this table, nor in the tables which follow. Our analysis of epenthesis is not affected by this.

Table 4: Tones on syllables with sonorant codas

	Tone	Example		Meaning	Source
a.	H	/kɔ́m/	[kɔ́m]	‘crab’	(Nissim 1981: 216)
b.	L°	/lə̀m°/	[lə̀m°]	‘condiment’	(Nissim 1981: 72)
c.	L	/lə̀m/	[lə̀m]	‘dry season’	(Nissim 1981: 72)
d.	HL	/fâm/	[fâm]	‘plantation’	(Eichholzer 2010: 16; < *farm*)
e.	LH	/bə̌m/	[bə̌m]	‘destiny’	(Nissim 1981: 74)

Let us next consider syllables closed by an obstruent coda, which in Ghomala' are only /p k ʔ/. Data are given in Table 5. A LH-toned syllable (row e) may be realized either as a monosyllable with a rising tone (faithful to the underlying representation) or a disyllable with a vowel epenthesized to the root. In this latter variant, the L portion of the tone falls on the lexical vowel and the H portion on the epenthetic vowel. Importantly, epenthesis is never found in other tonal contexts.

Table 5: Tones on syllables with obstruent codas

	Tone	Example		Meaning	Source
a.	H	/káp/	[káp]	'pipe'	(Eichholzer 2010: 23)
b.	L°	/bàp°/	[bàp°]	'animal'	(Eichholzer 2010: 3)
c.	L	/pàp/	[pàp]	'wing'	(Nissim 1981: 218)
d.	HL	/lâp/	[lâp]	'elegance'	(Eichholzer 2010: 31)
e.	LH	/lăp/	[lăp]~[làpə́]	'pool of water'	(Eichholzer 2010: 31)

The two pronunciations in row e are found throughout the Ghomala' literature for LH words in isolation. Often the same word is transcribed in both ways across sources. For example, what Nissim (1981: 198) transcribes as [vɔ̀pə́] 'dust', Moguo (2021: 141) transcribes as [vɔ̌p]. Forms with and without the final vowel are thus interchangeable, and there is no contrast between such forms.

In the most comprehensive description of Ghomala' to date, Nissim (1981) is explicit in treating this final vowel as epenthetic, stating that its only function is to support the tonal complex (pp. 65, 90). All cases of words with obstruent codas show the epenthetic vowel variant if and *only* if it has rising tone. The example set in Table 6 demonstrates epenthesis with the three possible obstruent codas /p k ʔ/. With coda /p/ and /k/, an epenthetic [ə] is inserted to host the H portion of the rising tone, while with /ʔ/ it is either [ə] or a copy of the root vowel (depending on the vowel quality).

As stated, there is no comparable variation for other types of tone. Considering forms in Table 5, there exists no variation for /pàp/ 'wing' between [pàp] and *[pàpə̀], or for /lâp/ 'elegance' between [lâp] and *[lápə̀], *et cetera*. This fact demonstrates that epenthesis of a final vowel is not triggered by a markedness constraint against final obstruent codas. If the latter were the case, we would expect epenthesis to be conditioned by the segmental context regardless of the tonal context.[2]

[2]In this table, note that there is an independent process of frication (and backing) which affects /k/ between vowels.

Table 6: Epenthesis when rising tone appears with obstruent coda

	Example		Meaning	Source
a.	/gɔ̌p/	[gɔ̀pə́]	‘hen’	(Nissim 1981: 63)
	/cǎp/	[càpə́]	‘corn cake’	(Nissim 1981: 74)
b.	/fɔ̌k/	[fɔ̀χə́]	‘cold’	(Nissim 1981: 65)
	/sǎk/	[sàχə́]	‘wall’	(Nissim 1981: 65)
c.	/gwɔ̌ʔ/	[gwɔ̀ʔə́]	‘termite’	(Nissim 1981: 146)
	/lǎʔ/	[làʔá]	‘village’	(Nissim 1981: 74)
	/pǔʔ/	[pùʔú]	‘package’	(Nissim 1981: 146)
	/gʉ̌ʔ/	[gʉ̀ʔʉ́]	‘strength’	(Nissim 1981: 90)

Recordings of Ghomala’ words and phrases pronounced in isolation confirm the variability between the presence or absence of a final vowel. These recordings were provided by Larry Hyman, and were originally recorded under the direction of Gabriel M. Nissim in Cameroon around the time of his writing (Nissim 1981). The recordings reflect the speech of a single male speaker of Ghomala’ saying individual words in isolation and within associative (i.e. genitive) noun phrases containing two nouns [N_1 N_2], in either N_1 or N_2 position (we describe these constructions in Section 3.3).

Figures 1 and 2 show roots with LH tones (the pitch is the red line, and the pitch range is marked at the right). Figure 1 shows a LH tone on an open syllable with a clear and steady rise, while Figure 2 shows a LH tone on a word with a coda /p/. It is clear from the spectrogram that in this latter context a full vowel [ə] appears after the final consonant and bears the H portion of the tone.[3]

Compare this to Figure 3 which shows a level low tone (L°) on a syllable closed by the obstruent /p/. Unlike Figure 2, here the /p/ is unreleased and no vowel follows it. Moreover, unlike the coda obstruents, the coda nasals /m ŋ/ never show variants with an epenthetic vowel. A spectrogram confirms the lack of a final vowel in such LH contexts, shown in Figure 4. It is clear that the rising portion of the pitch is realized on [ŋ] itself. These patterns show that the sonorant codas behave similarly to open syllables in permitting a rising tone realization without recourse to epenthesis.

[3]As a reviewer points out, the initial nasal bears pitch as well, which calls into question the actual number of syllables in these figures. We interpret this initial nasal as forming a single syllable with what follows (at least in the phonology), and its low pitch as due to phonetic interpolation. Regardless, the syllabicity of this nasal is orthogonal to our main point with respect to tone-driven epenthesis.

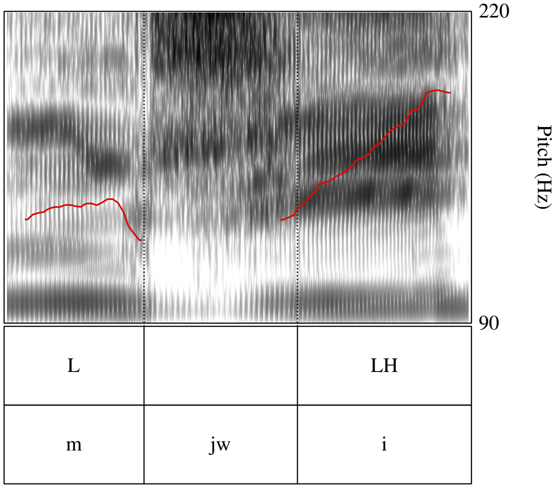

Figure 1: LH tone on open syllable – /mjwǐ/ [mjwǐ] 'woman' (spoken in isolation)

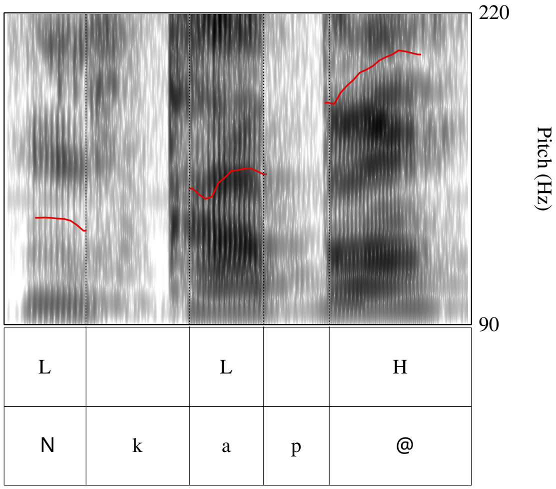

Figure 2: LH tone on syllable with coda /p/ – /ŋkǎp/ [ŋkàpə́] 'money' (spoken in isolation)

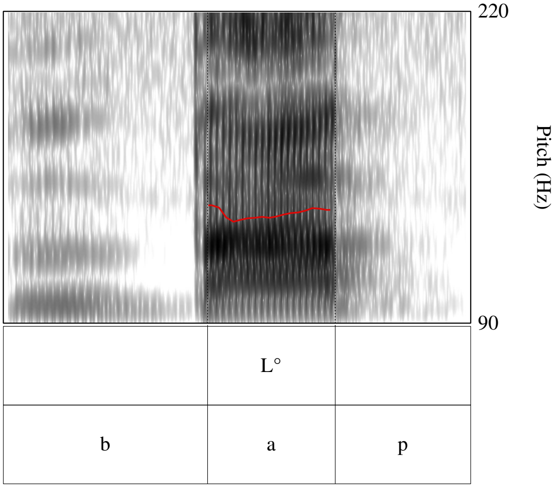

Figure 3: L° tone on syllable with coda /p/ – /bàp°/ 'animal' (spoken in isolation)

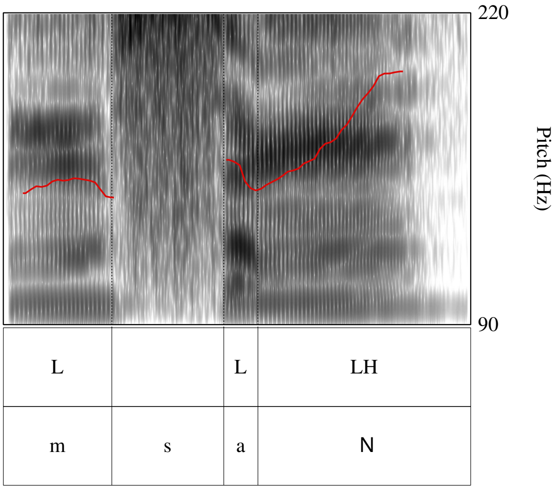

Figure 4: LH tone with sonorant coda – /msǎŋ/ [msàŋ́] 'birds' (spoken in isolation)

3.2 Against a deletion alternative

We now defend our analysis that this is indeed epenthesis, as opposed to an alternative hypothesis which would involve the deletion of an underlying final vowel, i.e. /cvc/ → [cvcə], rather than /cvcə/ → [cvc].

The first argument involves general root phonotactics. As stated, the vast majority of roots in the language are monosyllabic (e.g. CV/CVC shapes). The major exception to this generalization are exactly those [cv̀cə́] forms detailed above. If we treat these as underlyingly /cv̌c/ which only become disyllabic later in the derivation, this unifies the possible shape of roots.

Multisyllabic words which are not attributable to this epenthetic operation are nearly always decomposable into multiple morphemes. These include compounds of some type (e.g. *nɔ̀m-gʉ̈̀ì* 'panther', more literally 'animal-panther') or derived forms with a derivational affix (e.g. suffixes /-nyə/ and /-tə/ or the prefix /kə̀-/). Examples of the latter are given in (2). Disyllabic sequences with final [ə] are in fact quite common in morphologically complex words, demonstrating that there is no general phonological constraint against final [ə] in Ghomala'.

(2) Disyllabic stems as multi-morphemic (Nissim 1981: 91–92)

a. kùŋ-nyə̀
   love-RECIP
   'love each other'

b. pà-tə̀
   carry.on.back-with.care
   'carry carefully' (e.g. of a baby)

c. kə̀-lóʔ
   DEPR-?
   'badly put together'

Any remaining forms which cannot be decomposed into multiple morphemes constitute a marginal percentage of the lexicon, e.g. /bìyɛ́/ 'peanut', /gə̀fɑ̀/ 'corn', /kə́pák/ 'lizard', among others. To this we can add loanwords from English and French found in Eichholzer (2010), e.g. /bə̀lə̀ŋ/ from English 'blanket' or /bàtô/ 'boat' from French *bateau*.

The second argument for an analysis as epenthesis over one as deletion involves a restriction on the distribution of vowel quality. Recall the vowel inventory /i, e, ɛ, ʉ, ə, ɑ, a, u, o, ɔ/ of Ghomala' presented in Table 1 (where ɑ is IPA [ɐ]). Of these, not all are permitted in closed syllables. Before coda /p/ and /k/, only the low vowels /ɔ/ and /a/ are allowed (a few loanwords escape this generalization, e.g. /hɛ̂p/ 'help' – Eichholzer 2010: 21). The data shown from Table 6 above are representative of this restriction.

From a diachronic perspective, it is clear that multiple vowel categories have merged in these closed syllable contexts. Comparing Ghomala' data to Proto-Eastern Grassfields (Proto-EG) reconstructions (Elias et al. 1984), we see widespread neutralization before coda obstruents, such as before Proto-EG *b and *p codas shown in Table 7. Such data show that each of these distinct vowels in Proto-EG corresponds to a Ghomala' form with /ɔ/.

Table 7: Historical merger of vowel qualities before obstruent codas

Proto-EG (Elias et al. 1984)				Ghomala'		Source
*-gú̯ɓ	*chicken	(p. 52)	>	gɔ̌p~gɔ̀pə́	'hen'	(Eichholzer 2010: 18)
*-kíɓ	*fingernail	(p. 90)	>	ŋkɔ̀pə́	'nail'	(Nissim 1981: 198)
*-bóp-	*fear	(p. 90)	>	pwɔ́k	'afraid'	(Nissim 1972: 43)
*-béɓ	*he-goat	(p. 59)	>	pɔ̌p~pɔ̀pə́	'goat'	(Eichholzer 2010: 45)

Importantly, this constraint holds both for [cvᴋ] forms with a surface obstruent coda (e.g. [bàp°] 'animal'), as well as [cvᴋə] forms with a surface [ə] (e.g. [gàpə́] 'antelope'). If the latter forms were underlyingly /cvcə/ then we would have expected a wider range of vowels to be permitted, since the environment for the first vowel would not be a closed syllable on the surface. In short, we would expect non-existent native roots such as /bùpə́/ and /gɛ̀kə́/. Treating all such forms as underlying /cvc/ succinctly accounts for why such forms do not exist.

3.3 Morpho-phonological alternations

This subsection details further support for our analysis as epenthesis, involving morpho-phonological alternations between surface forms with and without a final [ə]. These data demonstrate that tone-driven epenthesis is an active part of Ghomala' grammar.

Let us first consider data from derivation which show the parity between monosyllables and disyllables with final [ə] in the realization of LH tone. In one type of deverbal nominalization, the lexical tone of the root is overwritten with LH tone, shown in Table 8. (Note that verb roots have only a H vs. L distinction – see Section 3.4 below). With open syllables (row a) or syllables with coda sonorants (b), the pattern surfaces with a rising tone on a monosyllable without complication. In contrast, the LH pattern induces an epenthetic [ə] in syllables with coda obstruents (c), mirroring the distribution of underived roots in the lexicon.

Table 8: [ə] alternations in V → N derivation (Nissim 1981: 288–289)

a.	tʉɔ̀	‘be strong’	→	tʉɔ̌	‘iron’
	sú	‘(to) weed’	→	sǔ	‘hoe’
b.	tùŋ	‘dig inside’	→	ntǔŋ	‘throat’
	tɔ́m	‘push’	→	tɔ̌m	‘fruit’
c.	tsʉ̀ʔ	‘twist’	→	dzʉ̀ʔʉ́	‘liana (vine)’
	fɔ́k	‘blow (cold)’	→	fɔ̀kə́	‘cold’

Next, consider [ə] alternations in noun phrases, specifically in the associative construction. To understand these data, first let us establish the relevant parts of this construction. Associative constructions are used to express possession and compounding, and involve two nouns where the first noun is the head and the second noun is the modifier. We exemplify it in Table 9, involving various H- and L-toned nouns in N_1 position and the noun /bàp°/ ‘animal’ in the modifier position N_2.

Table 9: Class-dependent grammatical tone (Nissim 1981: 249–250)

	Class	N_1		N_2		Output	Meaning
a.	CL1	/mú	Ⓛ	bàp°/	→	[mû bàp°]	‘the child of the animal’
		/gì	Ⓛ	bàp°/	→	[gì bàp°]	‘the voice of the animal’
b.	CL3	/thə́	Ⓗ	bàp°/	→	[thə́ bàp°]	‘the head of the animal’
		/kwə̀	Ⓗ	bàp°/	→	[kwə̀ ꜜbàp°]	‘the foot of the animal’

Notice that there are two classes indicated here, class 1 (CL1, in row a) and class 3 (CL3, in b). As is typical for related Bantu/Bantoid languages, Ghomala’ has an elaborate noun class system which is reflected morphologically in the shape of morphemes that are in agreement with the head noun. In the associative construction, noun class is reflected by distinct grammatical tones. Class 1 nouns condition a floating low grammatical tone (Ⓛ) which links the two nouns (following Yip 2002, floating tones unassociated in the input are circled). In contrast, other classes (e.g. class 3) condition a floating high tone (Ⓗ). These grammatical tones result in various tonal changes, e.g. in row a /mú/ becomes falling [mû], while in row b the second low tone becomes a downstepped low tone.

Nissim (1981) provides extensive paradigms of associative constructions. We schematize the relevant tonal patterns of these paradigms in Tables 10 and 11. The underlying tones of the first noun (the head noun, N_1) are listed in the first column, and the underlying tones of the second noun (the modifier, N_2) are listed in the top row. Table 10 shows the tone paradigm for associative constructions involving a class 1 head noun (e.g. /mú/ 'child' from Table 9). Such environments condition the floating Ⓛ grammatical tone between N_1 and N_2. Here, the tone of N_2 remains intact while the tone of N_1 is altered. In contrast, Table 11 summarizes those constructions involving a class 3 head noun (e.g. /thə́/ 'head'). These condition the floating Ⓗ grammatical tone between N_1 and N_2. Here, it is the tones of N_2 that are modified, while those of N_1 remaining largely unmodified.

Table 10: Associative tone paradigm with CL1 noun in N_1, conditioning floating Ⓛ

N_1 / N_2	H	ꜜH	L°	L	**LH**
H	[HL H]	[HL H]	[HL L°]	[HL L]	**[HL LH]**
L°	[HL H]	[HL H]	[HL L°]	[HL L]	**[HL LH]**
L	[L H]	[L H]	[L L°]	[L L]	**[L LH]**
LH	[HL H]	[HL H]	[HL L°]	[HL L]	**[HL LH]**

Table 11: Associative tone paradigm with CL3 noun in N_1, conditioning floating Ⓗ

N_1 / N_2	H	ꜜH	L°	L	**LH**
H	[H H]	[H ꜜH]	[H L°]	[H L]	**[H ꜜH]**
L°	[L H]	[L H]	[L ꜜL°]	[L ꜜL]	**[L H]**
L	[L H]	[L H]	[L ꜜL°]	[L ꜜL]	**[L H]**
LH	[LH H]	[LH ꜜH]	[LH L°]	[LH L]	**[LH ꜜH]**

For our examination of tone-driven epenthesis, the relevant portions of both these tables are the rightmost columns (in bold). For nouns in N_2 position with an underlying LH pattern, there are two surface realizations depending on the noun class of N_1. If a class 1 noun is in N_1 position (Table 10), N_2 surfaces with a rising tone. In contrast, if the noun of N_1 is class 3 (Table 11), N_2 surfaces with a downstepped high tone.[4]

This [LH]~[ꜜH] alternation surfaces as a purely tonal phenomenon in open syllables and in syllables with coda sonorants, e.g. /bvʉ̌/ [bvʉ̌] ~ [ꜜbvʉ́] ‘dog’ in (3).

(3) [LH]~[ꜜH] morpho-phonological alternation in N_2

a. /mú Ⓛ bvʉ̌/ → [mû bvʉ̌] ‘the child of the dog’ (Nissim 1981: 264)

b. /thə́ Ⓗ bvʉ̌/ → [thə́ ꜜbvʉ́] ‘the head of the dog’ (Nissim 1981: 153)

Importantly, when there is a coda obstruent, N_2 nouns show the expected co-variation between tonal pattern and the presence of a final epenthetic vowel. Consider the noun /gɔ̌p/ ‘hen’ which in isolation is pronounced [gɔ̀pə́]. Nissim (1981: 157–158, 250–252) provides the paradigms in Table 12 which show that in the surface [LH] context this surfaces as [gɔ̀pə́] with a final vowel (a), but in the surface [ꜜH] context it surfaces as [ꜜgɔ́p] without the final schwa (b).

Table 12: Co-variation between tone pattern and the presence of a final [ə] in morpho-phonological alternations (Nissim 1981: 157–158, 250–252)

a.	/mú	Ⓛ	gɔ̌p/	→	[mû	gɔ̀pə́]	‘the child of the hen’
	/kòʔ°	Ⓛ	gɔ̌p/	→	[kôʔ	gɔ̀pə́]	‘the rooster of the hen’
	/gì	Ⓛ	gɔ̌p/	→	[gì	gɔ̀pə́]	‘the voice of the hen’
	/dyə̌	Ⓛ	gɔ̌p/	→	[dyə̂	gɔ̀pə́]	‘the house of the hen’
b.	/thə́	Ⓗ	gɔ̌p/	→	[thə́	ꜜgɔ́p]	‘the head of the hen’
	/mkòʔ°	Ⓗ	gɔ̌p/	→	[mkòʔ	gɔ́p]	‘the roosters of the hen’
	/kwə̀	Ⓗ	gɔ̌p/	→	[kwə̀	gɔ́p]	‘the foot of the hen’
	/tǎŋ	Ⓗ	gɔ̌p/	→	[tǎŋ	ꜜgɔ́p]	‘the ear of the hen’

Recordings made by Ghomala’ language advocates and teachers confirm this distribution in morpho-phonological alternations. Consider the following recording publicly available on YouTube, titled *Animaux en ghomala*.[5] The speaker speaks in the Baham variety, which is part of the central Ghomala’ dialect very

[4]Notice in Table 11 that the high tone of N_2 is not downstepped after a low tone. There is no contrast between [H] and [ꜜH] in this environment.

[5]This is available at https://www.youtube.com/watch?v=M5S1Pmw4ND8, by speaker Kamdem Wambo.

closely related and geographically proximate to Bandjoun. The recording contains individual names of common domesticated and wild animals within the Ghomala' environs, as well as several basic nouns and noun phrases in isolation.

In this recording, open syllables or syllables with sonorant codas with rising tones surface as expected, e.g. [tsə̌] 'elephant' (at 9'33" in the video) and [bàpdə̌m] 'rat' (3'15"). There are also 28 instances of a root with an obstruent coda, and all 28 comply with the expected patterns of epenthesis. Representative examples are in Table 13, which provides a sample of words with coda consonants of all tone patterns. Each word in this table is accompanied by its corresponding entry in the Ghomala' dictionary (Eichholzer 2010). If the obstruent coda occurs with H, HL, L°, or L tone, then the form ends with a consonant. However, if it occurs with a LH tone (e.g. [sʉ̂ pɔ̀bə́] 'castrated goat'), then the word ends in an epenthetic vowel (row e).

Table 13: Corroborating evidence for tone-driven vowel epenthesis from the *Animaux en ghomala* video (Baham variety of Central dialect)

	Tone	Example		Location	Cf. Eichholzer (2010)
a.	H	[nɔ́k]	'snake'	(13'31")	[nɔ́k] 'snake'
b.	HL	[dzɔ̂p]	'hedgehog'	(16'20")	[dzɔ̂p] 'hedgehog'
c.	L°	[ŋgàp°]	'antelope'	(11'12")	[gàp°] 'antelope'
d.	L	[kwàk]	'jigger flea'	(32'02")	[kwàk] 'jigger'
e.	LH	[sʉ̂ pɔ̀bə́]	'castrated goat'	(6'51")	[sʉ́] 'castrate' & [pɔ̌p]~[pɔ̀pə́] 'he-goat'

Figure 5 shows that the root /gɔ̌p/ 'chicken' is realized in this video as [gɔ́p] with a high tone and no final epenthesis when spoken in isolation.[6] Although this pronunciation of a rising tone as high in isolation is different from the data from the Bandjoun variety (cf. Tables 5 and 7), it still supports our main thesis since there remains strict co-variation between tone and epenthesis. This is confirmed by Figure 6 of the noun phrase [mʉ̂ gɔ̀bə́] 'chick' (lit. 'baby chicken'). Here, the final noun is realized as [LH], with the low portion hosted on the lexical vowel and the high portion on an epenthetic vowel [ə], as expected.

[6]Faint aspiration can be detected in the recording, on this and many other obstruent-final tokens. Due to noise in the recording, however, it is more difficult to clearly see on the spectrogram. The indeterminacy of aspiration is notated as '(h)' in Figure 5.

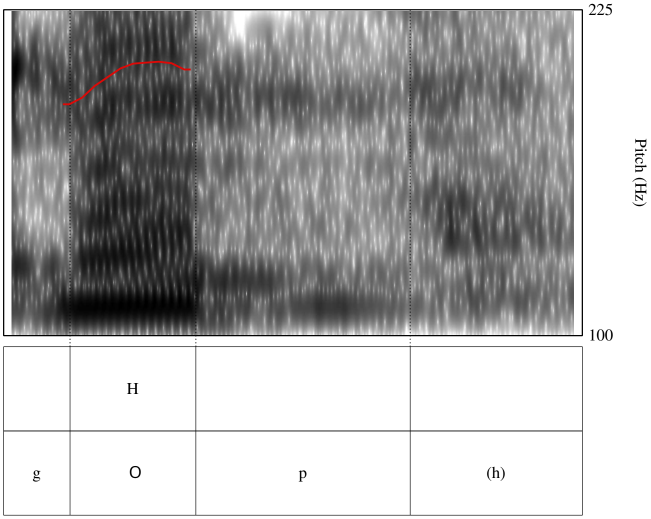

Figure 5: H tone without epenthesis – [gɔ́p] 'chicken' spoken in isolation (24'28")

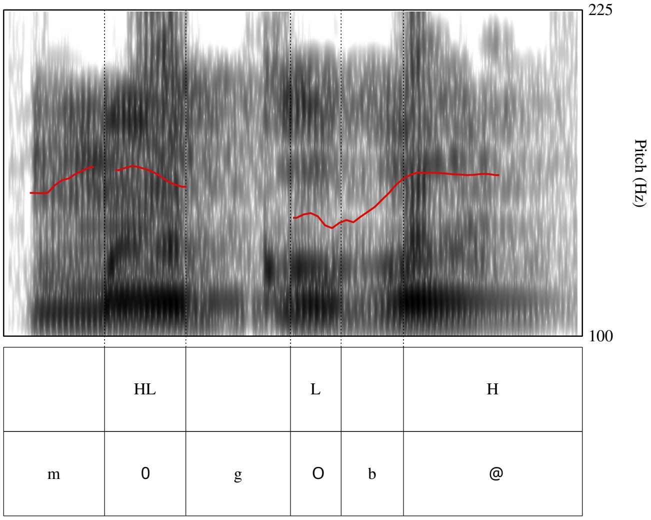

Figure 6: LH tone *with* epenthesis –[mʉ̂ gɔ̀bə́] 'chick' (25'10")

3.4 Indeterminate data from verb inflection

To wrap up our discussion of tone-driven epenthesis in Ghomala', we provide a final note on a set of indeterminate data from verb inflection. Unlike nouns, Ghomala' verb roots have only a basic underlying H vs. L distinction (Nissim 1972: 79, Mba 1997: 78), a property the language shares with other Bamileke languages (Elias et al. 1984: 62). Parts of the verbal system confirm the observations made for the nominal domain, e.g. for L-toned roots the imperative is expressed with LH tone realized as a rising tone on roots like [pàá] 'carry on the back!' but with an epenthetic [ə] on roots like [càpə́] 'insult!' (Nissim 1972: 80). However, other parts of the system complicate our generalizations.

Consider the data in (4) from Bessala & Moguo (2017) involving the lexically low-toned verb /ʒwɔ̀p/ 'dance' (in bold in the example). Here, too, there is an alternation between an obstruent coda and a final [ə]. Note that this source transcribes the level low tone (i.e. L°) as a mid tone, which we repeat.[7]

(4) a. bə́jə̄ pō **ʒwɔ̄p** áá, bə̄ gâ nə̄ŋ
COND you **sing** DEF COND I dance
'If you sing then I will dance.' (Bessala & Moguo 2017: 153)

b. tâmō bə̄ wə̄ **dʒwɔ́pə́**
Tamo COP PROG **sing**
'Tamo is singing.' (Bessala & Moguo 2017: 151)

While the form in (a) without epenthesis complies with our analysis, the form in (b) is unexpected, since it shows a final [ə] not co-occurring with a LH tone. We cannot attribute the presence of [ə] here to the avoidance of a rising tone on a syllable closed by an obstruent.

The presence of this inflectional 'final vowel' has been noticed already in the literature on Ghomala' (Bessala & Moguo 2017, Kamdem 2020: 100), but at this point its function and distribution are not yet established. To complicate things further, variability is common even within the same inflectional context. For example, one context where this final vowel appears is with lexically low-toned roots in the infinitive, e.g. /càp/ 'insult' surfaces as [šápə̀°] 'to insult' (Nissim 1972: 77). While Nissim more or less consistently transcribes final vowels in such infinitival contexts, in sources such as Mba (1997) (of the same Bandjoun dialect) there is no indication of such vowels in equivalent contexts. This is exemplified in Table 14. No final vowel appears in either source with roots of the H tone

[7]There are other orthogonal changes as well, such as changes to the initial consonant of the verb. These are not relevant to our discussion.

class (row a), but the sources differ as to whether another vowel is added with roots of the L tone class (b). (Notice as well that Mba indicates infinitives with an initial prefix *nə́-*, while Nissim often has initial consonant changes in infinitive context.)

Table 14: Variation for infinitive forms across sources

	Tone class		INF (Nissim 1972)	INF (Mba 1997)	Meaning
a.	H	fíʔ	[fìʔ°]	[nə́-fîʔ]	‘to descend’
		sɛ́	[sɛ̀°]	[nə́-sɛ̂]	‘to count’
b.	L	fìʔ	[fíʔì°]	[nə́-fìʔ]	‘to water’
		vɔ̀k	[bvɔ́χə̀°]	[nə́-vɔ̀k]	‘to live (on)’
		pà	[báà°]	[nə́-pà]	‘to carry on back’

In total, while tonal-driven epenthesis can be firmly established for nouns, the situation with verbs requires further data and analysis.

4 Tone-driven epenthesis in a typological perspective

In the previous section, we have shown that Ghomala’ disprefers a rising tone on a syllable closed by an obstruent. We can call this the *[CV̌K] constraint. To avoid such a structure, a final vowel is epenthesized which hosts the high tone portion of the contour (i.e. a word /gɔ̌p/ becomes [gɔ̀pə́] ‘hen’). Evidence came from root phonotactics as well as morpho-phonological alternations, showing that this is an active part of the Ghomala’ phonological grammar.

In this section, we situate the Ghomala’ *[CV̌K] constraint and tone-driven epenthesis in a cross-linguistic perspective, with comparison to similar types of patterns in various languages. We divide this section into three parts. In Section 4.1, we discus how both rising tones and syllables closed by an obstruent are marked structures with respect to tone-segment interaction. In this perspective, a *[CV̌K] constraint is exactly the type of constraint that is expected to emerge. Section 4.2 shows, however, that tone-driven epenthesis as a repair is vanishingly rare if not unprecedented. Finally, Section 4.3 discusses an important parallel to tone-driven epenthesis, namely intonation-driven epenthesis whereby a vowel is inserted to host part of an intonational tune. Although intonation-driven epenthesis has been purported more often than tone-driven epenthesis, it too is rare cross-linguistically.

4.1 The commonality of constraints on rising contours

The *[cv̌k] constraint of Ghomala' is a particular manifestation of two cross-linguistic markedness patterns: one pertaining to rising contours, and one pertaining to the ability of syllables closed by an obstruent to host tone. Let us begin with the former.

In a large-scale survey of contour tones, Zhang (2013) finds that if a language only allows one type of contour (falling or rising), languages which only allow surface falling tones (*n*=37) far exceed those which only allow surface rising tones (*n*=3). Furthermore, Zhang finds in numerous languages that rising tones have a more limited distribution than falling tones, such as with respect to syllable type or position within the word. In Mende [men], for example, a HL falling contour can occur on the final syllable of a disyllabic word while a LH rising contour cannot. Such cross-linguistic findings warrant the phonological markedness scale in (5) (Yip 2002, Hyman 2007), where level tones are less marked than falling tones, which are less marked than rising tones.

(5) Markedness scale of tones (from less marked to more marked):
{H,L} > F > R

Let us now consider the second markedness type. A large literature now exists which evaluates which syllable types are better hosts for tone and appear with a larger range of tone types, and which are worse. Surveys of contour tones (e.g. Gordon 2001, Zhang 2013) find a cross-linguistic implicational hierarchy. If a syllable that ends in a sonorant/resonant (what we shall abbreviate as 'CVN') can carry a contour, then a long vowel ('CVV') can carry a contour of "equal or greater tonal complexity" (Zhang 2013: 49). Moreover, if a syllable that ends in an obstruent (which we shall abbreviate as 'CVK') carries a contour, then CVN and CVV syllables can as well. Zhang shows that this implicational hierarchy is clearly seen in many Chinese languages. In the Changzhou variety of Wu Chinese [wuu], for example, five types of tone may appear on CVV/CVN syllables – 55, 13, 523, 24, and 45 (where 1 is the lowest and 5 the highest) – while only two tones may appear on CVK syllables – 23 and 5 (Wang 1988). This implicational hierarchy can be captured in a markedness scale parallel to the one posited above in (5). This is shown in (6).[8]

(6) Markedness scale of a syllable's ability to host a tone contour:
CVV > CVN > CVK

[8]Note that we specifically do not place short syllables (i.e. CV) in this scale. While Gordon (2001: 428) finds that "if a language allows contour tones on CV, it also tolerates them on [CVK], [CVN], and CVV", there are exceptions to this such as Ghomala' itself.

Hyman (2007: 11) connects these two scales, stating that "in principle, the more complex ('marked') a tone is, the more likely it is to...be restricted to a hospitable TBU (e.g. a long, prominent, sonorous TBU)". One exemplification of these two scales interacting comes from Standard Thai [tha] (Gandour 1975), discussed by Yip (2002). Gandour follows a common approach to tone-segment interactions in Asian languages, dividing syllables into 'smooth' syllables (e.g. ending in a nasal, glide, or vowel, i.e. CVN) versus checked syllables (e.g. ending in a stop such as [p t k ʔ], i.e. CVK). There are five tones in Thai – high, mid, low, falling, and rising – but not all tones are allowed on both syllable types, summarized in Table 15.[9] This table shows that rising but not falling contours show a categorical ban in certain syllabic environments. These syllabic environments are exactly the ones we would expect from the markedness scale in (6). To this, we can add the Ghomala' constraint *[cv̌k] as one further instantiation of the interaction of these two scales.

Table 15: Thai tone type by syllable type (Y=possible, (*)=marginal, *=impossible) (Gandour 1975)

	Syllable	High	Mid	Low	Falling	Rising
a.	CVV	Y	Y	Y	Y	Y
b.	CVN	Y	Y	Y	Y	Y
c.	CVVN	Y	Y	Y	Y	Y
d.	CVK	Y	*	Y	(*)	*
e.	CVVK	(*)	*	Y	Y	*

While the above discussion is based around phonological typology, accumulated research in phonetics corroborates the particular markedness of [cv̌k] sequences. It is well-known that of contour tones, rising pitch takes longer to execute than falling pitch, and consequently a rising tone has greater duration on average (e.g. Sundberg 1973, Zhang 2013). Moreover, the main phonetic correlate of tone is fundamental frequency (i.e. f_0), and rich harmonic structures are crucial to the perception of f_0. Because sonorous segments such as vowels and sonorants possess richer harmonic structures than obstruents, pitch targets are better perceived on them. It therefore follows that syllables with obstruents would make for worse tone-bearing units generally, which would be compounded by

[9] Marginal words which Gandour (1975: 172) mentions include *kʰlâk* 'be crowded' with a falling tone on a CVK syllable and *káát* 'gas' (a loanword) with high tone on a CVVK syllable. Importantly, Gandour is explicit that "mid and rising tones never occur on a checked syllable".

the complexity of the tone. Taking these two aspects together, [cvk] structures may not provide enough sonorous material to adequately realize the rising tone within its allotted duration.

4.2 The rarity of tone-driven epenthesis as a repair

In response to such phonetically motivated pressures, phonological systems respond in various ways. The simplest case are those languages which unequivocally prohibit [cv̌k]-type structures, which we saw in Thai (Table 15). In many languages, however, syllables closed by obstruents (or other inadequate hosts for contours) are 'repaired' in some way. One common repair is to lengthen the vowel (which may or may not neutralize a phonological distinction between short vs. long vowels). For example, Zhang (2013) cites lengthening in Mitla Zapotec [zaw] for syllables with rising contours, which does not apply to falling contours (Briggs 1961). Another common repair involves the compression, simplification, or flattening of the rising contour (see Zhang for examples). These two repairs are two sides of the same coin: there is a discrepancy between the amount of duration the syllable has versus the amount that the tone requires, and either the vowel lengthens or the tone compresses to accommodate.

In contrast, tone-driven epenthesis as a repair to a *[cv̌k] constraint (or a similar constraint) is exceedingly rare if not unprecedented. No such repair is mentioned in either of the large-scale typological surveys mentioned above (Gordon 2001, Zhang 2013). Nor does it appear in reference works on tone (e.g. Pike 1948, Fromkin 1978, Yip 2002, Wee 2019, *inter alia*), or on epenthesis (e.g. Broselow 1982, Itô 1989, Blumenfeld 2006, de Lacy 2006, Hall 2006, Hall 2011, *inter alia*). In fact, works which posit a maximally restrictive theory of epenthesis assume tone-driven epenthesis to be impossible/unattested (Blumenfeld 2006, Gleim 2019). Blumenfeld concludes that epenthesis is "used exclusively as a response to pressures of syllable structure, sonority sequencing, syllable contact, and word minimality" (p. 5), but that "tone conditions cannot affect string structure" and therefore tone "cannot force epenthesis/syncope" (p. 41).

It is, therefore, quite remarkable that an epenthetic vowel in Ghomala' appears in order to host part of a pitch contour, rather than being solely due to segmental or syllabic markedness. Other than Ghomala', we are aware of only four potential cases of tone-driven epenthesis: in Wamey, Kejom, Barain, and Arapaho. Of these, only Wamey looks as convincing as the Ghomala' case.

Wamey [cou] (also called Konyagi/Coniagui) is a language of Guinea and Senegal, traditionally placed in the "Atlantic" group of the Niger-Congo phylum (and only distantly related to Ghomala'). In a recent paper, Rolle & Merrill (2022) provide a number of arguments parallel to those developed for Ghomala', building on earlier description and insights found in Santos (1996). Like in Ghomala', in Wamey rising tones on closed syllables trigger epenthesis. This is evidenced by restrictions on the shape of roots. Wamey has a basic H vs. L tone contrast, and HL and LH contours are common. As summarized in Table 16, in isolation monosyllabic CVC-shaped roots may bear H, L, or HL tones, but no CVC root appears with a LH tone. At the same time, bisyllabic CVCə-shaped roots are not permitted with H, L, or HL patterns, but only appear with the LH tone.

Table 16: Complementary distribution in Wamey of bisyllabic CVCə vs monosyllabic CVC surface root shapes, based on tone (Santos 1996)

	Tone	Roots with surface [CVCə]		Roots with surface [CVC]	
a.	H	*cv́cə́		[cǽw̃]	'urinating'
b.	L	*cv̀cə̀		[cæ̀w̃]	'hiding'
c.	HL	*cv́cə̀		[cæ̂w̃]	'domestic animal'
d.	LH	[nkæ̀w̃ə́]	'dance'	*cv̌c	

This complementary distribution is naturally captured by a unified underlying representation /CVC/ for all four root types, plus tone-driven [ə] epenthesis to avoid a rising tone on a closed syllable. As in Ghomala' the overwhelming majority of roots are monosyllabic, and those CVCV structures which cannot be attributed to the epenthesis operation are either morphologically complex or loanwords.

We cannot attribute epenthesis here to segmental phonotactics, which would prohibit certain consonants in coda position. For any closed syllable bearing a rising LH tone, epenthesis is triggered. In Wamey, this applies with all coda consonants, not just by an obstruent as in Ghomala'. All consonants are otherwise allowed in coda position, shown in (7). (Note that the prefixes are noun class markers, not relevant to our discussion).

(7) a. H [ì-gwǽlǽɓ] 'to talk a lot'
 b. L [ì-còɓ] 'to stick on'
 c. HL [æ̀-kæ̂ɓ] 'rubber vine'
 d. LH [æ̀-kə̀ɓə́] 'a species of owl' (*Otus leucotis*)

Moreover, Wamey also demonstrates morpho-phonological alternations supporting the equivalency of coda-final and [ə]-final forms. For example, the suffix /-k/ (roughly equivalent to third person singular perfective) is one of several suffixes which show alternations of the type [-k]~[-kə́]. The data in (8) are representative for the distribution of the two variants: the [-k] form appears if the preceding vowel is high-toned (a), while the [-kə́] variant appears if the preceding vowel is low-toned (b). Such alternations are accounted for if we posit that the final schwa in (b) is inserted in order to avoid a rising tone on a syllable closed by /-k/ (see Rolle & Merrill 2022 for extensive argumentation).

(8) Tone-driven alternations in Wamey (Santos 1996: 43)
  a. After [H]: *ì-cǽs* 'to suffer' ⟶ *cǽsə́-k* 'he suffers'
  b. After [L]: *ì-tòk* 'to eat' ⟶ *tókə̀-kə́* 'he ate' (cf. *tókə̌-k)

While Wamey is a strong candidate for tone-driven epenthesis, the three other cases are much weaker. The first is another Grassfields language of Cameroon closely related to Ghomala', namely Kejom [bbk] (also called Babanki). The relevant data involve various verb inflection paradigms, found in Akumbu et al. (2020). For example, the authors analyze the imperative (specifically the non-indicative singular imperative) as involving a floating Ⓗ tone which appears after the verb. Representative imperative data are in (9), with high-toned and low-toned roots. If Ⓗ appears with a high-toned root (e.g. /lám/ 'cook'), then no overt marking is observed. However, if it appears with a low-toned root (e.g. /kùm/ 'touch'), then an overt inflectional suffix [-ə] appears. Note that in this example, there is high tone spreading onto the object's noun class prefix /kə̀-/, resulting in a surface mid tone.

(9) Non-indicative singular imperative in Kejom (Akumbu et al. 2020: 11)
  a. H root: /lám Ⓗ kə̀-báyn/ ⟶ [**lám** kə̄-báyn] 'Cook the fufu!'
  b. L root: /kùm Ⓗ kə̀-báyn/ ⟶ [**kùmə́** kə̄-báyn] 'Touch the fufu!'

Akumbu et al. (2020: 3) specifically characterize this distribution as lexically low verb roots having "acquired an epenthetic schwa to avoid the rising tone that would otherwise result from combining the root L with the H suffix tone of the imperative (**kǔm*)". This would constitute tone-driven epenthesis.

However, one aspect of Kejom which makes it distinct from Ghomala' and Wamey is that this epenthesis process is not regular across verbal paradigms. For example, in the analogous context under negation, no epenthesis is found. As Akumbu et al. (2020) make clear, the same imperative floating Ⓗ must be present in (10) as well, since it conditions tonal changes on the object.

(10) Non-indicative negative singular imperative (Akumbu et al. 2020: 14)

a. /kə́ à lám Ⓗ kə̀-báyn/ ⟶ [ká ꜜ**lám** kə̄-báyn] ‘Don’t cook the fufu!’

b. /kə́ à kùm Ⓗ kə̀-báyn/ ⟶ [ká **kùm** kə̄-báyn] ‘Don’t cook the fufu!’

If tone-driven epenthesis were fully regular in Kejom, we would expect the unattested form *[kùmə́] in (b).

Another similar case which falls short of tone-driven epenthesis is found in Barain [bva] (Chadic: Chad – Lovestrand 2012). In Barain, tone alone cannot condition epenthesis but rather makes otherwise variable segmentally-driven epenthesis obligatory. Lovestrand (2012: 21) details the strict requirements on complex onsets and codas, showing that an epenthetic vowel is inserted to satisfy these requirements. In (11), the vowel [i] is inserted to break up the heteromorphemic consonant cluster.

(11) Barain epenthesis (Lovestrand 2012: 44)
/wī́s-gà/ ‘boil-DO:3.M’ ⟶ [wīls**í**gà]

Speakers differ as to whether they manifest epenthesis in such heteromorphemic contexts. A coarse generalization is that younger speakers consistently insert epenthetic vowels in such cases while older speakers show more variation. This is exemplified in Table 17 with two speakers, A (of the younger generation, who consistently shows epenthesis) and B (of the older generation, who is more variable).

Importantly, Lovestrand (2012: 63) states that even “those speakers who allow the unlicensed cluster still prefer the epenthetic vowel in the case where not using the epenthetic vowel would create a word with fewer [tone-bearing units] than underlying tones”. One example involves the imperfective aspect realized as a floating Ⓜ tone (row b from Table 17). When such a floating tone is present, epenthesis is required by all speakers, and its absence is questionable/ungrammatical. In Barain, therefore, tone alone does not condition epenthesis per se, but rather increases the preference for it.[10]

Finally, a similar case comes from Arapaho [arp] (Algonquian: USA – Cowell & Moss Sr. 2008). This superficially resembles tone-driven epenthesis, but Gleim (2019) argues it is better understood as ‘tone-driven retention’. Here, vowels that are otherwise expected to delete according to the regular phonology are retained if and only if they bear tone. Several such cases of tone-driven retention have

[10]Two things should be noted in this table: a regular tonological rule changes M to L before L, and questionable forms are notated with a superscript ? as compared to ungrammatical forms which are marked with an asterisk.

Table 17: Barain epenthesis co-driven by both segmental structure and tone (Lovestrand 2012)

	Morphemes	Gloss	Speaker A	Speaker B (Older gen.)
a.	/séébˑ-tì/	fish-DO:3.F	[séébí̀tì]	[séébítì] ~ [séptì]
	/ēp-gà/	punish-DO:3.M	[èp**ì**gà]	[èp**ì**gà] ~ [èpgà]
	/pás̄-nù/	miss-DO:1.S	[pás**ù**nù]	[pás**ù**nù] ~ [pásnù]
b.	/dóp-Ⓜ-gà/	find-IPFV-DO:3.M	[dóp**ì**gà]	[dóp**ì**gà] (cf. $^{?}$[dópgà])
	/sééb-Ⓜ-gà/	fish-IPFV-DO:3.M	[séébìgà]	[sééb**ì**gà] (cf. $^{?}$[sébgà], *[séèbgà])

previously been identified in Roettger & Grice (2019: 279–280), e.g. in Cheyenne [chy], Acoma [kjq], Konso [kxc], Japanese [jpn], and the Shanghainese variety of Wu Chinese [wuu]. In general, our presentation of the Arapaho data here follows the argumentation developed in Gleim (2019).

In Arapaho, certain morphemes idiosyncratically co-occur with a floating high tone, shown in Table 18. In many contexts, this floating high appears on an epenthetic vowel [i]/[u]. In row a, the epenthetic vowel and its surrounding consonants are in bold. In contrast, if the morpheme does not sponsor a floating tone, then no surface epenthetic vowel occurs (row b). Such data demonstrate a co-occurrence of floating tones and epenthetic vowels, which reasonably could be interpreted as tone-driven epenthesis.

Table 18: Arapaho epenthetic vowels and floating tones (Gleim 2019)

a.	/tʃew-Ⓗsee/	[tʃe**bís**ee]	'to walk along'
	/oow-Ⓗsee/	[hoo**wús**ee]	'to walk downward'
	/nééʔeeθ-Ⓗnihií-noo/	[nééʔee**sín**ihiínoo]	'that's what I'm saying'
b.	/étʃex-nówoʔ/	[hétʃe**sn**ówoʔ]	'small fish'
	/nih-bebíiθ-tii-t/	[nihbebíi**st**iit]	's/he fixed it'
	/tʃew-kóóhu/	[tʃe**bk**óóhu]	'run along'

However, Gleim (2019) argues that it is not epenthesis that is triggered by the floating tone here, but rather an epenthetic vowel is merely retained by the presence of tone which otherwise would have been deleted (building on original observations in Cowell & Moss Sr. 2008: 16). The crucial evidence comes from a develarization process apparent, also seen in Table 18: velar segments /x/, /k/,

/w/ become [s], [tʃ], [b] before front vowels [i] and [e]. Crucially, develarization takes place both before surface [i] (e.g. [tʃe**b**ísee] in row a, where /w/→[b]), as well as opaquely applying where no surface vowel appears (e.g. [hétʃe**s**nówoʔ] in row b, where /x/→[s]).

Gleim shows that the opacity can be accounted for straightforwardly if we assume a 'Duke-of-York derivation' (Pullum 1976), where an operation of vowel epenthesis applies first and uniformly, followed by floating tone docking and develarization. After these operations, an operation of high vowel deletion takes place, but only if the high vowel does not bear high tone (hence, tone-driven retention). Because this deletion process can target an epenthetic vowel, the underlying form and the surface form look alike, characteristic of all Duke-of-York examples in the literature (i.e. of the type A → B → A).

To summarize, in Kejom tone-driven "epenthesis" is not fully regular across the verb inflection paradigms, in Barain tone alone cannot condition epenthesis but rather only makes otherwise variable segmentally-driven epenthesis obligatory, and in Arapaho what resembles tone-driven epenthesis is actually tone-driven retention. Ghomala' and Wamey, in turn, do not have these shortcomings.

4.3 A parallel: intonation-driven epenthesis

A noteworthy process comparable to tone-driven epenthesis exists in the intonation literature: intonation-driven epenthesis. Here, a vowel is inserted to host part of an intonational tune (and not a lexical/grammatical tone per se).

Intonation-driven epenthesis can be situated within a larger discussion of "text-tune" relationships in the intonation literature. In cases where there is a mismatch between the segmental structure (the "text") and the intonational melody (the "tune"), normally it is the melody which accommodates (e.g. through truncation). A growing literature shows evidence for the opposite as well: segmental structure changing to accommodate the intonation (Roettger 2017, Grice et al. 2018, Roettger & Grice 2019).

To illustrate, consider a recent study of Tunisian Arabic [aeb] intonation (Hellmuth 2022). Yes-no questions are commonly realized with a rise-fall intonational complex (i.e. L*+H H-L%) at the right edge of an intonational phrase. When this intonational complex appears, it often co-occurs with an epenthetic vowel to which part of this complex docks. An example of phrase-final [ə] epenthesis is in (12).

(12) nkemmil tˤuːl → [nkemmil tˤuːləː]
I-continue straight.ahead
'Should I go straight ahead?' (Hellmuth 2022)

Epenthesis only appears in the context of this complex rise-fall contour, and even then only half the time. Importantly, it *never* appears when there is only a simple rise or simple fall, even in the context of a yes/no question. Tunisian Arabic thus shows co-variation between a final vowel and a complex pitch event, suggestive of intonation-driven epenthesis.[11]

What unifies tone-driven and intonation-driven epenthesis is that both are attributable to a functional pressure to cultivate segmental environments best suited for realizing pitch targets. Still, intonation-driven epenthesis is quite rare within the world's languages, though there are more purported cases than for tone-driven epenthesis. See the above-mentioned sources for several other purported cases of intonation-driven epenthesis (especially Roettger & Grice 2019).

5 Conclusion

This chapter focused on a little-known tonological rarity: tone-driven vowel epenthesis. We showed that in Ghomala', an epenthetic vowel is inserted to avoid a rising tone on a syllable closed by an obstruent, e.g. /gɔ̌p/ → [gɔ̀pə́] 'chicken', but never triggered in other tonal contexts. We supported tone-driven epenthesis with evidence from root phonotactics and morpho-phonological alternations which show that when a rising tone is modified the epenthetic vowel is lost (i.e. complete co-variation). Finally, we situated these Ghomala' patterns within a larger cross-linguistic perspective. We demonstrated that the Ghomala' constraint against [cv̌ᴋ] structures has much typological and phonetic support, given the general markedness of rising contours, as well as the markedness of obstruent-final syllables acting as tone-bearing units. While the motivation for tone-driven epenthesis is clear, we examined all other purported cases of tone-driven epenthesis and showed that nearly all of them fall short compared to Ghomala'. We ended our study by comparing the Ghomala' patterns to a similar intonation-driven epenthesis, which, too, is seldom reported for the world's intonational systems.

There is one matter which has been conspicuously absent from our discussion thus far: if tone-driven epenthesis is so exceedingly rare, why? Its existence in Ghomala' entails that we cannot deny it as a universal constraint, requiring

[11]Note, however, that Hellmuth (2022) deliberates over the final [ə] in examples like (12) as to whether it is intonation-driven epenthesis or intonation-driven retention (analogous to Arapaho in Table 18). She ultimately concludes that it is "rather a "question vowel" particle of some type", analogous to similar interrogative clitics in the linguistic area. This speaks to the analytic indeterminacy of epenthesis, which is notoriously difficult (Morley 2015). Regardless, these Tunisian Arabic data suffice to illustrate intonation-driven epenthesis for our purposes.

a more nuanced explanation. One possibility we would like to put forward involves functional load (Hockett 1955, 1967, Wedel et al. 2013, Hall et al. 2019). Cross-linguistically, lexical and functional meaning cued by tone can also be cued simultaneously by a co-occurring segmental component, and only more rarely cued by tone alone. Because of this, if tone is fully or partially deleted in some environment, the meaning can still be recovered in general. In this way, the functional load of tone is quite low. In many tonal languages, therefore, there is little reason to excessively maintain tone contrast if other markedness considerations come into play. If there is enough segmental material to differentiate the morpheme from other paradigmatically-related morphemes (e.g. all nominal roots, or all tense/aspect suffixes), then adding more segmental material via epenthesis may be costlier than being faithful to the underlying tone pattern.

In short, because of the low functional load of tone, in most languages if the H portion of a hypothetical [CV̌K] sequence were simply deleted, little information would be lost to correctly identifying the intended meaning. At this point, such an explanation remains tentative, and a dedicated study is required before it can be evaluated further.

Abbreviations and glossing

´ (H)	high tone	CL	noun class
↓´ (↓H)	downstepped high	COND	conditional
¯ (M)	mid tone	COP	copular
` (L)	low tone	DEF	definite
`° (L°)	level low tone	DEPR	depreciative
ˆ (F)	falling tone	DO	direct object
ˇ (R)	rising tone	F	feminine
Ⓗ	floating high tone	H_PST	hodiernal past
Ⓜ	floating high tone	INF	infinitive
Ⓛ	floating low tone	INFL	inflection
C	consonant	IPFV	imperfective
V	vowel	M	masculine
N	sonorant (in syllable)	PROG	progressive
K	obstruent (in syllable)	RECIP	reciprocal
N_1	first noun in phrase	S	singular
N_2	second noun in phrase		

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Part IV

Rare vowels

Chapter 10

The contradictory nature of fricative vowels in Chinese and beyond

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This chapter is concerned with fricative vowels, an umbrella term for speech sounds that are syllabic but nevertheless typically involve frication so that they are difficult to categorise as either consonants or vowels. Because of these contradictory properties and their overall rarity, there are many different terms for fricative vowels and there is a general lack of awareness among linguists that these sounds exist. Very few studies have attempted to compare fricative vowels cross-linguistically, but it is clear that there are both similarities and differences among them. The goal of this chapter is to provide an overview of fricative vowels and of the major descriptive and theoretical questions that they raise.

1 Introduction

The distinction between consonants and vowels is perhaps the most fundamental dichotomy in phonology. The primary criteria for categorising sounds into either of these classes are their position within the syllable structure and the degree of constriction in the vocal tract. Vowels are always in the syllable nucleus and involve virtually no constriction of the vocal tract, whereas consonants are typically peripheral to the syllable nucleus and involve a partial or complete constriction of the vocal tract (Laver 1994; Ladefoged & Maddieson 1996). When a sound constitutes a syllable nucleus but clearly involves constriction as in [m̩] or [r̩], it is common practice to call the sound a syllabic consonant, i.e. a consonant that can form a syllable without a vowel. This is not controversial because there

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are the familiar non-syllabic sounds [m] and [r]. However, there are also syllabic sounds that involve non-vowel-like constrictions but that cannot be straightforwardly transcribed with a consonantal symbol due to their unusual articulation. Such segments typically have an airstream with a varying degree of frication and have constrictions at places other than or in addition to the tongue dorsum as in regular vowels. In this chapter, we shall refer to these sounds collectively as “fricative vowels” after Ladefoged & Maddieson (1996). Using the definition above, the distinction between fricative vowels and syllabic fricatives may sometimes be blurry. However, syllabic consonants typically develop from a CV or VC sequence in which the vowel disappears (Scheer 2004; Shen 2006). Such a sound change will never happen to all syllables in a language, so that syllabic consonants exist alongside non-syllabic counterparts. In other words, the presence of a syllabic consonant such as [r̩] implies the presence of [r]. In contrast, fricative vowels develop out of high vowels and there is often no phonetically comparable sound within the same language. In fact, it can be argued for many fricative vowels that there exists no true non-syllabic counterpart at all. Because of these reasons, fricative vowels cannot simply be equated with fricatives that happen to be syllabic.

Figure 1 below shows a comparison of a fricative vowel nucleus with an ordinary vowel from our Zhushan Mandarin data.[1] The oscillograms show the sound waves and the annotated individual segments. The corresponding spectrograms show the amount of acoustic energy through time, where darker shades indicate more energy. The f0 tracking shows lexical tones and is displayed within a range of 75–150 Hertz.

The transition from the onset to the nucleus is clearly visible in both spectrograms: the lower formants are well-defined horizontal bands and suggest a sonorant nucleus. However, the higher formants of the nucleus in [sz̩] or [sɹ̩] 死 ‘to die’ are less discernible because they are masked by the large amount of aperiodic acoustic energy above 4000 Hz. This is audible frication. It is in fact a continuation of the frication of the preceding sibilant onset [s]. Only near the end of the fricative vowel do we see that the frication decreases. This is also visible in the oscillogram, of which the middle portion shows both the regular pulses of a sonorant as well as the jaggedness of a fricative segment. In contrast, the transition from onset to nucleus in [sae] 赛 ‘race’ shows an immediate drop of energy in higher frequencies, and clear energy concentrations for the vowel formants.

[1]The data was collected in 2016 by the third author by means of elicitation sessions. Zhushan Mandarin is a regional variety of Mandarin spoken in Zhushan County, Hubei province. The speaker is a man from Nanba village who was born in 1980. For a description of the full sound system of Zhushan Mandarin, please refer to Chen & Guo (2022).

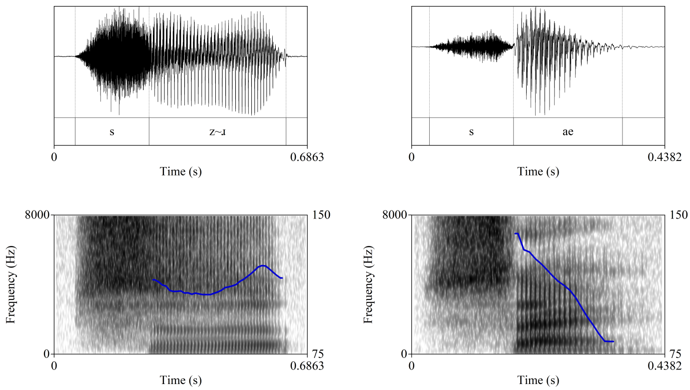

Figure 1: Left: the Zhushan Mandarin word 死 'to die', which is roughly [sz̩] or [sɹ̩] in standard IPA. Right: the word [sae] 赛 'race'

This ordinary vocalic nucleus is clearly distinct from the fricative vowel on the left. So what is the precise phonetic and phonological identity of this sound? On the one hand, it is a sonorant nucleus that bears a tone but simultaneously involves frication throughout a significant portion of its realisation. On the other hand, it does not sound like a vowel, it has developed out of a historical *i, and is synchronically still in complementary distribution with Zhushan Mandarin /i/. This illustrates the crux of the matter.

Because of the contradiction between their phonetic and phonological properties, i.e. the combination of their non-vowel-like articulation and obligatory syllabicity, fricative vowels defy a straightforward description with standard terminology and categories. Different lines of research have therefore come to use different terms, analyses, and (IPA) transcriptions that exist alongside each other. This stymies comparative research because it obscures the fact that fricative vowels across different languages have much in common. The general lack of awareness of fricative vowels among linguists maintains the status quo where fricative vowels are typically not included in theoretical discussions and receive little overall attention. The goal of this chapter is therefore to increase the awareness of these intriguing sounds and to point out which important questions they raise.

The structure of this chapter is as follows. Section 2 first provides an overview of different fricative vowels around the world and how they have been transcribed. The section ends with a comparison of the different fricative vowels and a discussion on their ambiguous manner of articulation. Sections 3 and 4 respectively highlight the complexities in their phonetics and phonology. Finally, Section 5 summarises and concludes the chapter.

2 Fricative vowels around the world

All fricative vowels described in this section have certain characteristics in common, but their manner and place of articulation vary. There is thus far no typological framework that categorises them into well-motivated and clearly delineated subgroups, but we will make some preliminary distinctions to add structure to the discussions and to facilitate referring to different fricative vowels. To begin, fricative vowels can be divided into two main groups: those that have labial frication and those that have coronal frication. Among the coronal fricative vowels, it is furthermore useful to separately discuss what we will call the apico-(post)alveolar fricative vowels. This subtype is very common among Chinese (Sinitic) languages, unlike other coronal fricative vowels. For this reason, they are much more extensively researched and are often discussed separately from other coronal fricative vowels. This distinction is sensible for other reasons, too. The apico-(post)alveolar fricative vowels canonically have an apical articulation that sets them phonetically apart from other coronal fricative vowels. In Sinitic languages that have both types of coronal fricative vowels, they can even be phonologically contrastive. The apico-(post)alveolar fricative vowels can also contrast with each other in place of articulation. It is well-established that there is a more anterior one and a more posterior one in Sinitic languages, referred to here as alveolar and postalveolar respectively. The historical origin and synchronic phonological behaviour of these apico-(post)alveolar fricative vowels also differs compared to other coronal fricative vowels. Finally, as will become apparent, there are non-Sinitic languages with fricative vowels that are similar to the apico-(post)alveolar fricative vowels, both phonetically and phonologically. It thus seems useful to distinguish them as a subtype of coronal fricative vowels beyond Sinitic languages. We emphasise, however, that this coronal subgrouping must not be understood as a simple division based on the passive or active articulators. Instead, this division takes all factors mentioned above into account, including historical origin. What this means is that this division does not preclude any coronal fricative vowel from being postalveolar or apical, even if it is not considered as belonging to the apico-(post)alveolar subtype.

It is worth noting that making a distinction of fricative vowels based on manner of articulation is not straightforward either. This issue is highly controversial and, as an inevitable consequence, there are also many discrepancies in terminology and transcription. As stated, we adopt the term "fricative vowel" from Ladefoged & Maddieson (1996) here because it is the most widely known term. However, fricative vowels have also been referred to as "apical vowels" (Karlgren 1915–1926), "apical dorsal vocoids" (Demolin 2002), "obstruent vowels" (Faytak 2014a), "strident vowels" (Hu & Ling 2019), "syllabic fricatives" (Chao 1968: 47;

Duanmu 2007: 44; Lin 2007: 72; Chen & Gussenhoven 2015; Shao 2020), "syllabic approximants" (Lee & Zee 2003; Chen & Guo 2022), "extra high vowels" (Yoder 2020), "laminal vowels" (Aoi & Niigata 2013), and "coronal vowels" or "blade vowels" (Laver 1994).

In this section, we begin the global overview of fricative vowels with Sinitic languages because they contain the most well-described and most diverse fricative vowels. Apico-(post)alveolar (§2.1.1), other coronal (§2.1.2), and labial (§2.1.3) fricative vowels are all attested in Sinitic languages, and some regional varieties even have all three. Each type could be further divided based on more precise places of articulation as well as the presence or absence of lip rounding. Section §2.2 discusses fricative vowels in other languages.

2.1 Fricative vowels in Sinitic languages

2.1.1 Sinitic-type apico-(post)alveolar fricative vowels

The apico-(post)alveolar fricative vowels are by far the most extensively studied owing to their widespread occurrence across almost all branches of the Sinitic family (Cui 2021), as well as the fact that this type appears in Standard Mandarin Chinese. As such, discussions on manner of articulation, terminology, and transcription have mostly focused on apico-(post)alveolar fricative vowels. They are typically called "apical vowels" in the literature, but they have also been analysed as fricatives and approximants, as discussed below. Canonically, their articulation is described as involving a raised tongue tip similar in position to sibilants. The example of a fricative vowel given above in Figure 1 is of this type. Below in (1) there are more examples from Hefei Mandarin, which has three of such fricative vowels. In these phonemic transcriptions from Kong et al. (2022), the fricative vowels are transcribed with approximant symbols and the numerals indicate tonal levels. There are two alveolar fricative vowels, an unrounded (1a-b) and a rounded one (1c), as well as an unrounded postalveolar fricative vowel (1d-e).

(1)	a.	sɹ^{53}	事 'thing'	d.	ʃɻ^{24}	时 'time'
	b.	pɹ^{213}	比 'to compare'	e.	tʃɻ^{213}	纸 'paper'
	c.	zɹ$^{w\ 213}$	雨 'rain'			

Traditionally, apico-(post)alveolar fricative vowels have been treated as vowels within modern Chinese linguistics. Historically, their general source is high front vowels, which can still be found in cognates of sister languages without fricative vowels. For example, Hefei Mandarin /sɹ^{53}/ 'thing' corresponds to /si^{22}/

in Hong Kong Cantonese. Furthermore, ancient philologists of the first and second millennia made no distinction between rhymes with vowels and rhymes with fricative vowels in their classifications of syllables (Shen 2020). However, this does not necessarily mean that they considered fricative vowels to have the same manner of articulation as regular vowels. After all, philologists were not concerned with manner of articulation in the modern linguistic sense and instead sought to efficiently order the logographic writing system of Chinese characters in dictionaries. Categorising fricative vowels along with other rhymes is convenient for classification given that a distinction between vocalic rhymes and non-vocalic rhymes is superfluous. Alternatively, this philological convention may well predate the emergence of fricative vowels in Sinitic languages, so the categorisation of fricative vowels as vowels by later philologists may merely reflect a continuation of tradition and not a contemporary phonetic/phonological analysis. Regardless, the vowel-analysis of apico-(post)alveolar fricative vowels is still influential among Chinese linguists. It is also warranted on the grounds of complementary distribution: the apico-(post)alveolar fricative vowels are often in complementary distribution with each other and with /i/. This is the case for Mandarin varieties such as Hefei Mandarin (Kong et al. 2022) shown above and for Standard Chinese,[2] and sometimes also applies to non-Mandarin varieties such as Shanghai Wu (Chen & Gussenhoven 2015) and Xiangxiang Xiang (Zeng 2020). On the other hand, there are many languages in which fricative vowels *do* contrast with /i/, such as Suzhou Wu (Hu & Ling 2019), Meixian Hakka (Lee & Zee 2009), and Yichun Gan (Li 2018). However, when there is a complementary distribution, the apico-(post)alveolar fricative vowels can often be analysed as allophones of /i/, albeit with a very different realisation. The conditioning environment for the allophony is then the onset, which is very often phonotactically restricted to sibilant fricatives or affricates. Additional arguments in support of the vowel-analysis are given by Baron (1974). He lists fricative vowels' long duration compared to consonants, their ability to bear tone, and their capacity to be in the syllable nucleus. These three arguments, however, cannot be considered as independent because they are all general properties of nuclei in Sinitic languages. Most of the arguments for a vowel-analysis are phonological in nature rather than phonetic. When considering articulation and acoustics, there are fewer favourable arguments available. One argument is that the fricative vowels have a clear formant structure (Howie 1976: 10), which is commonly considered an important property of vowels and not of fricatives. It was probably for the

[2]The single, possible exception to this complementarity could be 日 [ɻ̩] 'sun, day' if one analyses it as /ɻ̩/ instead of /ɻɻ̩/. It would then form a minimal pair with e.g. 易 'easy' /i/.

reasons above that the first linguist to describe the apico-(post)alveolar fricative vowels, Karlgren (1915–1926), chose to analyse them as vowels. He coined the term "apical vowels" and invented the symbols /ɿ, ʅ, ʮ, ʯ/ to transcribe them. The symbols /ɿ/ and /ʅ/ are respectively alveolar and postalveolar, and /ʮ/ and /ʯ/ are their rounded counterparts. These symbols are widely used among Chinese dialectologists but are not officially recognised by the IPA.

An opposing view is that the apico-(post)alveolar fricative vowels are fricatives. Instead of needing to invent new symbols, proponents of this analysis use the standardised IPA symbols /z, ʐ, zʷ, ʐʷ/ to indicate that the pronunciation is roughly that of a voiced sibilant.[3] Duanmu (2007), Lin (2007), and Wiedenhof (2015) consider them to be syllabic fricatives in Standard Chinese. However, Duanmu and Lin assume that this is only the case at the phonetic level, as will be discussed in Section 4. The reasons for a fricative-analysis of apico-(post)alveolar fricative vowels are very straightforward. First, there may be so much constriction that strong frication is involved, which is simply not characteristic for vowels. Second, their articulation is often assumed to differ only minimally from the sibilant onsets that typically obligatorily precede them. This gives the impression that the only difference between the sibilant onset and the fricative vowel nucleus is voicing. That is, the fricative vowel is a voiced fricative. This assumption has been verified for some Sinitic varieties by articulatory research. Lee-Kim (2014b) and Faytak & Lin (2015) showed that there is generally little change in tongue position in Standard Chinese between the sibilant onset and nucleus for apico-postalveolar fricative vowels. Shao (2020) found the same result for the Jixi Hui apico-alveolar fricative vowel and also examined its acoustic characteristics. Based on both articulatory and acoustic evidence, he adopts the fricative-analysis for Jixi Hui.

A third view is that apico-(post)alveolar fricative vowels are best analysed as approximants (Lee & Zee 2003; Lee-Kim 2014b; Li & Zhang 2017; Huang et al. 2021; Kong et al. 2022). Those who prefer an approximant-analysis may use the standard symbols /ɹ̺, ɻ, ɹ̺ʷ, ɻʷ/. The diacritic [̺] for apical articulation in the alveolar sounds is often omitted for convenience. What makes this analysis appealing is that apico-(post)alveolar fricative vowels do not always involve strong

[3] Some of the sources mentioned here actually only provide IPA transcriptions for the *unrounded* apico-(post)alveolar fricative vowels because the sound systems described in them only have unrounded fricative vowels. However, one can extrapolate from the symbols for unrounded fricative vowels that these authors might use the same symbols with the superscript [ʷ] to indicate roundedness, as Kong et al. (2022) did in their description of Hefei Mandarin. It should furthermore be noted that the retroflexion in phonetic symbols such as /ʐ, ʅ, ʯ/ for the postalveolar fricative vowels does not suggest an articulation with the tongue tip curled backwards, but instead an apical postalveolar sound, as is the convention within the literature.

frication. Faytak & Lin (2015) even report that some speakers employ an articulatory strategy that actively decreases frication. When frication *is* produced, it may merely be a carryover effect from the preceding sibilant (Lee-Kim 2014b: 274). Another argument is that the first and second formants of apico-(post)alveolar fricative vowels do not respectively correspond to the size of the pharyngeal and oral cavities as resonance chambers, as is the case in normal vowels (Ling 2007; Ling 2009; Lee-Kim 2014b). This means that the formants cannot be interpreted as indications of backness and openness. As a result, the positions of the apico-alveolar and apico-postalveolar fricative vowels within a vowel chart do not make sense relative to each other or to the positions of regular vowels. The position of apico-alveolar fricative vowels is more back in the chart than that of apico-postalveolar ones, which is misleading. Lee-Kim argued that these acoustic findings are more consistent with an analysis of these sounds as consonants. The arguments in favour and against each of the three analyses are summarised in Table 1.

Table 1: A summary of the arguments for each analysis of the apico-(post)alveolar fricative vowels in Sinitic languages. A "+" indicates that the argument supports the analysis, a "-" indicates a weakness, and "+/-" indicates that the argument neither supports nor weakens the analysis

	as vowels /ɿ, ʅ, ʮ, ʯ/	as fricatives /z, ʐ, z^{w}, ʐ^{w}/	as approximants /ɹ̺, ɻ, ɹ̺^{w}, ɻ^{w}/
complementary with /i/	+	-	-
tone, duration, nuclear position	+	-	+/-
formant structure	+	+/-	+
variable frication	-	-	+/-
acoustics of F1 and F2	-	+	+
articulatory overlap with sibilants	-	+	-

As could be expected, the arguments in favour of the vowel-analysis do not support a fricative-analysis and vice versa, and the approximant-analysis takes an intermediate position. Complementary distribution of apico-(post)alveolar fricative vowels with /i/ in Sinitic languages is common, and, when it applies, it is a valid argument for an analysis as (underlying) vowels. However, general nuclear properties such as bearing tone are not compelling. Syllabic consonants can also bear tone, have long duration and are by definition nuclear. Similarly, visible formant structures are not exclusive to vowels either (Duanmu 2007: 35). The argument of frication is, in fact, a problem for all analyses because the frication is not consistently there. Its variable presence is nevertheless the least inconsistent with the approximant-analysis. Finally, the formant values and the articulatory gesture support a consonantal analysis. Considering all the arguments, it should not be surprising that the debate on manner of articulation has gone on for decades. No consensus has been reached on the optimal analysis for Standard Chinese, let alone a uniform analysis for all Sinitic languages.

2.1.2 Other coronal fricative vowels

Other coronal fricative vowels typically involve a raised tongue blade that creates frication through its close proximity to the palate, although there are also speakers who pronounce them with an apical gesture (Ling 2009; Faytak 2022). Like their apico-(post)alveolar counterparts, the predominantly laminal coronal vowels have cognates with high vowels in related varieties that do not have these fricative vowels. What sets them apart from the apico-(post)alveolar sounds, however, are their free phonotactics and their more sparse geographical distribution. These coronal fricative vowels do not occur in Standard Chinese and are known to occur mostly in Wu Chinese (Faytak 2018), the Jianghuai Mandarin group (Shi 1998), and Jin Chinese (Karlgren 1915–1926). The following Suzhou Wu examples show (near-)minimal pairs between regular vowels and two coronal fricative vowels (Faytak 2018: 73), with the fricative vowels on the right. The symbols /i͡ʑ/ and /y͡ʑ/ are digraphs for unrounded and rounded fricative vowels, respectively.

(2)	i^{44}	烟 ‘smoke’	i͡ʑ^{44}	衣 ‘clothes’
	si^{44}	鲜 ‘fresh’	si͡ʑ^{44}	西 ‘west’
	y^{523}	怨 ‘blame’	y͡ʑ^{44}	迂 ‘circuitous’
	ɕy^{44}	休 ‘rest’	ɕy͡ʑ^{44}	虚 ‘weak’

This type of coronal fricative vowels is referred to in the literature with the general terms “strident vowels” and “fricative vowels” (Ladefoged & Maddieson

1990; Hu & Ling 2019). However, within Chinese linguistics in particular, "fricative vowel" is sometimes used in a narrow sense that explicitly does *not* include the apico-(post)alveolar type (Ling 2007; Hu & Ling 2019; Faytak 2022). In such cases, it is a translation of the term *mócā huà yuányīn* 摩擦化元音 'fricativised vowel', as opposed to *shéjiān yuányīn* 舌尖元音 'apical vowel'. The non-apical coronal fricative vowels always involve frication but are nonetheless invariably analysed as vowels within Chinese linguistics.

There appear to be only two types of these coronal fricative vowels in Sinitic languages: the unrounded variant and the more rare rounded variant, both of which are given in (2). Nevertheless, many transcriptions are in use because there is even less standardisation than for the apico-(post)alveolar fricative vowels. Because there is no official diacritic for frication in the IPA, there are authors who use sub- or superscript fricatives next to high vowels, e.g. [i$_{\text{z}}$], [i$^{\text{z}}$], or [i$_{\text{ʑ}}$, y$_{\text{ʑ}}$] (Ling 2007; Faytak 2019). Wu (2013) suggests [i$_{\text{j}}$, j, ʑ] for unrounded coronal fricative vowels of various levels of frication, with a subscript $_{\text{j}}$ instead.[4] The IPA diacritic for extra close articulation is also sometimes used, i.e. [i̝, y̝] (Hu & Ling 2019). Another IPA alternative without diacritics would be [ʝ, ʝ$^{\text{w}}$]. Recently, van de Weijer et al. (2021) and Shi & Chen (2022) opted for transcriptions such as [i̟ , y̟] in Wu Chinese to indicate that the articulation of these segments is more fronted than that of regular front vowels.

2.1.3 Labial fricative vowels

Finally, there are fricative vowels that have a labial constriction, be it bilabial or labiodental. Some also have an additional dorsal constriction (Hu & He 2019; Shao 2020: 48). According to Pan (1991: 258), the unrounding of /u/ to a segment with compressed lips is a characteristic of Wu, Gan, Hakka, and Min Chinese. In at least some cases, such segments have developed into fricative vowels. Labial fricative vowels are generally rare in Mandarin, but they do occur in more western Mandarin varieties, such as in Guanzhong (Zhang & Xing 2011) and Xining (Dede 2006). Below are some Xining Mandarin examples adapted from Dede (2006: 324).

(3)	lv^{22}	路 'road'
	lv^{35}	炉 'stove'
	tʃv^{55}	猪 'pig'
	v^{53}	五 'five'

[4]The transcription [ʑ] for the most fricated coronal fricative vowels does seem to indicate that Wu (2013) considers some realisations to be fricatives, but his work is not concerned with the phonological implications.

Labial fricative vowels are also referred to as "fricative vowels" in a narrow sense that excludes the apico-(post)alveolar type, and some of them have been referred to as "labiodental vowels" (Hu & He 2019). Phonological transcriptions typically use vowel symbols, although the corresponding realisations may be transcribed with consonantal symbols (Hu & He 2019; Yuan et al. 2019).

Various kinds of labial fricative vowels have been attested. Some have a labiodental constriction, as the data in (3) show. Others have a bilabial constriction (Faytak et al. 2019). Furthermore, in some varieties of Sinitic, the tongue dorsum simultaneously adds a front vowel or back vowel quality (Hu & He 2019; Shao 2020: 48), while this is not the case in other varieties (Faytak et al. 2019). Assuming these parameters of labial constriction (bilabial/labiodental) and lingual constriction (front/back/absent), one could distinguish as many as six different types of labial fricative vowels based on place of articulation. Given the above, it should not be surprising that there are once again many different transcriptions in use. The phonological transcription is usually /u/ unless the labial fricative vowel(s) contrast with a regular non-fricated vowel /u/, although /ɯ/ may be used instead to express the fricative vowel's lack of rounding. The labial constriction can be phonetically transcribed with common IPA symbols [v̩ , ʋ̩] for labiodental fricative vowels (Zhang & Xing 2011; Scholz 2012; Hu & Ling 2019), and, although we have not encountered this transcription, [β̩] could theoretically be used for bilabial fricative vowels. Alternatively, superscript or subscript are used, such as [u_{β}, ɯ^{β}, ɯ^{v}] (Zhu 2004; Faytak et al. 2019). The presence or absence of a dorsal constriction may be difficult to ascertain without articulatory research, and it is typically not mentioned in descriptions. An exception is a study by Hu & He (2019), who characterise the constriction of the two labial fricative vowels in Rui'an Wu as a labiodental constriction superimposed on a front vowel [y] and a back vowel [u]. Because these sounds contrast in backness, the authors use the non-fricative vowel symbols /ʉ/ and /ɯ/. For Jixi Hui, Shao (2020: 48) proposes a narrow transcription [v̩$^{\text{ɣ}}$] to indicate the "highly velarised" allophone of /u/ when it follows labiodental onsets.

2.2 Fricative vowels elsewhere

Compared to the fricative vowels in Sinitic languages, those in other language families are less abundantly attested. However, it is still clear that fricative vowels can be found in many geographically non-contiguous regions, and all subtypes of fricative vowels as described in §2.1 can be identified in non-Sinitic languages, too. A selection of diverse and representative languages is discussed per region.

2.2.1 Ryukyuan islands

Fricative vowels have been reported in Japonic languages spoken in the Ryukyu archipelago south of mainland Japan. Some Southern Ryukyuan languages such as Miyako have a fricative vowel where related varieties have /i/ or /ɨ/ (Jarosz 2018), which is reminiscent of the situation for Sinitic apico-(post)alveolar fricative vowels. The Ryukyuan segment has been called "fricative vowel" by some (Pellard & Hayashi 2012) but has also been referred to as an "apical vowel" (Jarosz 2018) or "laminal vowel" (Aoi & Niigata 2013). Jarosz (2018) and Pellard & Hayashi (2012) use the symbol /ɿ/, deliberately choosing the same non-standard symbol that is used for the apico-alveolar fricative vowel in Chinese linguistics. Although most researchers in this field consider the Ryukyuan fricative vowel to be a vowel, Pellard & Hayashi (2012: 15) mention that at least some researchers describe the fricative vowel as a consonant. For example, Sawaki (2000) notes that native speakers of Miyako accept a pronunciation of [z] as correct. He also writes that this segment sounds like [s] when it is devoiced (devoicing is common and predictable for high nuclei in Japonic languages). The phonotactics of the fricative vowel vary: this sound occurs after various labial and coronal onsets in Irabu Miyako, but is restricted to homorganic sibilant onsets in Ikema Miyako (Pellard & Hayashi 2012). Unlike the apico-alveolar sounds in Sinitic languages, however, the Ikema Miyako fricative vowel reportedly used to have a wider distribution until it merged with *i in all cases except for after the sibilant onsets (Pellard & Hayashi 2012: 16). Finally, it is unclear whether the syllabic [v̩] in some Ryukyuan languages is a labial fricative vowel, because it is not referred to as a vowel by any of the sources cited here. It has cognates with /u/, and its historical development parallels that of the Ryukyuan sound that *is* considered to be a fricative vowel (Jarosz 2018).

2.2.2 Africa

Fricative vowels in Africa have been attested in and around Cameroon in most branches of the Bantoid language family, a subgroup within the larger Atlantic-Congo family. They occur in Mambila (Connell 2007), Grassfields languages such as Limbum (Fransen 1995; Faytak 2017) and Kejom (Faytak & Akumbu 2021), Beboid languages such as Nchane (Boutwell 2020), Yemne-Kimbi languages such as Mundabli (Voll 2017), and at least in one Bantu language called Fang (Kelly 1974). All these Bantoid languages are (distantly) related, so it may be difficult to disentangle inherited traits from borrowed ones. It should be noted that a pair of "extra high vowels" *i and *u, distinct from regular *i and *u, is reconstructed for Proto-Bantu. The extra high vowels conditioned spirantisation of preceding onsets in several Bantu languages, and some authors have proposed that these vowels could have been phonetically similar to some present-day fricative vowels (Connell 2007; Faytak & Merrill 2014).

Judging by the transcriptions used for fricative vowels in central Western Africa, these languages have coronal and labial fricative vowels. For the coronal group, one can find phonetic transcriptions such as [i̻ , ʑ͜i, z̩ , ʒ̩]. For example, the digraph [ʑ͜i] is used to transcribe the fricative vowel in Fang (Kelly 1974), which has a free phonotactic distribution and is a full-fledged phoneme. In Kejom, on the other hand, the coronal fricative vowel transcribed as [i̻] occurs only as an allophone of /i/ after postalveolar sibilants (Faytak & Akumbu 2021). Kejom also has a rounded coronal fricative vowel [ʉ̻] as an allophone of /ʉ/, which similarly only occurs after postalveolar sibilants. All in all, the Fang and Kejom fricative vowels appear to differ considerably in terms of their phonetics and phonology. The labial fricative vowels in this area are equally diverse. One can find at least [v͜ɯ, ʉ^{v}, ʉ^{β}, v̩] as transcriptions. Some sounds, such as Kejom /ʉ^{v}/ and /ʉ^{β}/, are predictable and only appear after homorganic onsets, while Limbum [v̩] and Mambila [v͜ɯ] can co-occur with multiple onsets. Sometimes authors use plain [i, ɨ, u, ʉ] with the verbal description of "fricated", as Voll (2017) does for Mundabli and Boutwell (2020) for Nchane. Based on the information above, one can generalise that fricative symbols are used for fricative vowels with a free distribution and that vocalic symbols are used for fricative vowels with a restricted distribution. However, none of the authors cited here consider the fricative vowels to be consonants at the underlying level.

An African language with fricative vowels that is geographically and genetically unrelated to those mentioned above is Lendu, a Central Sudanic language, which is spoken in the Democratic Republic of the Congo. Kutsch Lojenga (1989) writes that Lendu has two contrastive fricative vowels, both of which are realised roughly as [z̩]. Kutsch Lojenga describes one as "sharp" and the other as "dull", and explains that there is a difference in voice quality that cannot be captured with IPA symbols. She indicates the difference by adding a " ˈ " symbol after the sharp fricative vowel, and "*" after the dull one. The following data are adapted from Kutsch Lojenga (1989: 120).[5]

[5] On the cited page, Kutsch Lojenga uses transcriptions that are neither phonetic nor phonological (she adjusts them at a later stage in her argumentation). For both fricative vowels, she uses "s" for [z̩] when preceded by a voiceless sound, and "z" for [z̩] when preceded by a voiced onset. Here, both are transcribed as [z̩], followed by ˈ or *.

(4)	[ì.sz̩̄]ˈ	‘woman’	[sz̩̄]*	‘shoe’
	[tsž̩]ˈ	‘red kaolin’	[tsž̩]*	‘lawn’
	[zz̩̄]ˈ	‘brother-in-law’	[zz̩̄]*	‘to milk (a cow)’
	[dzz̩̀]ˈ	‘price’	[dzz̩̀]*	‘to weep’

Both fricative vowels can only follow alveolar sibilants /s, z, ts, dz/. If the onset is voiceless, there is a slight non-contrastive delay in voicing in the transition from the onset to the fricative vowel nucleus. This limited phonotactic distribution and the phonetic descriptions of the Lendu fricative vowels are similar to what is common for the Sinitic apico-alveolar fricative vowels. There is also phonetic data on Lendu. Demolin (2002) reanalysed the Lendu syllabic [z̩] as a vowel based on data from acoustics, aerodynamic measures, electroglottography, and visual recordings of jaw movements.[6] According to Demolin, there is articulatory overlap between sibilant onsets and the syllabic segments that follow. This articulatory overlap causes the frication during the syllable nucleus, which is why this sound has been perceived as a fricative by linguists working on Lendu. Demolin furthermore compares the spectral properties of Lendu fricative onsets, fricative vowels, and regular vowels. The data show that the fricative vowels have visible formant structures and less intense frication than fricatives in the onset. Recall that the Zhushan Mandarin example in Figure 1 can be characterised in the same way and is likewise restricted to having homorganic sibilant onsets. As such, both the phonotactic distribution and the phonetic properties of the Lendu fricative vowels are comparable to the Sinitic apico-alveolar vowels.

2.2.3 New Guinea

A number of Lakes Plain languages on the island of New Guinea (the Indonesian half) have coronal fricative vowels. A front unrounded one and a back rounded one have been attested, respectively transcribed as [i’, u’] (Foley 2018) or [i̯ , u̯] (Clouse & Clouse 1993). Some languages, such as Iau and Abawiri (Yoder 2020), only have the unrounded fricative vowel, while others, such as Doutai and Kirikiri (Foley 2018: 533), have both. None have only a rounded fricative vowel. The fricative vowels in Lakes Plain languages are always considered to be vowels. However, there is reason to believe that the Papuan fricative vowels

[6]Curiously, Demolin mentions nothing of the “sharp/dull” distinction made by Kutsch Lojenga (1989). The latter cites other, older sources in her paper that make a similar distinction: “Tucker & Bryan (1966: 30) refer to this particular contrast as “dark” as opposed to “clear” articulation … though their examples are not completely consistent with my data” (1989: 120). The situation is therefore unclear.

do not have a high degree of frication compared to those elsewhere. Consonantal transcriptions such as [ʑ] have not been used in the Papuan literature, and Yoder explicitly describes the frication in Abawiri as only "faintly audible" (2020: 57).

2.2.4 Europe

In some varieties of Swedish, one can find the so-called Viby-*i* and Viby-*y*, named after the Swedish village of Viby. The vernacular pronunciation of the village name has both of these sounds. They are the realisations of /iː, yː/ that have a distinctive "damped" character and which reportedly often involve frication (Björsten & Engstrand 1999; Grönberg 2004). For speakers that have the Viby-*i* and Viby-*y*, those realisations have replaced ordinary [iː] and [yː]. Westerberg (2020) provides an in-depth phonetic study of these sounds. She writes that although they are not the standardised pronunciations, they are extremely common in Sweden's largest cities and sometimes considered as posh. Less common are "Viby-coloured" short /ɪ, ʏ/, but they are attested in e.g. the Bohuslän dialect (Westerberg 2020: 70). Westerberg (2020: 53) lists the following transcriptions for Viby-*i* in the literature: [iːᶻ, ɨ, ð, ʅ]. There are fewer descriptions of the Viby-*y*. Björsten & Engstrand (1999) consider the contrast between /iː/ and /yː/ to be neutralised, and Gross & Forsberg (2020) confirm that there is perceptual overlap. However, Westerberg (2020: 194) shows that a visible difference in lip posture is still present between /iː/ and /yː/.

2.2.5 Central and East Asia (non-Sinitic)

Although fricative vowels are best-studied in the Sinitic language family, they are an areal phenomenon in other languages of the region as well. They often occur in Tibeto-Burmese languages, which are only distantly related to Sinitic. An example is Nuosu Yi, as described by Edmondson et al. (2017), a Lolo-Burmese language spoken in Southern China. It has two pairs of fricative vowels: /z, z̠/ and /u, u̠/, where the retractedness in the phonemic notation is realised as a retracted tongue root and the labial fricative vowels are actually realised as [v] with a vowel offglide. Therefore, Edmondson et al. (2017) transcribe the realisations as [z, z̙ , vʊ, və̙]. The alveolar pair also has retroflex allophones [ʐ, ʐ̙] after retroflex onsets. As indicated by the transcriptions, Edmondson et al. (2017) consider the alveolar pair to be consonants phonemically, whereas the labial pair are only considered to have frication phonetically. The reason why the two pairs of fricative vowels are not analysed in a similar fashion is unclear. It is presumably because a fricative-analysis of /u, u̠/ would leave a gap in the Nuosu Yi vowel inventory, and the measured formants for /u, u̱/ are reasonably close to [u]. Meanwhile, /z, z̠/ cannot be analysed as allophones of any other vowel phoneme due to contrastivity. However, Edmondson et al. remark that /z, z̠/ have a more open articulation than ordinary fricatives.

Fricative vowels are also present in other branches of the Tibeto-Burman family, such as the Qiangic subgroup. An interesting example here is Ersu (Chirkova et al. 2015). Ersu has a coronal fricative vowel phonemically transcribed as /z/ and a labial fricative vowel /v/. However, despite the consonantal transcriptions, both are referred to by Chirkova et al. as "(fricative) vowels". This once again shows the difficulty of describing these speech sounds with the currently standardised transcriptions and terminology. The Ersu fricative vowels freely combine with different onsets and exhibit some interesting alternations. Alveolar /z/ has a voiceless allophone [s] that appears after aspirated bilabial stops, e.g. /pʰz̩̀pó/ 'wood shavings', realised as [pʰs̩̀pó]. After dental and alveolar onsets, /z/ assimilates fully in terms of place of articulation, as is common for fricative vowels. However, after a retroflex flap /ɽ/, /z/ is realised as a trill [r], which is highly unusual compared to other coronal fricative vowels. An example is /ʈɽź̩/ 'star', realised as [ʈɽŕ̩]. Finally, /z/ appears as a vowel [ɤ] after velars, as exemplified by /gź̩ɽóəʈ̺ʂ̺ź̩/ 'spine, backbone', realised as [gɤ́ɽóəʈ̺ʂ̺ź̩]. As for labiodental /v/, it is realised as a bilabial trill [ʙ] after bilabial stops and retroflex affricates. When preceded by /m/, it transmits its syllabicity to the nasal and is subsequently deleted. That is, /mv̩̀ʈ̺ʂ̺ɛ́/ 'carpenter' is realised as [m̩̀ʈ̺ʂ̺ɛ́].

Entirely unrelated to Sino-Tibetan are the Mongolic languages. Mangghuer has fricativised allophones of the central approximants /j, ɻ/ and the high vowels /i, u/ (Slater 2003). The allophones of the approximants are [ʝ, ʐ], and the fricativised allophones of the vowels are [ʝ(i), ᵛu]. Frication in these approximants and vowels is not obligatory in Mangghuer, but Slater notes that /i/ has stronger and more frequent frication than /u/. Frication in general is particularly salient when a segment is word-initial. Perhaps surprisingly, /i/ is *not* fricated after a retroflex onset, after which it surfaces as a fricationless [ɨ˞].

Additionally, fricative vowels can be found in the Austronesian language Atayal (Huang 2018), in Turkic languages such as Salar (Johanson & Csató 1998), and in Hmongic languages such as Qing-miao (Gao 1982) and Guiyang (Niederer 1998: 130). It may be difficult to determine whether the presence of fricative vowels in the languages of Central and East Asia is an independent innovation or a loaned feature. In the case of Atayal, it seems likely that the apico-alveolar fricative vowel has been borrowed from Taiwanese Mandarin. In Mangghuer, on the other hand, the fricative vowels seem to have little in common with those of the Sinitic languages spoken in the vicinity.

2.3 Comparison and summary

Fricative vowels, although not always labelled as such, clearly occur in many non-contiguous geographical regions. It is also clear from the descriptions above that the fricative vowels have a number of things in common. They all meet the criteria of being syllabic segments that involve frication in at least some realisations. They are also all phonetically and/or phonologically linked to high vowels in some way, and do not emerge through vowel deletion as syllabic consonants typically do. There are further similarities in the strategies used to transcribe fricative vowels. Authors converge on using centralised vowels, sub- and superscripts, diacritics, consonantal IPA symbols, and digraphs. This hints at shared struggles to accurately represent fricative vowels using existing phonetic symbols. Another similarity between fricative vowels is the place of articulation where frication occurs, which seems to be palatal or more anterior in all cases.

However, the manner of articulation ascribed to fricative vowels, even for fricative vowels in the same language, varies tremendously. The Sinitic apico-(post)alveolar fricative vowels have been analysed as vowels, fricatives, and approximants. All other types of fricative vowels in Sinitic languages and beyond are classified as either fricatives or vowels. The uniqueness of the approximant-analysis for the Sinitic apico-(post)alveolar fricative vowels is presumably a combination of their sibilant-like articulation and lack of much (or any) frication. Additionally, the diversity in the analyses is probably also due to the fact that the Sinitic apico-(post)alveolar fricative vowels have been studied most extensively. Regardless, the arguments proposed in favour and against certain analyses of apico-(post)alveolar fricative vowels in Sinitic languages cannot simply be applied to other fricative vowels. Even among more anterior coronal fricative vowels, the cross-linguistic phonetic and phonological differences are considerable. This is illustrated below in Table 2.

Table 2: Comparison of three languages with (post)alveolar fricative vowels

	Standard Chinese	Miyako	Swedish
frication	highly variable	strong	weak or absent
articulation	more consonantal	very consonantal	more vocalic
phonotactics	limited	somewhat limited	free
distribution	complementary with /i/	contrasts with /i/	has replaced /i/

A uniform analysis for the manner of articulation of these sounds is therefore not self-evident, let alone one for all existing types of fricative vowels. After all, "fricative vowel" is an umbrella term. At present, this term is clearly convenient to refer to sounds for which there are no appropriate IPA symbols and of which the manner of articulation is highly unusual. It is unclear, however, whether fricative vowels will prove to be a distinct category of speech sounds that has hitherto not been acknowledged as such. In the latter case, there need to be clear criteria to distinguish fricative vowels from syllabic consonants and vowels. It is possible that some of the sounds described in this chapter would not meet those criteria, and that they should instead be analysed as vowels, approximants, or fricatives. More research, especially cross-linguistic comparative research, is necessary to determine the best interpretation. Ideally, there would be a typology of fricative vowels rooted in a thorough understanding of their articulation, acoustics, and perceptual cues. However, such a typology is not yet within reach. The following two sections provide an overview of the phonetic and phonological properties that fricative vowels are currently known to have.

3 Complexities in phonetics

3.1 Frication

As the name suggests, fricative vowels typically have frication. For most languages, we only have verbal descriptions and sometimes a spectrogram. There are few acoustic studies that have quantified the frication throughout the realisation of fricative vowels. We do have such data for certain Sinitic vernaculars (e.g. Hu & He 2019; Shao 2020; van de Weijer et al. 2021) and Swedish (Westerberg 2020). When considering the qualitative and quantitative data, there is clear variation in how much frication there is. The fricative vowels in Lendu and Ryukyuan are described as always having strong frication. Others, such as fricative vowels in Kejom and Lakes Plain languages, have frication that is highly context-dependent or generally weak. In other languages still, such as in Sinitic languages, the apico-(post)alveolar fricative vowels consistently lack frication in some speakers while other speakers always produce frication (Faytak & Lin 2015). In addition to the degree in frication, languages can also differ in where this frication is the strongest. The frication in Standard Chinese apico-(post)alveolar fricative vowels is the strongest at the beginning of the segment and may quickly fade away. In fact, Lee-Kim (2014b) suggested for Standard Chinese that the frication is only a carryover effect from preceding sibilant onsets. In contrast, Swedish fricative vowels have more frication halfway through their realisation (Westerberg 2020), frication in Amdo Tibetan is claimed to occur at the end (Janhunen & Norbu 2014), and for Mambila it varies between being more initial or more final (Connell 2007).

The handful of studies that have specifically investigated frication have used Harmonics-to-Noise-Ratio (HNR) or Zero-Crossing Rate (ZCR) analyses to quantify the frication. Those quantitative results confirm that there is high variability among fricative vowels between different languages. Van de Weijer et al. (2021) performed HNR-analyses on the fricative vowels in Huangyan Wu Chinese. The apico-alveolar fricative vowel had a value of 17.1 dB, which barely differed from "regular" [u]. Van de Weijer et al. indeed describe the Huangyan apico-alveolar fricative vowel as involving no frication. In contrast, the rounded coronal fricative vowel [y̝] had a much lower value of 12.1 dB, indicative of more frication. The bilabial fricative vowel [u̝] had a value of 14.7 dB, which is intermediate and suggests a fair amount of frication. However, Hu & He (2019) performed an HNR-analysis on fricative vowels of a closely related variety, Rui'an Wu, and found rather different results. They found that the Rui'an Wu apico-alveolar fricative vowel has *more* frication than the non-apical rounded coronal and labial fricative vowels, and that the latter two are not much more fricated than regular vowels. As such, there is considerable variation in which types of fricative vowels have frication, even between closely related varieties.

3.2 Formant values

Formant values are typically used to infer vowel articulation. The common assumptions are that a higher F1 suggests a more open articulation and that a lower F2 is indicative of a more back quality, hence the organisation of the two-dimensional vowel quadrilateral. However, it has been known for a long time that the relationship between tongue configuration and formant values is exceedingly complicated (Delattre 1951).[7] This is true in particular for fricative vowels, as evidenced by the formant values of the apico-(post)alveolar fricative vowels in Sinitic languages. Although the place of articulation of the postalveolar type is more posterior, their F2 values are higher than those of their alveolar counterparts. This goes against the basic assumption that higher F2 correlates with a more anterior constriction. For example, in Kaifeng Mandarin, Wang (2020) found an average F2 value of 1262 Hz for the alveolar fricative vowel and an average F2 value of 1667 Hz for the postalveolar one. Similar results have also

[7] For more recent discussions related to this topic, see Faytak (2018: 52–55), Esling et al. (2019: 22–44), Westerberg (2020: 217–218), and Makeeva & Kuznetsova (2022).

been found for Standard Chinese (Lee-Kim 2014b) and various other Mandarin varieties (Huang et al. 2021). The proposed explanation for this is that F1 and F2 in these fricative vowels do not correspond to a back and front cavity separated by the tongue dorsum, as would be expected. Instead, F2 corresponds to the cavity *behind* the tongue while the front cavity corresponds to F3 rather than to F1 (Ling 2007; Ling 2009; Wang et al. 2013; Lee-Kim 2014b). This explains why the postalveolar fricative vowel has both higher F2 and lower F3 than the alveolar one.

The same explanation may apply to certain other coronal fricative vowels, but the picture is more complicated because the formant values differ across languages. This is perhaps expected because there is so much room for articulatory differences within a category as wide as "coronal". Some coronal fricative vowels have lower F2 values than [i]. This has been found for Mambila (Connell 2007) and various varieties of Wu Chinese (Ling 2007; van de Weijer et al. 2021; Shi & Chen 2022). These particular fricative vowels are also transcribed in similar ways, [ʑ͜i, i̝ , i$_z$], which further suggests they sound similar, containing frication but retaining an [i]-like timbre. However, this is also what is suggested by descriptions and transcriptions of coronal fricative vowels in Lakes Plain languages. Clouse & Clouse (1993) (for Kirikiri) and Yoder (2020: 53) (for Abawiri) report *higher* F2-values for the palatal fricative vowel [i̝] than for [i]. This suggests that, despite the similar place of articulation, the tongue configuration is likely different. Finally, there are also languages in which coronal fricative vowels have formant values that are not significantly different from [i]. This seems to be the case for Kejom based on data from one speaker in Faytak & Akumbu (2021). The regular [i] and its fricated allophone transcribed as [i̻] have virtually the same F1-F2-F3. Because [i] and [i̻] are not contrastive, one could argue that there is no need for the formants to differ. The same cannot be said for the palatal fricative vowel in Mundabli. This fricative vowel has the same average F1 and F2 as the non-fricated [ɪ] despite this pair being contrastive (Voll 2017: 40). Voll therefore assumes that the frication must be the most important acoustic cue to distinguish these phonemes and does not discuss any other possible cues. It must be noted, however, that the Mundabli data also come from a single speaker, and that the data are based on the single tokens deemed representative by Voll.

Labial fricative vowels are similar to the coronal fricative vowels in the sense that both have mixed results. On the one hand, van de Weijer et al. (2021) report lower F2 values for [u̝] compared to [u] in Huangyan Wu, as do Clouse & Clouse (1993) for Kirikiri [u̝]. On the other hand, the labial fricative vowel of Rui'an Wu has higher F2 than a regular [u] (Hu & He 2019). In the Tibeto-Burman language Ersu, too, the fricative vowel [y̩] has higher F2 than a cardinal [u] so that it is placed in the centre of the vowel space (Chirkova et al. 2015). For Kejom, as is the case for its coronal fricative vowel, the labial fricative vowel allophones [ʉ̻, ʉ^{β}, ʉ^{v}] have values for F1-F2-F3 that are comparable to the non-fricated realisation of the phoneme /ʉ/, of which they are positional variants (Faytak & Akumbu 2021).

3.3 Articulation

The precise articulation of fricative vowels is highly controversial. For most languages, there is no elucidating data whatsoever. The extent of articulatory variation among fricative vowels is therefore unknown. Although one might expect that transcriptions for labial fricative vowels are more reliable because the labial constriction can be inspected visually, it remains the case that any dorsal constriction cannot be examined without the appropriate articulatory equipment. A sound transcribed as [v̩] likely has a labiodental constriction, but it is unclear whether or not the labiodental constriction is superimposed on a vowel as Hu & He (2019) have found in Rui'an Wu.

The articulatory data that *do* exist, show that speakers use a multitude of strategies to achieve a certain acoustic target (Faytak & Lin 2015; Faytak 2018; Shao 2020; Westerberg 2020). For example, Hu & Ling (2019) used electromagnetic articulography to examine two different coronal fricative vowels in Suzhou Wu Chinese. Figure 2 shows the articulation of an ordinary high front vowel /i/, a non-apical coronal fricative vowel /i̞~ʑ/, and an apico-alveolar fricative vowel /ɿ/. All three sounds contrast with one another. The three "+" signs in each image indicate the positions of the three receiver coils that were placed on the tongue. From left to right, they show the location of the tongue dorsum, tongue blade, and tongue tip. The line connecting the "+" signs is a rough extrapolation of the rest of the tongue body, and the curved line to the right of the tongue represents the hard palate and the alveolar ridge.

For /i̞~ʑ/, the tongue dorsum is lower than for /i/ and lower than the tongue blade. The tongue tip is low. The speaker in the middle of the figure has a much lower tongue blade compared to the others, but the relative heights of the different parts of the tongue are the same. The apical fricative vowel /ɿ/ distinguishes itself by having a low tongue dorsum *and* blade, but the relative height of these to the tongue tip varies. In the leftmost speaker, the tip is raised above the tongue blade, which is itself higher than the tongue dorsum. Conversely, for the other two speakers, the tongue dorsum is raised more than either the blade or the tip.

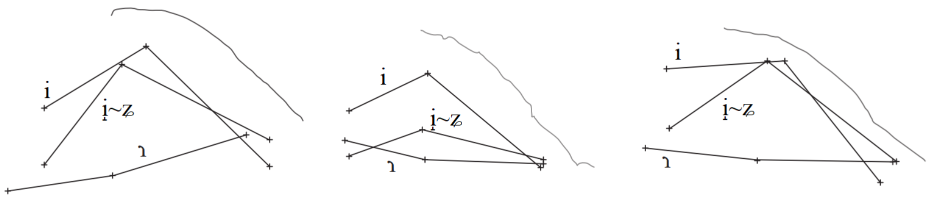

Figure 2: Midsagittal images of the tongue in the oral cavity for /i/ and two different coronal fricative vowels as articulated by three speakers of Suzhounese. In the images, the speakers are facing the right. Originally from Hu & Ling (2019: 10), with adapted transcriptions

3.4 Perception

Research into the perception of fricative vowels is almost non-existent. Björsten & Engstrand (1999) asked native listeners of Swedish to listen to recordings of Viby-*i* with manipulated formant values and to judge whether the pronunciation was acceptable. They concluded that F2 values show the strongest correlation with acceptance rates. The Viby-*i* has an average F2 of around 1600 Hz, far lower than regular [i]. The importance of F2 to the realisation of Viby-*i* is consistent with the articulatory and acoustic results in Westerberg (2020). For Standard Chinese, Cheung (2003) found that the perceived difference between the apico-alveolar and apico-postalveolar fricative vowel mostly depends on F3, whereas manipulation of F2 has a more modest effect. These findings for Swedish and Standard Chinese cannot be generalised to other fricative vowels, and these studies have only investigated the importance of formants. It is therefore unknown which formant values affect the perception of other (types of) fricative vowels, how crucial the presence of frication is, what the cue-weighing is between formants and frication, whether fricative vowels are processed as consonants or vowels, and so on.

4 Complexities in phonology

4.1 Phonemic status

The phonemic status of fricative vowels is sometimes controversial. This mostly depends on the patterns of their phonotactic distribution. The most widely discussed are the "apical vowels" in Sinitic languages, i.e. the apico-(post)alveolar fricative vowels. They are very often in complementary distribution with /i/ and frequently only occur following sibilant onsets of the same place of articulation.

Examples of languages that conform to both tendencies are Standard Chinese (Duanmu 2007), Shanghai Wu (Chen & Gussenhoven 2015), Xiangxiang Xiang (Zeng 2020), and Zhushan Mandarin (Chen & Guo 2022). Other Sinitic varieties have the complementary distribution but not the onset restrictions, e.g. Hefei Mandarin (Kong et al. 2022), while others only have the onset restriction, e.g. Meixian Hakka (Lee & Zee 2009). The possible syllables with fricative vowel nuclei in Standard Chinese are illustrated in (5). There is also an additional syllable [ɻ̩] that could be phonemically transcribed as /ɻ̩/ or /ɻɻ̩/. Either way, this syllable obeys the constraint on non-homorganic onsets.

(5)	sɹ̩	*si	ʃɻ̩	*ʃi
	tsɹ̩	*tsi	tʃɻ̩	*tʃi
	tsʰɹ̩	*tsʰi	tʃʰɻ̩	*tʃʰi
			ɻɻ̩	*ɻi

In such cases, a typical analysis is one of allophony. Fricative vowels are then considered to be allophones of a high vowel that is conditioned to (partially) assimilate to the preceding onset (Cheng 1973; Lee & Zee 2007). Cases where a fricative vowel is assumed to be a non-high vowel are rare. For many other fricative vowels, however, it is clear that they constitute independent phonemes. This is the case for Swedish Viby-i. For speakers who have this sound, it fulfills the function of what used to be [i], and so it cannot be analysed as a conditioned allophone. The phonemic status is also clear in languages such as Abawiri and Miyako, where numerous minimal pairs are distinguished by the contrast between the fricative vowel and /i/. The following Abawiri minimal pairs come from Yoder (2020: 53–54).

(6)	i̯ɾɛ	‘song’	iɾɛ	‘garden’
	tɾi̯	‘fish sp.’	tɾi	‘lizard sp.’
	sɔɾi̯kei	‘banana sp.’	sɔɾikei	‘red’

For the apico-(post)alveolar fricative vowels in Standard Chinese, an analysis exists that proposes that fricative vowels do not belong to any phoneme but instead “fill up” underlyingly empty nuclei as an extension of the onset (Duanmu 2007; Lin 2007; Wee & Li 2015). In his influential book on Standard Chinese phonology, Duanmu envisages this analysis as the process shown in Figure 3. The figure shows phonological features organised in a tree according to the principles of Feature Geometry (Clements 1985). Duanmu uses his own version of the theory based on about a dozen sources (see 2007: 17 for the list of sources). The node with S stands for the syllable, the X’s are timing slots (all nuclei in Standard

Chinese are assumed to be long), and the place of articulation nodes are abbreviations for Vocal Cords (VC) and Coronal (Cor). Fricatives are [+fricative] and affricates are [+stop, +fricative] underneath branching nodes with [coronal].

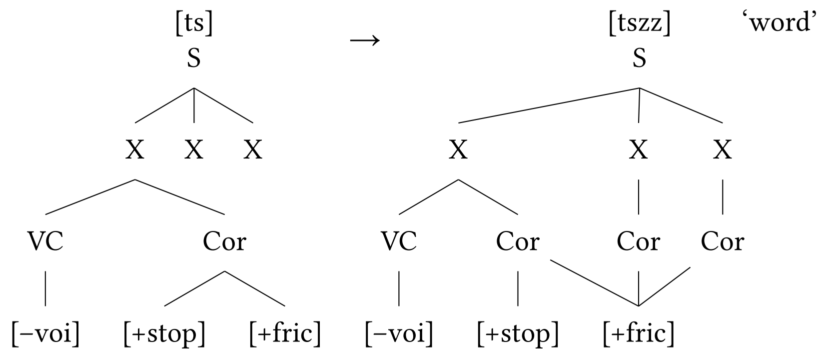

Figure 3: An analysis of the Standard Chinese alveolar fricative vowel as an onset that spreads into the nucleus as proposed by Duanmu (2007: 44)

Duanmu proposes that the empty nucleus triggers the spreading of the feature [+fricative] from the sibilant onset to the nucleus if [+fricative] is dominated by [coronal]. This, in turn, triggers the spreading of the full place node from the onset to the nucleus as well. This analysis explains why the Standard Chinese fricative vowels obligatorily take an onset that must be of the same place of articulation. Although this analysis appears to only ever have been applied to Standard Chinese, it could hypothetically be applied to any fricative vowel that obligatorily follows onsets to which it seemingly assimilates in place and manner.

Finally, there are some unique and language-specific analyses. According to Kutsch Lojenga (1989), the underlying vowel quality of the "dull" fricative vowels in Lendu cannot be known, and she leaves open the option that there is no underlying vowel. She does, however, attribute the feature [-ATR] to this fricative vowel based on its phonological behaviour. In Amdo Tibetan, Janhunen & Norbu (2014) choose to analyse the fricative vowels [iʑ] and [uv] as peculiar realisations of underlying diphthongs /iə/ and /uə/. The main argument is that /aə/ would otherwise be the only diphthong in the language. Assuming the underlying diphthongs /iə/ and /uə/ makes the system symmetrical. Diachronic and comparative evidence provides additional support for the diphthongal analysis. For example, the spelling of Tibetan is extremely conservative, and suggests that some present-day fricative vowels used to be vowel sequences. An example Janhunen and Norbu give is <we> [bu] 'son', which has the derivation <wie> [buvi]

'son's'. The assumption is that the historical sequence *ie evolved into a sequence of the fricative vowel [uv] followed by [i]. For Kirikiri, Clouse & Clouse (1993) entertain an analysis in which the fricative vowels are regular high vowels followed by an underlying consonant without segmental features. In other words, /VC/ → [V̝].

4.2 Underlying manner of articulation

Manner of articulation has been discussed in Section 2, and the conclusion was that a uniform analysis for all segments described as fricative vowels seems unlikely. However, the choice of the best analysis remains a problem even on a language-specific basis. By their very nature, fricative vowels pattern with vowels phonologically while having frication as if they were consonants. Therefore, one may wish to treat them as vowels phonologically and as consonants phonetically. Such a hybrid view, however, cannot be maintained in light of phonological theories where manner of articulation is not merely a descriptive category. In a standard framework such as Feature Theory (Clements 1985; Hayes 2009; Lahiri 2018), for example, a fricative on the surface must have a phonological feature such as [+fricative], or [+delayed release] in Hayes' version. That is, the manner of articulation in Feature Theory inevitably entails the presence of certain abstract properties, so that the phonetic structure cannot be separated from the phonological representation.

If the nuclear properties of a fricative vowel have to be reconciled with frication, then one option is to consider it a vowel with a frication feature. This is the treatment suggested by Ladefoged & Maddieson (1990), who consider frication a "minor vowel feature" as opposed to major features such as lip rounding. This raises the questions such as whether a feature [frication] would be distinct from a [fricative] feature, or how it would fit in Feature Geometry (Clements 1985). To the best of our knowledge, such phonological details of vocalic frication vs. consonantal frication have never been explored.

If an analysis as an underlying vowel is unappealing for a given language, its fricative vowels may be considered syllabic fricatives or approximants. A typological issue for the fricative-analysis, however, is that many languages with fricative vowels do not have syllabic nasals or syllabic approximants. Some examples are Standard Chinese, Abawiri, Swedish, and Amdo Tibetan. The issue is that there is a very strong implicational hierarchy between sound classes for the capacity to function as a nucleus in a language, wherein the presence of syllabic fricatives implies the presence of syllabic nasals and approximants (Clements

1990: 294). This pattern has been formalised in Sonority Theory, which is discussed in more detail in the next subsection. Examples of languages that have syllabic obstruents but no syllabic sonorants are rare. Easterday (2019) created a sample of 100 languages of different degrees of syllable complexity, and the only language with exclusively syllabic obstruents was Tohono O'odham. If fricative vowels are analysed as fricatives, however, one could add many more languages to this group, so that the implicational hierarchy of syllabic consonants would no longer be a useful concept. Faytak (2017) discusses this problem and its implications in a case study on the fricative vowels in Limbum and Kom. An approximant-analysis of fricative vowels has the advantage of not defying this typological tendency. However, if frication is always present, as for the Miyako or Lendu fricative vowels, an approximant analysis still seems undesirable.

A possibility that merits further consideration is that some fricative vowels require an out-of-the-box analysis for their manner of articulation. Some fricative vowels initially have much frication but lose it throughout their realisation, becoming more approximant-like. This can be said of at least some apico-(post)alveolar fricative vowels in Sinitic languages. One could compare this to affricates. If affricates are plosive-fricative sequences, some fricative vowels could be considered fricative-approximant sequences. Affricates already set a precedent for a single phonological unit that involves a transition in manner. For other fricative vowels, it may be better to assume that they have secondary or double articulation, as phonetic transcriptions such as [uᵝ] imply. When considering a labial fricative vowel with a significantly raised tongue body, it intuitively makes sense to categorise it as a complex segment with more than one constriction, rather than as a simplex vowel or consonant. There are already precedents for phonemes with multiple simultaneous constrictions, such as those with secondary articulation (e.g. labial-velar /w/) and double articulation (e.g. labial-velar /k͡p/). The only difference is that the simultaneous constrictions in such sounds differ only in place and not in manner of articulation, too. However, there is no inherent reason to assume that such phonemes do not exist. Consider the Efe phoneme /qɓ/, of which the phonetic realisation [qɓ] has been verified through instrumental analysis (Demolin & Soquet 1999). This phoneme involves a double articulation of a voiceless uvular stop with egressive lung air and a voiced bilabial implosive stop. The two components of this phoneme differ in place, voicing, *and* airstream mechanism. It is not too far-fetched, then, to propose hypothetical complex phonemes such as, for example, any of /uᵝ, β͡u, βˠ/ for labial fricative vowels. Future studies could investigate whether this is a viable idea.

4.3 Sonority

According to Sonority Theory (Clements 1990; Zec 1995; Parker 2008; Yin et al. 2023), the major classes of speech sounds are organised into a hierarchy. Vowels, as the most sonorous sounds, are at the top, and each lower class is progressively less sonorous. This hierarchy is used to explain a number of phonological generalisations, most notably cross-linguistic commonalities in syllable structure. This principle is known as the Sonority Sequencing Principle (SSP), predicting that the sonority levels of the segments of a well-formed syllable form the shape of a bell-curve (Clements 1990). In other words, the onset is increasingly sonorous, the nucleus is the sonority peak, and the coda decreases in sonority. The implicational hierarchy of permissible nuclei that was mentioned in the previous subsection is also a prediction that follows from Sonority Theory. As already stated, a fricative-analysis of fricative vowels is problematic for the SSP. Sonority Theory is, however, already very controversial. We refer to Ohala & Kawasaki-Fukumori (1997), Harris (2006), and Parker (2012) for critical discussions of the theory. One major problem addressed in these works is the nature of sonority itself. There is no consensus on whether it is a purely abstract property of a speech sound or whether it has reliable physical correlates. None of the claimed correlates, such as loudness and aperture, are consistent predictors of sonority. The definition of sonority is another issue: it cannot be defined without referring to the syllable, but at the same time sonority is claimed to determine what well-formed syllables are, suggesting a problem of circularity. Finally, Sonority Theory makes many incorrect predictions. A recent and comprehensive study that tests the theory against empirical data is Yin et al. (2023).

How fricative vowels fit into Sonority Theory has barely been explored. Fricative vowels with weak or absent frication such as in Swedish and Standard Chinese have never been discussed in the literature on sonority, and they are absent even in extensive sonority hierarchies (Parker 2008: 60). Fricative vowels with strong frication, as mentioned earlier, do not bear out the predictions that Sonority Theory makes. Because sonority is assumed to correlate with phonetic properties such as intensity (Parker 2008), those fricative vowels should have a low amount of sonority similar to fricative consonants, which should prevent them from being licensed as syllable nuclei. This problem has been identified and discussed by Faytak (2014a; 2017). He suggested that the solution may lie in a multidimensional approach to sonority. Instead of a single correlate such as acoustic intensity, sonority levels could be determined by a number of parameters. To account for the seemingly high sonority of fricative vowels, Faytak proposes that one such parameter could be the presence of high-frequency noise. Fricative vowels could then be licensed as nuclei through language-specific parameter settings for sonority. This is a promising avenue for future research. However, it must be noted that this conception of sonority is closer to the ideas on speech perception as sketched in Harris (2006), who is critical of sonority, than it is to common views on Sonority Theory. In conclusion, the position of any type of fricative vowel is unclear within Sonority Theory. They arguably violate its principles, so that fricative vowels can be put forward as yet another argument against Sonority Theory.

4.4 Diachronic phonology

4.4.1 Language-specific pressures

A number of hypotheses have been put forward to explain the origin of fricative vowels on a language family-specific basis. One hypothesis for the origin of apico-(post)alveolar fricative vowels in Sinitic languages is that they are the result of a process that involved assimilation to the onset in order to enhance the perceptual cues of its place of articulation (Lee-Kim 2014b). In many Sinitic languages, the apico-(post)alveolar fricative vowels can only occur in place of historical *i and after homorganic sibilant onsets. Phonetic research has shown that [i] always causes a substantial amount of palatalisation in sibilants, which weakens the perceptual cues for the place of articulation of the preceding onset (Lee-Kim 2014a; Lee-Kim 2014b; Li & Zhang 2017). Lee-Kim (2014b) therefore makes the following argument. Given that Middle Chinese had three coronal sibilants /s, ʂ, ɕ/, palatalisation from a following /i/ must have affected perception in that context. The alveolar and retroflex place cues would have been more difficult to perceive if it is assumed that the sequences were articulated as [sʲi, ʂʲi, ɕi]. This perceptual difficulty is thought to have triggered a sound change that induced assimilation from /i/ to the sibilant instead of from the sibilant to /i/, culminating in an apical fricative vowel.

If this assimilation hypothesis is correct, then it would account for the limited phonotactic distribution of some fricative vowels. However, it does not provide much detail about the change from [i] to an apical fricative vowel. Clues from synchronic data may shed more light on the matter. Hu & Ling (2019) compared the phonetic properties of the apico-alveolar fricative vowel in Suzhou Wu with its two other coronal fricative vowels, i.e. the alveolar fricative vowel described in §2.1.1 vs. the rounded and unrounded pair described in §2.1.2. Hu and Ling concluded that high vowels which change into fricative vowels undergo fricativisation first, then apicalisation, and finally may lose their frication. This is based on the observation that the non-apical coronal fricative vowels have articulatory and acoustic properties that are intermediate compared to high vowels and apico-alveolar fricative vowels. As could be seen in Figure 2, the unrounded non-apical fricative vowel (transcribed as i̝~ʑ̝ in the figure) holds an intermediate position compared to the ordinary high vowel and the apical fricative vowel in terms of tongue body posture. Because it is known that both fricative vowels correspond to historical *i, this suggests that there were two instances of vowel fricativisation at different times, and that the earlier one has undergone subsequent apicalisation.[8] Across Sinitic languages, all unrounded alveolar coronal fricative vowels can then be considered to be at different stages of the developmental trajectory in (7).

(7) i > i̝ > i̝ᶻ > z > ɹ̺

According to the hypothesis, a regular high vowel first gains frication. At this stage, frication is still a necessary cue to distinguish it from non-fricated high vowels. The fricative vowel then presumably assimilates to a preceding sibilant and apicalises. Once the apicalisation is complete, the lingual articulation is sufficiently different from ordinary [i] for the frication to become a redundant cue. When the frication is lost, an approximant-like [ɹ̺] remains. Suzhou Wu, then, has fricative vowels at two different stages of development. Interestingly, the [i̝]-like fricative vowel is “stuck” in the hypothetical trajectory above because it can neither lose its frication nor apicalise. The place of /i/, after all, has been taken up by syllables that historically had a nasal coda, i.e. *ɪn (Hu & Ling 2019: 3). For rounded apico-alveolar vowels, the trajectory would start at [y] and finish with [ɹ̺ʷ]. If this hypothesis is correct, then a similar scenario could apply to the apico-postalveolar and labial fricative vowels. This would mean that the apico-postalveolar fricative vowel of Standard Chinese (roughly [ɻ]) and the two Rui’an Wu labial fricative vowels /ʉ ɯ/ described by Hu & He (2019) are at the final stage of development. Their articulation and acoustics are very different from the high vowels [i] and [u], so that their weak or even absent frication could be a superfluous secondary cue.

A different idea on the emergence of fricative vowels is that they are the result of a vowel raising chain shift where high vowels “move out” of the ordinary vowel space, i.e. their articulation becomes so close (in the IPA sense) that frication is generated. For a fricative vowel that has developed out of [i], this means that the articulation is somewhere on the spectrum between [i̝] and [ʑ̝]. This has been proposed for the fricative vowels in Ryukyuan languages (Jarosz 2018)

[8]This is what Baron (1974) also assumed, although he does not provide any strong evidence.

and some Wu Chinese and Grassfields Bantu languages (Faytak 2014b). A vowel raising chain shift would yield fricative vowels with much freer phonotactic distributions, which is indeed the case for the language families mentioned above compared to e.g. the apico-(post)alveolar fricative vowels in Standard Chinese. An unanswered question is why a vowel raising chain shift results in fricativisation in some cases and in other cases in the more commonly seen diphthongisation or centralisation of high vowels (Faytak 2014b). There may be more than one language-specific pressure on a sound system at the same time. For example, vowel raising also happened in the history of Mandarin Chinese at around the same time as apicalisation (Shen 2020: 258–261). Vowel raising and the perceptual difficulty of sibilant+[i] sequences could have worked in concert to induce fricativisation and subsequent apicalisation. Perhaps there are hitherto unidentified language-specific pressures in Ryukyuan and Grassfields Bantu that have made vowel fricativisation happen instead of diphthongisation.

In the Lakes Plain languages, fricative vowels are thought to originate from the consonant following it (Clouse & Clouse 1993; Yoder 2020: 56). A word with a fricative vowel such as Kirikiri /ɸu̞/ 'fat' has the Obokuitai cognate /hub/, and Kirikiri /ɸi̞e/ 'pandanus palm tree' corresponds to Tause /ɸide/ (Clouse & Clouse 1993: 14). This regular correspondence between fricative vowels and postvocalic obstruents is robustly attested in the Lakes Plain languages. Therefore, the rationale is that the obstruents were lost, after which only the high vowels could signal the contrast. Although this seems probable given the empirical data, it is puzzling why a sequence as ordinary as CVC(V) would have become a highly unusual sequence CV̞(V).

There are therefore three different language-specific suggestions about how fricative vowels can develop: assimilation to fricative onsets to prevent perceptual difficulties, raising of high vowels in a vowel raising chain shift, and assimilation to following consonants that are subsequently deleted. However, there is no reason to assume that these hypotheses are the only pathways to vowel fricativisation. If more research is dedicated to fricative vowels, it is likely that new hypotheses can be put forward.

4.4.2 Inherent properties of high vowels

Although the formation of fricative vowels appears to have different causes in different languages, there is at least one fact they have in common: all fricative vowels are diachronically related to high vowels. For many of them, this is synchronically still true (e.g. through complementary distribution). It is therefore of interest to explain what makes high vowels so special. A first reason is that high vowels have the greatest degree of constriction, which already makes their articulation the most consonant-like. It only takes a slight raising of the tongue to produce frication in a high vowel such as [i], which is not the case for vowels with a lower tongue height. As for [u], the lips can be pressed together without much effort to create some frication.

There are at least two more ways in which high vowels differ from other vowels, as described by Mortensen (2012). The first is that the oral cavity in high vowels is comparatively small, which results in higher air pressure. Because vocal fold vibration requires the subglottal air pressure to be higher than the supraglottal air pressure, sustaining voicing is more difficult when the air pressure in the oral cavity is high. As such, high vowels may be partially devoiced during the offglide, producing faintly perceptible [ç~x] frication. A second relevant property of high vowels is that their intrinsic duration is shorter than that of more open vowels, which means that a larger proportion of their articulation potentially overlaps with neighbouring consonants. The relatively large gestural overlap with consonants adds credence to the hypothesis that some fricative vowels apicalise through assimilation to adjacent sibilants. Mortensen (2012) discusses these properties of high vowels not in relation to fricative vowels, but as part of a description of post-vocalic obstruent emergence. This is a sound change where obstruents appear after high vowels in open syllables. Compare the Proto-Tangkhul reconstructions below with its daughter language Huishu (Mortensen 2012: 438–440). The Proto-Tangkhul high vowels conditioned post-vocalic obstruent emergence (8a-c), while other vowels did not (8d).

(8)	a.	*ni	→	kʰə-nik	‘two’
	b.	*bu	→	ʔa-vuk	‘grandfather’
	c.	*hwɨ	→	ʔa-huk	‘dog’
	d.	*da	→	kə-kə-re	‘to sharpen’

Interestingly, in Huishu’s sister language Tusom, the Proto-Tangkhul high vowels *i and *u have merged into one phoneme /ɯ/ with fricated allophones (Mortensen 2012: 438). After labial onsets, /ɯ/ is realised as [v̩], and after coronal sibilants it is realised as [z̩]. Mortensen identifies these allophones as syllabic fricatives, but they developed out of high vowels and therefore fall under the definition of fricative vowels used in this chapter. Post-vocalic obstruent emergence is perhaps a different outcome of the phonetic factors that may induce vowel fricativisation. Cross-linguistically, post-vocalic obstruent emergence has been attested in North Germanic (Danish, Swedish), Tibeto-Burman (Huishu, Maru), Grassfields Bantu (Moghamo, Oshie), and some Austronesian languages (Lom, Singhi). It might not be a coincidence that fricative vowels have been reported in the first three of these language families.[9] A clear relationship between post-vocalic obstruent emergence and fricative vowels, however, has not been established.

Another phenomenon related to high vowels which is potentially relevant in gaining a better understanding of vowel fricativisation is glide strengthening. Strengthening, also known as fortition, can cause a glide to become a fricative (Huang 2020; Blevins 2025 [this volume]; Blust 2025 [this volume]; Culhane & Edwards 2025 [this volume]). Consider the following processes in Atayal (Huang 2020), in which approximants fricativise before high vowels that are their vocalic counterparts.

(9) /j/ → [ʑ] / __ i
/w/ → [ɣ] / __ u

Bybee & Easterday (2019) have studied consonant weakening and strengthening in a diverse sample of 81 languages.[10] In order to avoid biasing the sample towards languages with historically attested strengthening and weakening, the authors examined synchronic allophonic variation. One of their main findings was that 12 out of the 31 cases of strengthening involved a change from glides into fricatives, which is a much higher proportion than would be expected based on chance. The glides in question were all [j] and [w], notably the consonantal counterparts of the cardinal high vowels. The explanation for glide strengthening proposed by the authors is that the articulatory trajectory of the tongue and lips is, through use, under pressure to be as efficient as possible in terms of time and effort. Instead of moving the articulators as little as possible, efficiency is attained by moving them at higher speeds and with more fluid motions. This results in inertia and overshoot of the articulators during the maximum point of constriction. The approximants [j] and [w] are particularly susceptible to this, although for different reasons. In [j], the fronted tongue dorsum is bulky (Recasens & Espinosa 2009). As for [w], the lips are slower articulators than the tongue (Gordon 2016: 111), and the lips are both moving separately. As such, the articulators experience much inertia and overshoot, which results in frication at

[9] Although Atayal is Austronesian, it is spoken on Taiwan and only distantly related to Lom and Singhi which are spoken in Indonesia. Atayal possibly owes its apico-alveolar fricative vowel to language contact with Sinitic languages.

[10] Strengthening was defined in the study as an increase of the magnitude and duration of the movement of the active articulator(s). The survey specifically focused on central approximants, fricatives, affricates, plosives, and nasals.

the maximum point of constriction. This argument could be extended to [i] and [u] due to their respective articulatory similarities to [j] and [w].

All in all, then, high vowels have several properties that can lead to occasional frication. The combination of these inherent properties and language-specific pressures such as a vowel raising chain shift is what likely induces increased frication. Once the frication is reliably present as a secondary cue in speech perception, it can be phonologised, resulting in a full-fledged fricative vowel.

5 Conclusion

This chapter presents an overview of the-state-of-the-art literature on fricative vowels, an umbrella term for speech sounds that cannot simply be classified into the canonical categories for manner of articulation due to their contradictory phonetic and phonological properties. Fricative vowels are defined, after all, as syllabic and sonorous segments that simultaneously involve some degree of frication. One crucial property that they all share is that they have developed out of high vowels. However, the descriptions of fricative vowels in this chapter also show that these sounds are also clearly diverse in many ways. In terms of phonetics, fricative vowels differ in how intense their frication is, what their spectral properties are, and in their place of articulation. The variable presence of frication has caused much debate about what fricative vowels' manner of articulation is, and this issue is difficult to resolve. The phonological properties of fricative vowels also diverge strongly. Some of them have a very limited phonotactic distribution. A recurring pattern is an apico-alveolar fricative vowel that is in complementary distribution with /i/ and that takes only sibilant onsets. Other fricative vowels, however, have few phonotactic restrictions and are contrastive with high vowels. In accordance with these differences, fricative vowels are sometimes analysed as allophones and sometimes as independent phonemes. The phonemic analysis and phonetic realisation can be difficult to reconcile, but both need to be considered when deducing the possible underlying manner of articulation. As discussed, some differences in properties of fricative vowels can potentially be linked to different historical sources and how far fricative vowels are along their developmental trajectory. On a language-family specific basis, fricative vowels are hypothesised to have emerged through assimilation to sibilants, vowel raising chain shifts, and consonant deletion. More transparent is the relationship between the historical vowel quality and the place of articulation. The most common pattern is that labial fricative vowels develop out of a rounded back vowel [u], whereas coronal fricative vowels develop out of an unrounded front vowel [i]. The rarity of rounded coronal fricative vowels, then, follows naturally from the rarity of rounded front vowels. Numerous articulatory and aerodynamic reasons are suggested as to why only high vowels may develop into fricative vowels. All of these reasons ultimately have to do with the close proximity between different articulators.

The research reviewed in this chapter raises many questions, of which some are fundamental to linguistics. First, fricative vowels test the adequacy of our current descriptive terminology. Although researchers have used novel terms and diacritics to describe fricative vowels, it is at present unclear whether any official amendments and additions to the IPA are justified. It is unclear whether fricative vowels form a valid, separate category of speech sounds, or whether each of them can be re-categorised appropriately using existing terms. Much more cross-linguistic research is necessary to be able to create a comprehensive typology of fricative vowels and to find answers to these questions. Phonetically, fricative vowels highlight the complex relationship between articulation and acoustics, and much could be learnt from how their formant values relate to the multifaceted articulation of the tongue. This issue furthermore relates to the shortcomings of the vowel quadrilateral, which is based on a model that assumes a rather straightforward interaction between formant values on the one hand and backness and openness of the constriction on the other hand. Phonologically, fricative vowels pose a challenge to frameworks of subsegmental structure and Sonority Theory. However, they are hardly ever considered in theoretical phonology, so the implications of their existence are not yet worked out. Finally, the uncertainty of the diachronic development of fricative vowels makes it clear that there is much more to be learnt about exactly how they come to be. Sound changes involving vowel fricativisation, although perhaps rare, should be of great interest to historical linguists.

Given that fricative vowels have so much to offer to the study of speech sounds, it is our hope for the future that they receive the scientific attention that they deserve. This chapter can then hopefully serve as a useful introduction to fricative vowels and spark a wider interest in them.

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Chapter 11

Uvularization in Queyu phonology

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This chapter examines uvularization in Queyu, a Qiangic language within the Tibeto-Burman language family. Queyu contains a series of uvularized vowels characterized by the constriction of the styloglossus and other muscles which draw the tongue dorsum towards the uvula (Evans et al. 2016: 1). Uvularity in Queyu can spread leftwards across morpheme boundaries and can trigger a uvular allophone of a preceding velar consonant. In addition to describing relevant phonological phenomena associated with uvularized vowels, this chapter provides an overview of current literature on uvularization and other similar vowel qualities in closely-related languages, and discusses possible origins of this unique phenomenon. As different labels are used for similar vowel qualities in the literature, this chapter draws attention to the need for detailed acoustic studies and terminological systemization.

1 Introduction

This chapter examines the phonological characteristics of Queyu (Qiangic < Tibeto-Burman (TB), ISO 639: qvy) in the context of nearby languages. The Queyu language contains an unusual combination of elaborate onset clusters and highly reduced codas. While uvular consonants and uvularized vowels are typologically rare among languages of the world, they are common in the region where Queyu is spoken. Uvular consonants and uvularized vowels are related to each other in Queyu. Uvular consonants only occur before uvularized vowels, suggesting that uvular and velar consonants are allophones. This chapter argues that in Queyu, the appearance of uvular consonants is triggered by uvularized vowels. Vowel qualities similar to what is described here as uvularized are mentioned in descriptions and analyses of related neighboring languages, where they are variously

Xuan Guan. 2025. Uvularization in Queyu phonology. In Natalia Kuznetsova, Cormac Anderson & Shelece Easterday (eds.), *Rarities in phonetics and phonology: Structural, typological, evolutionary, and social dimensions*, 437–473. Berlin: Language Science Press. DOI: 10.5281/zenodo.15148182

termed as pharyngealization, velarization,[1] tenseness, and rhotacization (Gong 2020: 193, Chirkova 2024: 734). The similarities among these vowel qualities have been noted by several authors (Evans 2006a: 94, Evans 2006b: 737, Suzuki 2011: 492, Suzuki 2013: 30, Gong 2020: 194). In this work, I withhold judgement about whether these various vowel qualities represent differing descriptions of a common set of acoustic features which have yet to be systematically defined, or are indeed truly distinct. These studies show that the marked vowels in question differ from plain vowels in different ways across the languages they are identified in. While some marked vowels have lower F2, others may have higher F1 and/or F3, yet all marked vowels can be implicated in similar phonological processes, like vowel harmony (Lin et al. 2012, Evans et al. 2016, van Way 2018, Chiu & Sun 2020). In addition to describing rare phonological phenomena in Queyu and the spreading of this unusual vowel quality within a word as areal features, this chapter looks at Queyu phonology from both comparative and typological perspectives, and examines the possible origins of uvularized vowels.

Section 2 briefly introduces Queyu and its current available literature, then provides a description of relevant phonological phenomena. Section 3 presents a typological overview of uvularized vowels and related phonological processes within the Qiangic branch and discusses the possible origins of uvularization. Section 4 concludes the chapter.

2 Introduction to Queyu and Queyu phonology

2.1 The Queyu language and Qiangic branch

Queyu is a Tibeto-Burman (TB) language spoken in Ganzi Tibetan Autonomous Prefecture, Sichuan Province, China. Though the language's 6,000–7,000 speakers are ethnic Tibetans (Lu 1985: 67, Wang 1991: 46), Queyu belongs to the Qiangic branch rather than Tibetic. The subgrouping of Queyu and its related languages is still under debate. For example, Sun (2016: 4) puts thirteen languages under the Qiangic branch, while Jacques & Michaud (2011) propose a Na-Qiangic subbranch containing 25 languages. In Sun's (2016) classification, Queyu, Muya (Minyag, Munya), Pumi (Prinmi), Tangut (Xixia), Qiang (Rma), and Zhaba (nDrapa) belong to the Central sub-branch, while Shixing (Shuhi), Namuyi, Ersu and Guiqiong belong to a Southern sub-branch, and Rgyalrong, Ergong (Stau, Daofu,

[1]This is not to be confused with the "highly velarized allophone of /u/" mentioned in van Hugte et al. (2025 [this volume]), which is associated with fricative vowels, another rare phenomenon that is also present in Qiangic languages.

Horpa), and Lavrung (Khroskyabs) belong to a Northern sub-branch.[2] Though there is controversy regarding the Qiangic grouping (Chirkova 2012), morphological evidence supports Sun's proposed Northern sub-branch as a group. This group is often referred to as Rgyalrongic in the literature (Sun 2000a,b).

Language data from Qiang, Tangut, Khroskyabs, Rgyalrong, and Tibetan will be presented in the discussion on the origins of uvularization given in Section 3.5. In TB literature, it is a common practice to use the place name (such as village/ town/county name) where a specific language/variety is spoken in labeling different languages or varieties within a language (e.g. Puxi Stau, Xiaoyili Khroskyabs, Mawo Qiang). This chapter follows this convention when citing data from other sources.

The literature reports that Queyu speakers mainly reside in the counties of Xinlong, Litang, and Yajiang (Lu 1985: 67, Wang 1991: 46, Sun 2001: 159, Nishida 2008: 77). My primary interest in this study is the Queyu variety spoken in Yajiang County, Pubarong Town. This variety is hence referred to as "Pubarong Queyu".

Compared to other languages in the proposed Qiangic group, Queyu has received relatively little attention and is one of the least studied languages in the area. To date, there are only two published grammar sketches on Queyu varieties: Lu (1985) introduces basic information on the Queyu variety spoken in Yajiang County, Tuanjie Town (now renamed Gala Town), and Wang (1991) describes the Queyu variety in Xinlong County, Youlaxi Town. Partial descriptions of other Queyu varieties are also available. Nishida (2008) discusses the phonology of the Queyu spoken in Litang County, Rongba Town. Zheng (2023) is a more detailed description and analysis of the Rongba Queyu phonology. Nagano & Prins (2013) provide a wordlist with 407 words from Yajiang County, Gala Town. Recently a moribund variety of Queyu was identified near Yajiang County in Lhagang, Kangding County (Suzuki & Sonam Wangmo 2016, Suzuki & Sonam Wangmo 2018, Suzuki & Sonam Wangmo 2019).

The description and analysis of Pubarong Queyu presented in this chapter is based on data collected through fieldwork undertaken from 2018–2021. I worked mainly with Pubarong Queyu speakers from the village of Suoyi. The villages of Pubarong are divided into *lə̀ndʒə́* and *və̀ndʒə́* based on their locations in relation to the Yalong River, with the *lə̀ndʒə́* villages upstream and the *və̀ndʒə́* villages downstream. Suoyi belongs to the downstream *və̀ndʒə́* group. The location of Suoyi Village is labeled with a star in the map below. Other Pubarong Queyu speaking villages are labeled by a pin.

[2] Alternative names and spellings of a language that are used in various literature are given in parentheses.

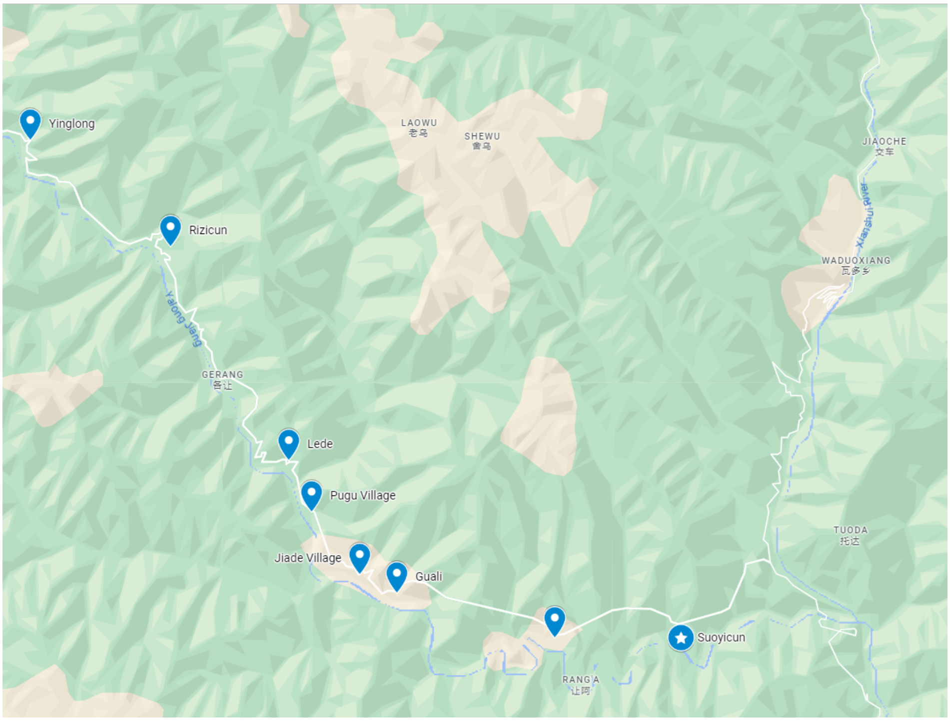

Figure 1: The location of Suoyi Village in relation to other Pubarong Queyu speaking villages along the Yalong River

2.2 Phonological sketch of Queyu

2.2.1 Phoneme inventory

There has not been much work on Queyu varieties from a phonological perspective. The current study is the first description of Pubarong Queyu variety. There are forty-three consonants in Pubarong Queyu, which are given in Table 1.

Consonants in brackets are predictable allophones. Bilabial stops /p/ and /b/ have fricative allophones ([ɸ] and [β]) that only occur in the preinitial position under certain conditions (see Section 2.2.2 for syllable structure). Velar consonants (except for /x^h/) have uvular allophones conditioned by a following uvularized vowel. The /x^h/ phoneme is marginal in this language, as it has only been documented in three words in my data so far, *x^hǽ* '(rainbow) appear', *x^hə́* 'meat' and a homophonous word *x^hə́* 'strength'. All three words are Tibetan loans,[3] suggesting that this is a loan phoneme corresponding to the Tibetan letter <ཤ> /ʃ/.

[3]Here, a word is referred to as a "Tibetan loan" if it reflects either the phonology of a Written

Table 1: Consonant inventory of Pubarong Queyu

		Bilabial	Labio-dental	Alveolar	Retroflex	Palatal	Velar
Plosive	voiceless aspirated	p^h		t^h			k^h [k^h, q^h]
	voiceless unaspirated	p [p, ɸ]		t			k [k, q]
	Voiced	b [b, β]		d			g [g, ɢ]
Affricate	voiceless aspirated			ts^h	ʈʂ^h	tʃ^h	
	voiceless unaspirated			ts	ʈʂ	tʃ	
	Voiced			dz	ɖʐ	dʒ	
Fricative	voiceless unaspirated			s	ʂ	ʃ	x [x, χ, h]
	voiceless aspirated			s^h	ʂ^h	ʃ^h	x^h
	Voiced		v	z		ʒ	ɣ [ɣ, ʁ]
Nasal	Voiceless	m̥		n̥		ɲ̊	ŋ̊ [ŋ̊, ɴ̊]
	Voiced	m		n		ɲ	ŋ [ŋ, ɴ]
Liquid	Voiceless			l̥			
	Voiced			l	ɭ		
Glide	Voiced	w [w, ɥ]				j	

Voiceless sonorants are common among TB languages (Chirkova et al. 2019: 18). In Queyu, they start with a voiceless period, so are also inherently aspirated. There are thirteen plain monophthongs, which are illustrated in Table 2. In addition to these thirteen plain vowels, there is a set of nine uvularized vowels, illustrated in Table 3.

Table 2: Vowel inventory of Pubarong Queyu

	Front		Back
High	i, y	ɨ, ʉ	u
	ɪ, ʏ	ɘ	ʊ
Mid	e	ə	o
Low		æ	

Table 3: Uvularized vowels

	Front		Back
High	iʶ	ɨʶ, ʉʶ	
	ɪʶ	ɘʶ	ʊʶ
Mid	eʶ	əʶ	
Low		ɑʶ	

Phonetically speaking, uvularized vowels tend to be lower and backer than their plain counterparts. Figures 2–3 provide spectrograms for a minimal pair contrasting plain and uvularized vowels. Figures 2–3 compare *lɘ́* 'seed' and *lɘ́ʶ* 'highland wheat,' which contrast /ɘ/ and /ɘʶ/. A more systematic comparison between such sets of vowels in the same phonetic environments is needed before a more thorough acoustic analysis can be done.

Phonologically speaking, uvularized vowels trigger uvular allophones of preceding velar consonants. Uvular consonants occur before uvularized vowels only, and velar consonants only occur before plain vowels. This complementary distribution of dorsal consonants is best demonstrated in the allomorphic alternation of the verbal prefixes *kɘ-* and *qɘʶ-*, discussed in Section 2.3.3.

There is one diphthong, /eɪ/, that is attested only in Tibetan loanwords thus far (e.g. *hméɪ* 'medicine'). Other potential diphthongs, such as [ye, ui, uə, uɑʶ, ie, iæ, iɑʶ] have been analyzed and transcribed here as the consonant-vowel sequences /ɥe, wi, wə, wɑʶ, je, jæ, jɑʶ/, respectively. The glide /w/ has an allophone [ɥ], conditioned by the frontness of the following vowel and/or the place of articualtion of the preceding consonant. The phonemes /ʏ/ and /iʶ/ each occur only once in my data, in *nʏ̌* 'rest.3', and *xsʰíʶ* 'see clearly'. The latter word reflects the Written Tibetan *gzhigs*[4] 'to see'.

Tibetan form, or the phonology of the local Kham Tibetan farming dialect. It should be noted that various historical layers of Tibetan loans entering the language via Buddhism and contact with neighboring Tibetan dialects may be identified. However, with the present state of research it is not always possible to date loanwords or to distinguish loans from cognate forms.

[4]In this chapter I use Wylie's transcription for Written Tibetan (Wylie 1959).

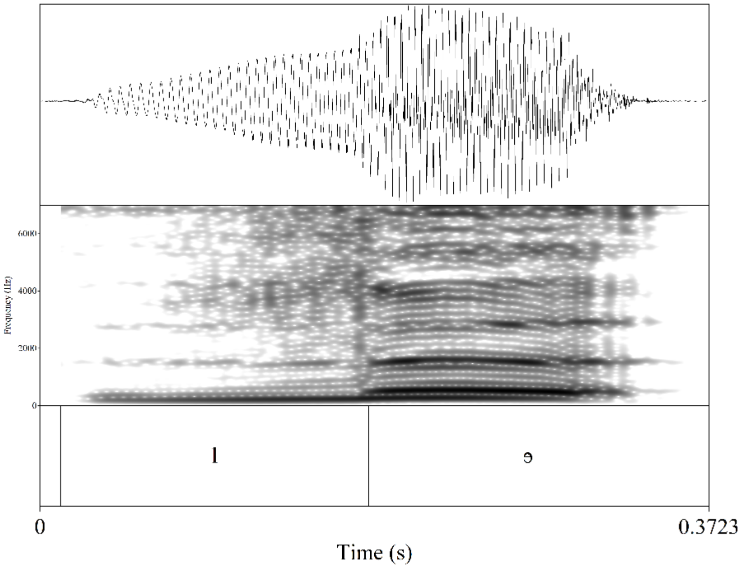

Figure 2: Spectrogram for lə́ ‘seed’

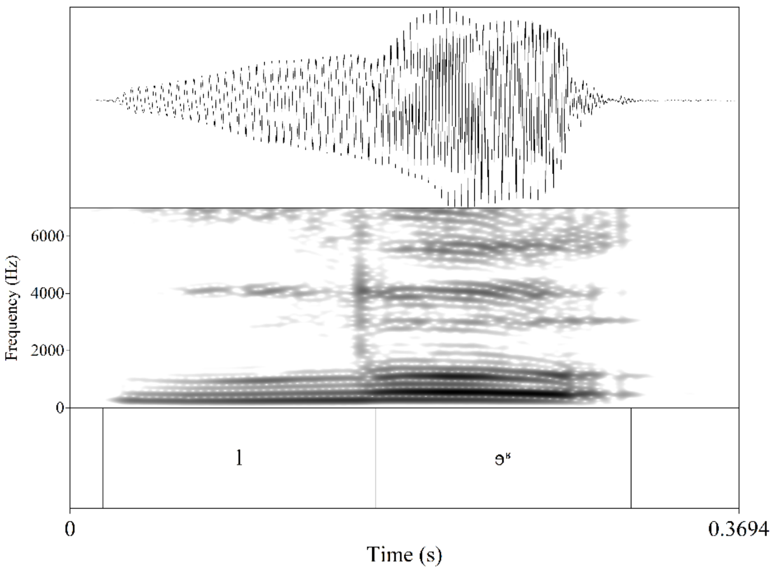

Figure 3: Spectrogram for *lə́ʁ* ‘highland wheat’

Queyu is a tonal language. Two tones are distinguished on monosyllabic words, a high level tone (e.g. ǽ) and a rising tone (e.g. æ̌). The high level tone on monosyllabic words can also be pronounced as a high falling tone without changing the meaning. When it comes to multisyllabic words, a low level tone may occur (e.g. æ̀). But a word can never bear only low level tone. For example, for disyllabic words, three tonal patterns are observed: high + high, high + low, low + high. The combination of low + low or a monosyllabic word bearing only low tone are never found in the data. In multisyllabic words and connected speech, the rising tone can sometimes be realized as a low level tone or high level tone. For example, the egophoric marker *tsɨ̌* 'EGO' and the generic marker *tʂ̥ɨ̌* 'GNR' bear a rising tone when pronounced in isolation. When the two words are pronounced together, the tone pattern becomes low level + high level: *tsɨ̀ tʂ̥ɨ́* 'something that happens on a regular basis / it is the case that…'. Two consecutive rising tones within a word are not found in the present data set, either. When combining two morphemes with a rising tone, one or both morphemes' tones will change. Below are examples demonstrating contrastive tones in monosyllabic words, tonal patterns in disyllabic words, and tonal change in morphosyntactic processes. For more details on the description and analysis of tones, plase refer to Guan (2024). xlǐ

(1) a. Monosyllabic words
  i. High level *xlí* 'tongue'
  ii. Rising *xlǐ* 'rabbit'
 b. Disyllabic words
  i. high + high *kʰímí* 'bovine'
  ii. high + rising *l̥ʊ́ʁbə̀* 'wind'
  iii. rising+ high *tʂ̥ʊ̀mbɘ́*'justice'
 c. Combination of morphemes
  i. Rising *tə̌-* 'PFV'
  ii. Rising *kʰʊ̌* 'give.1SG'
  iii. *ŋə̌ tə̀-kʰʊ́*
   1SG PFV-give.1SG
   'I gave.'

2.2.2 Queyu syllable structure

The syllable structure of Queyu is: (P) (C) (G) V. A preinitial (P) is the first consonant of two non-glide consonants in the onset. Their intensity and duration are much shorter than those of regular consonants. The consonants (including allophones) that can appear in the preinitial position are limited to twelve: [p, b, ɸ, β, x, ɣ, χ, h, n, m, ŋ, ɴ]. Their distribution is partly predictable. Properties such as voicing and manner of a preinitial can be conditioned by the following consonant. For example, [p] occurs before voiceless coronal consonants, while [b] occurs before voiced stops and fricatives. [ɸ] occurs only before lateral sounds, and [β] occurs before voiced fricatives and liquids. C stands for any consonant, and G represents a glide. Three consonants can fill the glide slot. These are [j, w, ɥ], with [ɥ] being an allophone of /w/ conditioned by the following front vowel or preceding velar consonant. More information on the phonotactics of Queyu can be found in Guan (2024). Below are illustrative examples of each onset combination.

(2) a. V *í* - 'UP'
b. CV *vә́* 'flour, powder'
c. GV *jæ̌*- 'UP.Q'
d. PCV *xpʰí* 'dust, ash'
e. CGV *vjé* 'pig'
f. PCGV *xpjé* 'rough, coarse'

2.3 The spreading of uvularization and other features in Pubarong Queyu prefixes

Uvularization in Pubarong Queyu can spread leftward across a morpheme boundary within a word. This is most clearly seen in the alternation of two sets of verbal prefixes, plain and uvularized.

One way to analyze the alternation of prefixes is through the lens of vowel harmony. Though not common in TB languages, vowel harmony is consistently reported in Qiangic and Naic languages within the TB family (Chirkova 2024: 1). However, some Queyu data presents patterns that do not fit the traditional definition of vowel harmony, as is examined in more detail in Section 2.3.3.

This section presents data on the spreading of uvularity and other features in Queyu prefixes. A brief typological overview on vowel harmony as well as an examination of argument indexation on verbs will be presented first in Sections 2.3.1 and Section 2.3.2. Information given in these sections will serve as a background for demonstrating and discussing how allomorphs of prefixes are conditioned in Section 2.3.3.

2.3.1 A brief overview of vowel harmony and uvulars in the Eurasian context

Traditionally speaking, vowel harmony refers to the agreement among all vowels in a word (or the harmonic domain) for some feature (van der Hulst 2016). Vowel harmony patterns can vary based on different parameters, including static vs. dynamic harmony, root-controlled vs. dominant-recessive harmony, and directionality (Makeeva & Kuznetsova 2022). In terms of static vs. dynamic harmony, Pubarong Queyu uvularized vowels in verbs can trigger the appearance of uvularized verbal prefixes, indicating that Queyu belongs to the dynamic harmony type. As for the second and the third parameters mentioned above, vowels in the verbal prefixes are subject to harmony, while suffix vowels are not, indicating that Queyu data demonstrate regressive root-controlled harmony. In addition to the vowels in the verb stem, a voiced velar preinitial in the verb can also trigger a uvularized prefix, which is not commonly seen in vowel harmony cases. Furthermore, this feature spreading can affect the onset consonant of the prefix, which is also not typical for vowel harmony. Lastly, three verbal prefixes are not subject to this harmony process, despite the fact that the hypothetical uvularized versions of them are phonetically and phonologically possible in Queyu, while two vowels, /u/ and /o/, behave like plain vowels in some verbs and uvularized vowels in other verbs.

Geographically speaking, vowel harmony is a major areal feature in Eurasian languages spoken in Northeast Asia (Barrere & Janhunen 2019: 47). There are two major types of vowel harmony systems in languages spoken in Eurasia: palatal-velar harmony (PVH) and tongue root harmony[5] (TRH) (Barrere & Janhunen 2019: 47). Palatal-velar harmony distinguishes palatal (front) and velar (back) vowels and is prevalent in languages spoken in the western part of Eurasia, while tongue root harmony distinguishes vowels with advanced vs. retracted tongue root (ATR/RTR) and is prevalent in languages spoken in the eastern part of Eurasia. The Mongolic family is in a transitional state with both types of harmony systems (Barrere & Janhunen 2019: 47–48). There is controversy regarding which type is more archaic, with some studies arguing for the greater antiquity of TRH (Ko 2012, Ko et al. 2014) and other studies arguing that TRH is merely an ancient areal feature introduced from the Northeast Pacific Rim (Barrere & Janhunen 2019). TRH presents a type of harmony comparable with that present in Queyu and other Qiangic languages.

The presence of uvular consonants in Southwest China is also considered to be an areal feature. Hill (2019: 124) describes the region as a "uvular-prone Sprachbund" and considers the presence of uvular sounds in local Tibetan and Mongo-

[5] TRH is also prevalent in African languages, but these are not discussed here.

lian languages to reflect the influence of a Qiangic substrate. Similarly, post-velar consonants are commonly reported as phonemes or allophones of velar consonants in Mongolic and other Northeast Asian languages (Nugteren 2011: 30–33, Sylak-Glassman 2014: 32–36). The phonological phenomenon of vowel harmony related to post-velar consonants is also one of the major areal features of languages spoken in that region (Barrere & Janhunen 2019: 47, Robbeets 2020: 129). A study investigating the geographical patterning of ejectives and uvulars suggests that language contact plays an important role in the development of uvular sounds in TB languages (Urban & Moran 2021: 27).

2.3.2 Argument indexation on Queyu verbs

Pubarong Queyu presents complex argument indexation patterns. While argument indexes are suffixed to verb stems, they fuse with the vowel in the verb stem but do not effect change in the stem vowel quality. Vowel fusion processes are prevalent in Pubarong Queyu but will not be examined in detail in this chapter. All verbs contain a stem vowel, and when the stem is fused with a person suffix, the fused vowel is considered as part of the stem. Except for the situations illustrated in Sections 2.3.3 and 2.4, the fused vowel can condition the prefix allomorph. This subsection merely provides a basic description of the verb types and argument suffixes to lay the groundwork for discussing allomorphic alternation in verbal prefixes in Section 2.3.3.

There are three types of verbs based on the conjugation patterns. The first type does not conjugate for person or number. A large class of this type is stative verbs, or verbs expressing property concepts. Several examples of this type include ‘big’ *ndʒʉ́ʶ*, ‘say, speak’ *pʃə́*, ‘win, beat’ *kʰǐ*, ‘lock (a door)’ *kwə́*, and ‘dig’ *pɘ́ʶqwə́ʶ*.

The second type of verb only distinguishes Speech Act Participants (SAP) and non SAP, with the non SAP form containing an inserted bilabial consonant—a relic of an inverse marker still prevalent in nearby Rgyalrongic languages. Examples of this type include ‘throw’ (*ɽə́* for SAP form and *βɽə́* for non-SAP form), ‘pay, submit’ (SAP form: *ɖɽæ̌*, non-SAP form: *ɖɽwæ̌*), ‘cut, saw’ (SAP form: *ʈɽæ̌*, non-SAP form: *pʈɽæ̌*), ‘wipe’ (SAP form: *də́*, non-SAP form: *bdə́*), ‘release’ (SAP form: *ɭ̥ə́ʶ*, non-SAP form: *ɸɭ̥ə́ʶ*), and ‘hand, give’ (SAP form: *xtə́ʶ*, non-SAP form: *xtwə́*).

The third type of verb contrasts both person and number. This is the type that shows the most diversity. Within this type, first person singular and plural forms end with *-ʊ* and *-æ* for plain vowel stems (such as ‘say, speak’ and ‘feed, give’ in Table 4), and with *-ʊʶ* and *-aʶ* for uvularized vowel stems, respectively. Only a few verbs with a plain vowel stem contrast number in second person (such as 'say, speak'), while verbs with uvularized vowels do not distinguish number in second person. Third person forms exhibit the greatest variation. Some third person forms contain an inserted bilabial consonant like the second type of verb described above (e.g. 'sit', 'dip', 'hold, take'), while others do not (e.g. 'say, speak', 'feed, give', 'poke, stab'). Several examples of this type are demonstrated below.

Table 4: Verbs that contrast both person and number

Verb	1SG	1PL	2SG	2PL	3
'say, speak'	ɲʊ̆	ɲæ̆	nə̆	ɲɪ̆	ɲɪ̆
'feed, give'	ʃʊ̆	ʃæ̆	ʃɨ̆	ʃɪ̆	ʃʏ̆
'sit'	tsʊ́	tsǽ	tsí	tsí	ptsʊ́
'dip'	ʃə́ʶʃʊ́ʶ	ʃə́ʶʃɑ́ʶ	ʃə́ʶʃéʶ	ʃə́ʶʃéʶ	ʃə́ʶpʃʊ́ʶ
'hold, take'	zʊ̆ʶ	zɑ̆ʶ	zĕʶ	zĕʶ	βzʊ̆ʶ
'poke, stab'	xtʃʰʊ̆ʶ	xtʃʰɑ̆ʶ	xtʃʰĕʶ	xtʃʰĕʶ	xtʃʰʉ̆ʶ

2.3.3 Allomorphic alternations of verbal prefixes

Uvularization in Pubarong Queyu can spread leftward across morpheme boundaries. This is most clearly seen in the verbal prefixes that are given in Table 7 in comparison to the prefixed verb examples in Table 6. For most prefixes, there are two sets which can be conditioned by the vowel quality in the verb stem. Only the prefixes for 'downstream' and the three allomorphs for 'upward' do not have uvularized forms. Table 5 illustrates the plain and uvularized versions of the prefixes, which include six directional prefixes (prefixes that indicate the direction of motion), a question marker, a prohibitive marker, and three negation prefixes that are used in different TAME contexts. Among them, only two directional prefixes and a negation prefix do not have uvularized forms, and they are the 'downstream' and the three allomorphs for 'upward' prefixes, as well as the méɪ- negation marker.

Table 6 presents examples of prefixed verbs with plain vowel argument suffixes. Notice that the directional prefixes can also function as perfective and imperative markers in addition to indicating the direction of motion. When this is the case, the change in meaning is explained in the translation according to the context.

Table 5: Prefixes in Queyu

Queyu prefix	Uvularized version	Gloss
í-, rɨ́, ə́-	-	UP
nə̌-	nə̌ʶ-	DOWN
lə́	lə́ʶ-	UPSTREAM
ǐ-	-	DOWNSTREAM
kə́-	qə́ʶ-	IN
tə̌-	tə̌ʶ-	PFV
æ̀-	ɑʶ-	Q
tǽ-	tɑʶ-	PROH
mǽ-	mɑʶ-	NEG
mə-	məʶ-	NEG
méɪ-	-	NEG

Table 6: Prefixes with verbs containing plain vowel suffixes

Queyu	Gloss	Translation
í-tʃì	UP-go.3	'go upwards'
nə̀-tʃí	DOWN-go.3	'go downwards'
lə́-tʃì	UPSTREAM-go.3	'go upstream'
ì-tʃí	DOWNSTREAM-go.3	'go downstream'
kə́-pə̀	IN-wet	'got wet'
tə̀-kʰwí	PFV-give.3	'He/she/it gave.'
ǽ-ʒí	Q-delicious	'Is it tasty?'
tǽ-pʰə̀tʰì	PROH-scatter.2	'Don't scatter!'
mǽ-sʰí	NEG-die	'won't die'
kə́-mə́-ɲʊ̀	IN-NEG-listen.1SG	'I didn't listen.'
méɪ-ndʊ̀	NEG-see.1SG	'I didn't see it.'

Uvularized prefixes can be triggered by the vowel quality of the vowel in the argument suffix. In Table 7, examples of prefixes with verbs containing a uvularized vowel are presented. From the examples below, we see that the vowels in the prefixes are uvularized (except for the three situations mentioned above).

Table 7: Prefixes with verbs containing uvularized vowels

Queyu	Gloss	Translation
í-zʊ̀ʶ	UP-take away.1SG	‘I took’
nə̀ʶ-χqʊ́ʶ	DOWN-boil.1SG	‘I boiled’
lə́ʶ-xpʰə̀ʶ	UPSTREAM-vomit	‘(someone) threw up’
ì-xtʊ́ʶ	DOWNSTREAM-closed (door).1SG	‘I closed the door.’
qɘ́ʶ-pə̀ʶ	IN-rot	‘(It is) rotten.’
tə̀ʶ-hmʊ́ʶ	PFV-close (eyes).1SG	‘I closed (eyes).’
ɑ́ʶ-xsʰíʶ	Q-see clearly	‘Can you see clearly?’
jɑ́ʶ-zèʶ	PROH.DOWNSTREAM-take.2	‘Don’t take it!’
mɑ́ʶ-xsʰíʶ	NEG-see clearly	‘can’t see it clearly’
nɘ́ʶ-mɘ́ʶ-χqò	DOWN-NEG-trouble	‘You are welcome.’
méɪ-mə̀ʶ	NEG-hear	‘I didn’t hear it.’

Beyond the vowel, it is worth noting that for the ‘inward’ prefix *kɘ́-*, the plain form has a velar initial consonant. When the verb stem contains a uvularized vowel, uvularity not only spreads to the vowel in the prefix, but also to the initial stop, change it to a uvular, hence the form *qə́ʶ-*. Examples ‘got wet’ *kɘ́-pə̀* from Table 6 and ‘rotten’ *qɘ́ʶ-pə̀ ʶ* from Table 7 illustrate this alternation. This alternation is the reason I term this phenomenon in Queyu “uvularization” instead of “velarization” or “pharyngealization”. In addition, this allomorphic alternation is one piece of evidence that Queyu data do not present a typical case of vowel harmony, as consonants also undergo uvularization.

Uvularization does not spread rightwards, as suffixes containing plain vowels remain plain when following a stem that contains uvularized vowels. Examples with a plain vs. uvularized root are given in (3) and (4). The patient nominalizer *-ʃə* contains a plain vowel, regardless of the vowel quality in the preceding root.

(3) tʃʰɨ́-ʃə̀
eat-NMLZ
‘food’

(4) ptə̀ʁ-ʃə́
chop-NMLZ
'things to be chopped'

Uvularized prefixes can also be triggered when the stem contains a voiced velar preinitial, which is demonstrated in examples (5–7). The vowels in verb stems are plain in (5–7), but these verbs still pair with uvularized prefixes. The only thing these verbs share in common is that they contain a voiced velar preinitial. The fact that uvularized prefixes can be conditioned by consonants, in the absence of a uvularized vowel, is further evidence indicating that uvularity spreading in Pubarong Queyu may not be vowel harmony in the classical sense.

(5) nə̀ʁ-ɣɲʊ́
PFV-knead.1SG
'I kneaded (the dough).'

(6) tə̀ʁ-ɣʒʊ́
PFV-toss.1SG
'I tossed (something).'

(7) ʃʰʊ̀pʃʰí qə́ʁ-ɣʒɥè
child PFV-feed
'I raised (provide food and materials for) kids.'

There is another type of vowel alternation in verbal prefixes unrelated to uvularization. See (8) and (9), where the directional prefixes *lə́-* turns into *lɘ́-* when followed by *mɘ-* and *tæ-*, and *nə̌-* into *nɘ̌-* when followed by *tæ-*. This type of alternation differs from those just described. The verb stem vowel does not seem to play a role in conditioning the prefixes, as can be seen in the comparison between (8a) and (8b). The verb stem vowel remains the same, but the vowel in the directional prefix changes. However, as uvularity spreading is root controlled, meaning the feature in the verb stem determins the prefix vowel quality, the changed prefixes can still have a uvularized counterpart. This is demonstrated in (10) and (11), where the uvularized *lɘ́ʁ-*, *mɘʁ-*, and *taʁ-* occur. For this type of vowel change, with only limited examples so far, no concrete conclusion can be drawn. More data are needed for further exploration of this type of prefix alternation.

(8) The *lə́-* prefix changes to *lɘ-* when preceding *mɘ-* and *tæ-*:
  a. lə́-ʃʰʊ̀
  UPSTREAM-go.1SG
  'I went upstream.'

b. lə́-mə́-ʃʰʊ̀
UPSTREAM-go-NEG.1SG
'I didn't go upstream.'

c. lə́-tæ̀-ʃʰɨ̀
UPSTREAM-PROH-go.2SG
'Don't go upstream.'

(9) The *nə̆-* prefix changes to *nɘ-* when preceding *tæ-*:

a. nə̀-ʃʰʊ́
DOWN-go.1SG
'I went down (to Chengdu's direction).'

b. nə́-tæ̀-ʃʰɨ
DOWN-PROH-go.2SG
'Don't go (to Chengdu's direction).'

(10) The *lə́ʶ-* and *mɘʶ-* prefixes can also be uvulairzed:

a. lə́ʶ-xpʰə̀ʶ
UPSTREAM-vomit
'(Someone) vomited.'

b. nə́-tæ̀-ʃʰɨ
UPSTREAM-NEG-vomit
'(Someone) hasn't vomited yet.'

(11) The prohibitive marker *taʶ-* can also be uvularized:

a. ə́-zèʶ
UP-take.2
'(You) take it.'

b. í-tàʶ-zèʶ
UP-PROH-take.2
'Don't take it.'

2.4 Exceptions to vowel harmony

While plain and uvularized vowels in a verb stem can trigger different sets of prefixes, there are two vowels that do not follow this pattern: /o/ and /u/. Some verbs containing these two vowel suffixes pair with plain prefixes, while others trigger a uvularized allomorph. As shown in Table 8, verbs containing /o/ and

Table 8: Vowels /o/ and /u/ exhibiting uvularized vowel behavior

Lexicon	Gloss	Translation
qə́ʶ-dò	IN-tie	‘tied up, chained up’
ɑ́ʶ-tʂó	Q-cold	‘Is it cold?’
tɑ̌ʶ-xtù	PFV.Q-hit.3	‘Did he hit?’

/u/ can pair with uvularized prefixes. Morphologically speaking, the /o/ and /u/ phonemes in these cases trigger uvularized prefixes, which is strong evidence suggesting that /o/ and /u/ belong to the uvularized set of vowels.

However, in some verbs /o/ and /u/ behave like plain vowels. From Table 9, we see that ‘happy’ *gó*, ‘dance’ *dʒó,* and ‘hug’ *xtú* pair with a plain prefix. If /o/ and /u/ were behaving like uvularized vowels in these words, they would trigger the uvular allomorphs of the prefixes. Additionally, if uvular consonants in Pubarong Queyu are allophones of velar sounds triggered by uvularized vowels, then the fact that ‘happy’ *gó* starts with a velar consonant rather than a uvular consonant suggests that /o/ behaves like plain vowel here.

Table 9: Vowels /o/ and /u/ exhibiting plain vowel behavior

Lexicon	Gloss	Translation
mǽ-gó	NEG-be.happy	‘unhappy’
mǽ-dʒó	NEG-dance	‘won’t dance’
jæ̌-xtù	PFV.Q-hug.3	‘Did he hug?’

Another piece of morphological evidence suggesting that /u/ behaves both as a plain and a uvularized vowel comes from verbal paradigms. There are both plain and uvularized verbs whose third person forms end with a *-u* suffix. Examples are given below.

Table 10: 3rd person verb forms ending with /u/

Gloss	1SG	1PL	2SG	2PL	3
‘buy’	xkʊ́	xkǽ	xkí	xkí	xkú
‘hit, pound’	xtʊ̌ʶ	xtɑ̌ʶ	xtɪ̌ʶ	xtɪ̌ʶ	xtǔ

Since /o/ and /u/ may behave like either plain vowels *or* uvularized vowels, this is further evidence that analyzing this data from a traditional vowel harmony perspective can be problematic. That /o/ and /u/ behave like both plain and uvularized vowels suggests that historically for each there may have been be two sets of vowels, plain and uvularized, that have merged into /o/ and /u/ respectively.[6] Phonetically there is no distinction now, and there is only morphophonological evidence as a trace of this possible merger.[7]

3 Uvularized vowels and other similar vowels in regional typological studies

The data presented above show that Queyu contrasts plain and uvularized vowels. Uvularity in Queyu can spread leftward across morpheme boundaries, which is best evidenced by the presence of uvularized prefixes triggered by uvularized vowels in verbs. In addition to vowels, velar consonants can also be the target of uvularization, as they become uvular consonants when preceding a uvularized vowel. Uvularized prefixes can also be triggered by a voiced velar preinitial consonant in the verb stem. Two vowels, /o/ and /u/, do not follow this pattern, and behave as plain *and* uvularized both morphosyntactically and morphophonologically. The vowel /o/ can occur after both non-uvular and uvular consonants, and *-u* can be a verbal suffix for third person forms in both paradigms, pairing with both plain and uvularized prefixes.

These facts lead to the following four questions:

1. What are the phonetic differences between plain and uvularized vowels in terms of acoustics and articulation?

2. How can we account for the spreading of uvularity in Pubarong Queyu?

3. What is the origin of the uvularized vowels in Pubarong Queyu?

4. For /u/ and /o/, one possible hypothesis is that there used to be both /u/ and /uʶ/, and /o/ and /oʶ/ which then merged into /u/ and /o/ respectively. Or could /uʶ/ and /oʶ/ still exist in this language?

[6] Personal communication with Dr. Lin You-jing and Dr. Lai Yunfan.

[7] However, we cannot rule out the hypothesis that /oʶ/ and /uʶ/ still exist. Further acoustic measurements are required to investigate this issue. I would like to thank Dr. Spike Gildea for pointing this out.

This section presents data from closely-related languages attesting similar phenomena, and aims to address the first three questions. Literature on other Qiangic languages are introduced first, and it is important to note that different terms have been used to label marked vowel qualities, similar to Queyu's uvularized vowels, in Qiangic/Rgyalrongic languages. There is no consensus among Tibeto-Burmanists about how to describe and analyze the phenomena associated with uvularization and other similar vowel qualities. Detailed comparison among each author's suggestions will be beyond the scope of this chapter; therefore readers are suggested to consult the original works mentioned here for further reference. Section 3 merely presents a summary of the current available literature on this topic within Qiangic/Rgyalrongic. Tables and data from other languages in this section are reproduced from other works with no changes made to transcription or glossing style.

This overview of the literature has two aims. The first is to introduce the current state of the analysis of uvularization and relevant phenomena within Qiangic/Rgyalrongic. The second is to show discrepancies in current findings on this topic that have not been well explained and draw attention to the need for more acoustic studies and systematic explanations.

In this section, a brief summary of uvularized vowels and similar vowel qualities in the TB family is given in Section 3.1, followed by an examination of the articulation of uvularized, velarized, and pharyngealized vowels in Section 3.2. Section 3.3 reviews acoustic and ultrasound studies done in Qiangic/Rgyalrongic languages, summarizing the acoustic characteristics of the marked vowels in comparison with their plain counterparts. Section 3.4 presents information on vowel harmony within Qiangic, a phenomenon associated with uvularization. Section 3.5 discusses possible origins of phenomena relevant to uvularization.

3.1 Similarities among uvularized, velarized, and pharyngealized vowels noted in the literature

While velarization and pharyngealization are usually secondary articulations associated with consonants, these qualities are vowel features in Qiangic languages such as Puxi Stau (Ladefoged & Maddieson 1996: 360, 365, Lin et al. 2012: 87). The similarity between velarization and pharyngealization is noted in Ladefoged & Johnson (2011: 236), who point out that there is no language that distinguishes these two possibilities. This similarity is also brought up several times in the descriptions of Qiangic languages summarized below.

The rare vowel distinction discussed here is first mentioned for a TB language in Sun's (2000b) description of verbal inflection in the Puxi variety of Stau, under the term “velarization”. Evans (2006a,b) describes the vowel quality in the Hongyan variety of Northern Qiang as “pharyngealization” and discusses the feature’s origins. Evans (2006b) is the first study that addresses pharyngealization in TB languages. Evans (2006a: 94; 2006b: 737) mentions that Jackson Sun, through personal communication, has pointed out the phonetic similarity between velarized vowels in Rgyalrongic languages and pharyngealized vowels in Hongyan Qiang. In a later study, Sun & Evans (2013) revisit the vowel quality issue in Yunlinsi (Hongyan) Qiang, and amend the analytical umbrella label to “uvularization” rather than “pharyngealization”.

In a study on uvularization in Tangut, an extinct Qiangic language, Gong (2020: 193–194) reconstructs uvularized vowels, describing uvularization in Qiangic languages as a case of guttural secondary vocalic articulations (GSVA), and notes that this distinction is similar to one found in Eastern Minyag,[8] which is described as a lax/tense distinction by Huang (1985) and as an ATR/RTR (Advanced tongue root/Retracted tongue root) distinction by Gao (2015). In Eastern Minyag, velar consonants only occur preceding lax/ATR vowels, and uvular consonants only occur preceding tense/RTR vowels. The Eastern Minyag tense/RTR vowels, to Gong’s ear, sound as though they contain pharyngealization (Gong 2020: 194).

Pharyngealized vowels are also found in non-Qiangic languages of the region. Suzuki (2011) presents data on pharyngealized vowels in Gagatang Tibetan and examines their origins by comparing data from Written Tibetan, adjacent Tibetan varieties, and Naxi, a local Naic language. He discusses the connection between pharyngealization and rhotacization in vowels and points out in a later study (Suzuki 2013: 29–31) that rhotacized vowels in Naxi are velarized or pharyngealized in some varieties. He also notes that the tense vowels in Naxi brought up by Yang (1984, 1991) correspond to rhotacized vowels in other scholars’ descriptions. It is worth noting that the pharyngealized vowels found in Gagatang Tibetan are unique among Tibetic varieties (Suzuki 2011: 489). Furthermore, Gagatang Tibetan is spoken in Yunnan Province, near the border of Sichuan Province, just to the south of where the Qiangic languages are spoken. The languages within the family attested to have these vowel distinctions are therefore spoken roughly within the same geographical region. Suzuki (2011: 492–493) suggests that the development of pharyngealization in Gagatang Tibetan vowels may come from the influence of neighboring languages, possibly from Naxi. The spreading of uvular

[8] However, the literature that Gong (2020) cited, i.e. Huang 1985 and Gao (2015), are based on Minyag spoken in Kangding, which is classified as the Western variety of Minyag rather than the Eastern variety. This chapter keeps the original wording of the source literature when citing them, but the mismatch in use of terminology should be noted.

consonants is also suggested to be due to contact by Urban & Moran (2021: 27) in Sino-Tibetan.

3.2 The articulation of uvularized vowels and similar vowel qualities

Ladefoged & Johnson (2011: 235–236) summarize that the back of the tongue is raised during velarization, and that pharyngealization involves the narrowing of the pharynx during articulation. Uvularized vowels are characterized by constriction of the styloglossus and other muscles, which draws the tongue dorsum towards the uvula (Evans et al. 2016: 1). Other vowel qualities such as velarization and pharyngealization mentioned in related languages have similar articulatory gestures. Sun (2000b: 215) points out that the articulatory gestures of velarized vowels in Puxi Rgyalrong are characterized by the dorsum of the tongue arching towards velum. Evans et al. (2016) use ultrasound imaging to explore the articulatory gestures of uvularized vowels in Mawo and Luhua, two Northwestern Qiang varieties spoken in Heishui Town. In terms of articulation, ultrasound imaging shows that the tongue is retracted towards the uvular region when producing a uvularized vowel, in juxtaposition with a plain vowel counterpart (Evans et al. 2016: 22). An ultrasound imaging study on pharyngealized vowels in two Northern Horpa (*aka* Stau, Ergong, Daofu) varieties shows that the tongue body retracts and forms double bunching when producing pharyngealized vowels (Chiu & Sun 2020: 2938).

In sum, these articulations involve a stricture at the velum, uvula, or pharynx region, and the tongue body is usually retracted. The acoustic characteristics of these vowels are also similar, as will be addressed in Section 3.3. The correlation between articulatory features and acoustic measurements will be discussed in the next subsection.

3.3 Acoustic properties of uvularized, velarized, and pharyngealized vowels in Qiangic languages

There are occasional mentions of the similarities among uvularized, velarized, and pharyngealized vowel qualities in the literature on TB languages spoken in Southwest China. There are also mentions of the fact that these vowels can trigger vowel harmony. Lin et al. (2012: 88) acoustically examine velarized vowels in Puxi Stau, finding that velarized vowels have a significantly lower F2 and a raised F3 when compared to their plain vowel counterparts. Though change in F1 is not significant, lower F2 indicates retraction of the tongue root, which matches the articulatory gesture identified for velarized vowels (Lin et al. 2012: 88–89).

Sun & Evans (2013) re-examine the vowel system in Mawo Qiang, a Northern Qiang variety with a series of uvularized vowels, finding the most prominent acoustic feature of uvularized vowels to be a lowered F2 (Sun & Evans 2013: 141). Both F1 and F3 are raised in uvularized vowels as compared to their plain-vowel counterparts.

Evans et al. (2016) also acoustically examine vowel uvularization in Mawo and Luhua Qiang. Compared to their plain counterparts, uvularized vowels have higher F1 (significant for non-schwa vowels), lower F2, and increased difference between F3 and F2.

The study by van Way (2018) is a description and analysis of the phonetics and phonology of another Qiangic language, Nyagrong Minyag. He examines uvularization in vowels, and provides acoustic measurements which show a raised F1 value for uvularized high vowels compared to their plain counterparts ([i], [y], and [u]). He also finds a lower F2 for uvularized non-high vowels ([ə], [ɔ], and [a]). F3 is slightly increased in all uvularized vowels except for [iʶ] and [aʶ] (van Way 2018: 103). All in all, drop in F2 is found to be the most salient acoustic cue for uvularized vowels (van Way 2018: 123).

Chiu & Sun (2020) examine pharyngealized vowels in two Northern Horpa (Stau) varieties—Rtsangkhog and Yunasche. In addition to the articulatory study mentioned in Section 3.2, which found tongue retraction, backing, and double bunching during the production of pharyngealized vowels (Chiu & Sun 2020: 2938), the authors conducted an acoustic study. The results showed that F1 is higher in pharyngealized vowels than in plain vowels and that this higher value corresponds to the lowering of the tongue (Chiu & Sun 2020: 2939). The change observed for F2 is not as consistent as that of F1, in that F2 is lowered substantially for most pharyngealized vowels, but not for [uˤ] in Rtsangkhog or [oˤ] and [uˤ] in Yunasche (Chiu & Sun 2020: 2941). For F3, the formant frequency increases for certain vowels ([əˤ], [ɐˤ], [oˤ] and [uˤ] in Rtsangkhog, [ɐˤ], [oˤ] and [uˤ] in Yunasche), and decreases for front vowels (Chiu & Sun 2020: 2941–2942).

Table 11 summarizes the results from previous studies on the comparison of formants between two sets of vowels (plain and uvularized/velarized/pharyngealized) in different Qiangic languages. Blank cells indicate that the study did not address a property specifically.

3.4 Vowel harmony in Qiangic

Despite the fact that different terms are used to describe vowel qualities in the Rgyalrongic/Qiangic languages reviewed in Section 3.1 and Section 3.2, these vowel contrasts behave similarly in that they participate in a similar phonological

Table 11: Acoustic differences in Qiangic languages between uvularized/ velarized/ pharyngealized vowels and their plain counterparts. *Note*: Although the acoustic measurements are inconsistent between plain and uvularized/ velarized/ pharyngealized vowels in the Rgyalrongic/Qiangic languages, this does not necessarily mean that vowel qualities/ cues are different in different languages. Differences may emerge from insufficient statistical power, which is very likely in phonetics, especially with understudied languages, or between-speaker variability in cue use within the language. Another reason might be due to differences between methods of measurement or the design of experiments. Refinement of existing descriptions will need to test interactions between cues and the language. I would like to thank Dr. Volya Kapatsinski and Dr. Natalia Kuznetsova for bringing these points to attention.

Sources	Language	Vowel quality	F1	F2	F3	F3-F2
Lin et al. (2012)	Puxi Stau	Velarization	No significant change	Decrease	Increase	
Sun & Evans (2013)	Mawo Qiang	Uvularization	Increase	Decrease	Increase	
Evans et al. (2016)	Mawo Qiang	Uvularization	Increase[a]	Decrease		Increase
	Luhua (Yunlinsi-Hongyan)	Uvularization	Increase[a]	Decrease		Increase
van Way (2018)	Nyagrong Minyag	Uvularization	Increase	Decrease	Increase[b]	Increase
Chiu & Sun (2020)	Rtsangkhog Horpa	Pharyngealization	Increase	Decrease[c]	Increase[d]	
	Yunasche Horpa	Pharyngealization	Increase	Decrease[e]	Increase[f], little difference[g]	

[a] significant for non-schwa vowels
[b] except for [iʶ] and [aʶ]
[c] except for [uˤ]
[d] significant for [əˤ], [ɐˤ], [oˤ] and [uˤ]
[e] except for [uˤ] and [oˤ]
[f] significant for [ɐˤ], [oˤ] and [uˤ]
[g] for [eˤ] and [əˤ]

process, vowel harmony. Vowel harmony is not common among TB languages, with most cases reported in Qiangic, and only a few in the Naic and Tibetic languages of the Himalayish subgroup (Chirkova 2024: 729). Sun (2016: 10) considers vowel harmony to be a feature of the Qiangic branch. While vowel harmony is commonly reported in languages spoken in the Middle East, Africa, Northeast Asia, and the Pacific Northwest coast of North America, information on vowel harmony in Qiangic and Naic is limited. Chirkova (2024: 730) asserts that these latter languages are "virtually unknown in literature on vowel harmony". Examining the relationship between vowel harmony and uvularized vowels in Queyu in the contexts of both TB linguistics and other languages can contribute to typological as well as phonological understandings of vowel harmony.

There is great diversity among the vowel harmony systems of Qiangic languages (Chirkova 2024: 731). For example, Yadu Qiang, reported in Evans & Huang (2007), has five vowel harmony processes: front, low, ATR, round, and rhotic. On the other hand, Ersu, another Qiangic language spoken in South Sichuan, only has low vowel harmony (Chirkova et al. 2015). In the rest of this section, I will examine vowel harmony processes in Qiangic and other languages and similar processes in Queyu, specifically harmony processes triggered by post-velar consonants and/or by vowel quality.

In a typological phonological study of post-velar consonants, Sylak-Glassman (2014: 75) states that "[p]ost-velar harmony processes are neither consonant nor vowel harmony, but consonant-vowel (CV) harmony systems", and that the phonetic form of post-velarization can be either uvularization (as in the case of Arabic) or pharyngealization (as in the case of Nakh-Daghestanian languages). This statement also fits the situation of many Qiangic languages.

Gong (2020: 193) divided Rgyalrongic/Qiangic languages into three types based on their realization of what he terms "guttural secondary vocalic articulation" (GSVA). These are:

(1) uvularity-coupled secondary articulation, where velar and uvular onsets are conditioned by the presence of GSVA and are in complementary distribution; that is, uvular initials occur with uvularized vowels and velar initials occur with plain vowels (Gong 2020: 193);

(2) uvularity-decoupled secondary articulation, where GSVA is not phonologically bound with a consonantal velar-uvular distinction;

(3) absence of GSVA.

Pubarong Queyu is of the first type. Other Qiangic languages of this type include Mawo Qiang and Yunlinsi Qiang (Evans et al. 2016), and Eastern Minyag, as described by Huang (1985) and Gao (2015). Examples of Yunlinsi Qiang phonotactics are given in Table 12. From the example pairs given in Table 12, it is clear that uvularized vowels pair with uvular consonants, while plain vowels pair with velar consonants.

Table 12: Yunlinsi plain-uvularized vowel harmony (Evans et al. 2016: 18)

	i	iʶ	u	uʶ	ə	əʶ	a	aʶ
k-	/ki/ 'house'		/ku/ 'turnip'		/kə/ 'go'		/kaχuʶ/ 'koklass pheasant'	
q-		/qiʶ/ 'win'		/quʶ/ 'afraid'		/qəʶ-/ 'head'		/qaʶ/ '1sg'

Languages of the second GSVA type include Zbu Rgyalrong (Sun 2004), where the distinction between the two sets of vowels is analyzed as velarization. This type of GSVA differs from the first one in that in the root, the plain vowel /ɐ/ can appear after both velar and uvular consonants (Gong 2020: 194–196). Velarized vowels in roots also trigger regressive vowel harmony in prefixes. Examples demonstrating this type are given in Table 13 from the *rɟaltsúˠʔ* variety of Zbu Rgyalrong, where /a/ is the velarized allophone of /ɐ/. In 'my cat', and 'my horse', the feature of velarization is spreading regressively to the prefix vowel. As evident from Table 13, however, both velar and uvular consonants can occur with /ɐ/ in roots (Gong 2020: 194).

Table 13: Zbu Rgyalrong plain-velarized vowel harmony (Gong 2020: 194)

Vowel pair	Plain vowel	Translation	Velarized vowel	Translation
/ɐ a/	/ɐ-wɐmɐ̂/ /ɐ-qɐ́ʔ/	'my cat' 'my wheat'	/a-ⁿbrâ/ /ɐ-rkɐ̂/	'my horse' 'my mule'

The third type, absence of GSVA, is the most widespread in Qiangic languages (Gong 2020: 194). However, it should be noted that uvular consonants are not always simply the result of harmonic processes and are present in all Qiangic languages (Sun 2016: 10).

3.5 Origins of uvularized, pharyngealized, and velarized vowels

The origins of the velarization, uvularization, and pharyngealization attested in different TB languages have been discussed in previous studies. The most common proposed source for these uncommon vowel distinctions is the loss of a velar or uvular initial and/or coda (that is, a preceding or following consonant). Much of the Queyu data are examples of this type. Evidence can be found in Tibetan loanwords such as ‘leopard’ *gzig* and ‘farming area’ *rong*, which are *ɣzɨ́ʶ* and *rʊ̌ʶ* in Queyu, respectively. A similar phenomenon can also be observed in related languages like Tangut, in which reconstructed uvularized syllables correspond to Japhug Rgyalrong words with uvular codas or initials (Gong 2020). In fact, syllable reduction is an areal feature where Queyu is spoken. In her typological study on syllable structures, based on synchronic, historical, or comparative evidence, 24 out of 100 languages were observed to have gone through a change from more simple to more complex structures (Easterday 2019: 290). Queyu shows the opposite diachronic pathway, supported by evidence from comparison with Written Tibetan and contemporary TB languages such as Khroskyabs (see Section 3.5.1). The dominant local language, Kham Tibetan, has less complex syllable structure compared to Written Tibetan and Amdo Tibetan.

The connection between velar/uvular sounds and rhotic sounds is addressed in Section 3.5.2, as is the possibility that the various vowel qualities discussed here may have come from the same historical source.

3.5.1 Sources of uvularization, velarization, and pharyngealization in Qiangic languages

Sun (2000b) suggests that one important source of vowel velarization in Puxi Stau is rounding in the rimes of proto-words,[9] with evidence in comparative Rgyalrongic data given in Table 14. In Table 14, velarized vowels in Puxi Stau correspond to rounded rimes in other Rgyalrongic languages.

Evans (2006a: 114–118) on the basis of data from several Qiangic languages in comparison to Proto-Southern Qiang (PSQ) and Proto-Tibeto-Burman (PTB) argues that pharyngealized vowels may have come from PTB *-w- that led to the

[9] Though the rounding in the rime for the example for ‘to melt’ is unclear from Sun’s presentation, the presence of /w/ in the Caodeng example may suggest a rounded element in the proto-form.

Table 14: Comparative Rgyalrongic data (Sun 2000b: 215). An underlined vowel in the Puxi Stau data indicates a vowel with a low tone (Sun 2000a: 166)

Puxi (Stau)	Geshizha (Stau)	Mu’erzong (Khroskyabs)	Caodeng (Rgyalrong)	Zhuokeji (Rgyalrong)	Translation
lmə̱^{ɣ}	lmu	lmoʔ	tə-rmu	tə-rmo	‘hail’
ts^{h}ə^{ɣ}	ts^{h}uə	ts^{h}oʔ	ts^{h}o	ts^{h}o	‘be fat’
dʒvə̱^{ɣ}	dʑə	dʑə	^{n}dʒwiʔ	–	‘melt’
znə̱^{ɣ}	snə	mnə	‘nos	nos	‘dare’

retraction of the tongue root. Table 15 is adapted from Evans (2006a: 114) showing only Hongyan Qiang (HY), PSQ, and PTB data.

Table 15: Hongyan pharyngealized vowels corresponding to PTB *-w- (Evans 2006a: 114)

Translation	Hongyan Qiang	Proto-Southern Qiang	Proto-Tibeto-Burman
‘pig’	pji^{ʕ}	*pia	*pwak
‘yellow’	χa^{ʕ}	*χa-χa	*hwaːr
‘water’	tsə^{ʕ}	*tsuə	*twəy
‘light, bright’	ɕi^{ʕ}	*ɕya	
‘sole of foot’	pa^{ʕ}		*p^{w}a-n

Evans (2006a: 119) also suggests that the development of pharyngealized vowels in Hongyan Qiang may be due to the influence of velarized vowels in nearby Rgyalrongic languages. Lin et al. (2012) point out that the source of some velarized vowels in Puxi may be the dropping of a velar consonant in consonant clusters. Evidence can be found in related languages like Khroskyabs and Stau. For example, ‘to buy’ is *rə*^{ɣ} in Puxi, *ɣdə* in Xiaoyili Khroskyabs, and *ɣruʔ* in Yelong Khroskyabs, while ‘horse’ is *ri*^{ɣ} in Puxi, but *rɣi* in Stau (Lin et al. 2012: 90). These authors also argue that velarization may be a feature inherited from Proto-Rgyalrong, as the three modern Rgyalrongic languages that preserve velarized vowels show correspondence in cognates. This is strong evidence suggesting that Proto-Rgyalrong contrasted plain and velarized vowels (Lin et al. 2012: 90). Examples are given in Table 16.

Gong (2020) also argues that uvularized syllables should be reconstructed for Tangut. The uvularized syllables he reconstructs correspond to Japhug Rgyalrong

Table 16: Velarization correspondence in three modern Rgyalrongic languages (Lin et al. 2012: 90)

Translation	Puxi Stau	Xiaoyili Khroskyabs	Showu Rgyalrong
‘ice’	lvôˠ	rpʰəˠm	ta-lvāˠm
‘(man’s) sister’	snôˠ	–	tə-snāˠm
‘wide’	lo̰ˠ	lə̰ˠm	kə-lāˠm
‘neck tumor’	zvâˠɣ	zvʌˠv	tə-zbâˠv
‘spicy’	ltsʰʌ̂ˠv	ltsʰaˠv	kə-vartsāˠv
‘deep’	nʌˠv	nʌ̂ˠv	kə-nôˠɣ

words with a uvular initial or coda. Comparative data supporting his argument are given in Table 17.

Table 17: Reconstructed uvularized syllables in Tangut corresponding to Rgyalrongic uvular initials and codas (Gong 2020: 199)

Translation	Tangut examples	Japhug Rgyalrong	Other Rgyalrong
‘weave’	{lɑʶ}	/-taʁ/	Zbu /-tɐ̂ʁ/, Khroskyabs /dɑ̂ɣvi/
‘be thirsty’	{pɑʶ}	/ɕpaʁ/	Zbu /-sphjɐ́ʁ/, Stau /spar/
‘brain’	{noʶ}	/tɯ-rnoʁ/	Zbu /tə-rnôʁ/
‘winter’	{tsuʶr}	/qartsɯ/	Zbu /qɐrtsóʔ/, Khroskyabs /rtsô/
‘frog’	{pʕiʶ}	/qaɕpa/	Zbu /qɐchíʔ/, Stau / spəɟcher/
‘buy’	{lwəʶ}	/-χtɯ/	Zbu /-χtə̂/, Khroskyabs /jdə̂/, Stau /rə/
‘sun’	{biʶ}	/ʁmbɣi/	Stau /ɣbə/

From Table 17, we see that Tangut uvularized syllables correspond to Japhug Rgyalrong words with either uvular codas (for ‘weave’, ‘be thirsty’, and ‘brain’) or uvular initials (for ‘winter’, ‘frog’, ‘buy’, and ‘sun’). Miyake (2012) uses the term “compression effect” to describe this spreading of a feature from the syllable periphery over the entire syllable. In fact, this phenomenon applies to rhotacized syllables (syllables with an -r ending) in Tangut, too, as rhotacized syllables developed from both preinitial *r- and coda *-r (Jacques 2014: 23–29). For example, ‘put inside’ in Tangut is *kur*, corresponding to *-rku* in Japhug, and ‘sour’ in Tangut is *tśhwər*, corresponding to *-tɕur* in Japhug (Gong 2020: 199).

Pubarong Queyu has a similar story with respect to the origins of uvularization. Comparison between cognates and loanwords between Queyu and neighbouring related languages shows that uvularized vowels in Queyu are related to the loss of a velar or a uvular consonant in either initial or coda position. Table 18 compares loanwords from Tibetan in Queyu alongside their forms in Written Tibetan. For ‘tiger’, ‘see (clearly)’ and ‘leopard’, the Tibetan words contain a velar coda, which corresponds to the uvularized vowel in the Queyu loanword forms. The case of ‘leopard’ and ‘Tibetan agate’ is tricky, in that these words are homophonous in Queyu (both uvularized), whereas Tibetan ‘leopard’ contains a velar coda, but ‘Tibetan agate’ does not.

Table 18: Comparing Tibetan loan words in Queyu and Written Tibetan

Translation	Written Tibetan	Queyu
‘tiger’	stag	xtɑ́^{ʁ}
‘see clearly’	gzhigs (‘see’)	xs^{h}ɪ́^{ʁ}
‘leopard’	gzig	ɣzɨ́^{ʁ}
‘Tibetan agate’	gzi	ɣzɨ́^{ʁ}

Table 19 presents data from Khroskyabs (Lai Yunfan, p. c., July 6, 2021) and Queyu. The word ‘to rot’ in Khroskyabs has a velar coda that is lost in Queyu, which results in vowel uvularization. In ‘to close eyes’, ‘asleep’, and ‘scar’, uvularized vowels in Queyu correspond to a velar/uvular initial in Khroskyabs words.

3.5.2 Rhotacization and other phenomena relevant to uvularization

The correspondence between uvularized syllables in Tangut and other Rgyalrongic languages addressed in Gong (2020), together with the comparative data shown for Queyu and related languages, raises questions about the relation between uvularization and rhotacization.

Notions of vocalic rhotacization, velarization, pharyngealization, and tenseness are confounded in synchronic studies (Evans 2006a,b, Gong 2020, Chirkova

Table 19: Comparing Khroskyabs and Queyu data

Translation	Khroskyabs	Queyu
‘rot’	pə́ɣ	pə́^{ʁ}
‘close eyes (VT)’	χsmə́	hmʊ̌^{ʁ}
‘asleep’	ʁmə́ (‘close (eyes), VI’)	mě^{ʁ}
‘scar’	ɣmí	mé^{ʁ}

2024), and seem to be connected to historical changes. In his study examining pharyngealized vowels in Gagatang Tibetan, Suzuki (2011) points out that one important source of pharyngealized vowels is the initial or medial *r* from Written Tibetan. For example, ‘mountain’ ´ *ɦɜˤː* in Gagatang corresponds to *ri* in Written Tibetan. In a later study, he describes sound changes related to the medial *r* in Tibetan with a focus on how they affected vowel quality (Suzuki 2013). He concludes that the dropping of initial or medial *r* can result in vowel pharyngealization or rhotacization among the Tibetan varieties spoken in Gagatang. Suzuki (2013: 30–31) also discusses several similar and overlapping phenomena in nearby languages and bring up the issue of using different terminologies for these phenomena. He argues that this is due to the fact that “rhotacization” and “tenseness” are umbrella terms that cover multiple characteristics and articulatory gestures. Ladefoged & Johnson (2011: 229–230) point out that *r*-colouring in American English can also have multiple gestures, all of them involving a narrowing of the pharyngeal cavity and characterized by a marked lowering of F3. Zhu (2010: 106) also notes that the terms “tense/lax” have been used to describe as many as sixteen different phenomena in the TB literature. Suzuki (2013:31) then suggests that the term “tense vowels” covers velarized or pharyngealized vowels, and “rhotacized vowels” may refer to rhotacized vowels, but also to velarized and pharyngealized vowels. Vowel velarization and pharyngealization, therefore, overlap in the terminology with rhotacization and tenseness.

4 Conclusion

This chapter examined phonological, typological, and diachronic features of uvularized vowels, which contrast with plain vowels, in Queyu, an understudied TB language within the Qiangic branch. Uvularized vowels trigger uvular allophones of preceding velar consonants, as well as regressive uvularization in the vowels of certain prefixes. One way to analyze the effect of Queyu uvularized vowels on surrounding phonemes is from the perspective of vowel harmony. However, Queyu feature spreading is not a typical case of vowel harmony because it also involves allophonic variation in consonants and can even be triggered by consonants. Many Qiangic languages contain two similar classes of vowels that differ in terms of vowel quality and vowel harmony processes. In different languages, specific vowel quality may differ slightly in terms of articulation and acoustics. Terms like "velarization", "uvularization", and "pharyngealization" are used to describe these similar phonological phenomena in different languages. It is unclear to what extent these different terms reflect distinct synchronic phenomena (both in terms of actual pronunciation and phonological patterns) as opposed to being different ways of talking about the same or similar phenomena.

The articulation of these non-plain vowels involves a constriction of the root of the tongue towards the velum, uvula, or pharynx wall. Vowels that are supposed to be pronounced with a retracted tongue root can be phonologically grouped in a harmonic set with several phonetic manifestations. Among the latter, higher F1 (which is at the same time also a correlate of tongue height) and pharyngealization are the two most important (Sylak-Glassman 2014: 75, Barrere & Janhunen 2019: 54).

Variation in the acoustic measurements for marked vowels exists not only in TB languages, but in languages with similar vowel qualities or phonological processes. Within TB languages, Lin et al. (2012), Sun & Evans (2013), and van Way (2018) find the change in F2 to be the most prominent acoustic cue for a marked vowel, while Chiu & Sun (2020) find a change in F1 to be more consistent than F2. Lin et al. (2012) do not find a significant change in F1, but Evans et al. (2016) find higher F1, lower F2 and increased difference between F3-F2 to be defining acoustic properties of marked vowels. There is more variation found in F3 values across languages, with Puxi Stau and Nyagrong Minyag having a raised F3, and no consistent pattern for Mawo and Luhua Qiang, or Rtsangkhog and Yunasche Stau (Lin et al. 2012, Evans et al. 2016, van Way 2018, Chiu & Sun 2020). For non-TB languages, studies show variation in the acoustic measurements for pharyngealized vowels as well. For example, F3 rises in pharyngealized vowels in Arabic (Yeou 2001) and Upper Saxon (Khan & Weise 2013) but decreases for Amis (Maddieson & Wright 1995) and !Xóõ (Ladefoged & Maddieson 1996). In a study on ATR harmony in Akebu, a Niger-Congo language spoken in Africa, F1 is found to be the most robust acoustic correlate for [+ATR] vowels among other phonetic properties measured. However, F1 alone is not enough to differentiate [ATR] from vowel height or tenseness (Makeeva & Kuznetsova 2022).

Inconsistency in the acoustic properties of the members within a harmonic set might explain the inconsistency in their transcriptions and nominations across studies. In fact, the vowel pair /æ, ɑʶ/ sound like [æ, a] and were previously transcribed that way in Queyu. This is also the case in Qiang, as Evans et al. (2016: 5) note that both in Yunlinsi and in Mawo Qiang, /a, aʶ/ sound like [æ, a], and /u, uʶ/ pair sound like [ʉ, o]. These instances suggest that the vowel quality discussed here as "uvularization" may be more of a phonological than a phonetic feature, and one which has spread with different phonetic manifestations across languages.

While vowel uvularization may have arisen due to the loss of a velar or uvular initial and/or coda in Queyu and other Qiangic languages, the origins of uvular consonants in TB languages are still controversial. In Gagatang Tibetan, the development of vowel pharyngealization corresponds to an initial and medial *r* in Written Tibetan.

More descriptions of Queyu, as well as other Qiangic languages, are needed to investigate the uvularization phenomenon and others like it. A particularly important direction for future research on Queyu is the systematic acoustic and articulatory analysis of vowel qualities in order to see how the articulation and acoustics of uvularized vowels pattern in comparison to those found in other related and unrelated languages of the region. Such studies would help to determine the extent to which acoustic properties of vowel quality may themselves be areal features.

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Abbreviations

1	first person	C	consonant
2	second person	DOWN	downward
3	third person	DOWNSTREAM	downstream/ outward/right
ATR	advanced tongue root		

EGO	egophoric	PVH	palatal-velar harmony
G	glide	Q	question
GNR	generic	RTR	retracted tongue root
GSVA	guttural secondary vocalic articulation	SAP	speech act participant
HY	Hongyan	SG	singular
IN	inward	TB	Tibeto-Burman
IPFV	imperfective	TRH	tongue root harmony
NEG	negation	UP	upward
NMLZ	nominalizer	UPSTREAM	upstream/left
P	pre-initial consonant	V	vowel
PFV	perfective	VT	transitive verb
PL	plural	VI	intransitive verb
PROH	prohibitive		
PSQ	Proto-Southern Qiang		
PTB	Proto-Tibeto-Burman		

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Part V

Rare consonants

Chapter 12

Silent sonorant articulations in Mehri and Shehret

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Mehri and Shehret, two languages in the endangered Modern South Arabian group spoken in the south of the Arabian Peninsula, exhibit the heretofore cross-linguistically unreported feature of silently articulated sonorant consonants in the codas of utterance-final syllables. While these utterance-final sonorants are all pre-glottalised in Mehri, Shehret contrasts pre-glottalised and pre-aspirated sonorants, all of which become silently articulated utterance-finally. Our study presents and discusses video and electropalatographic evidence for their silent articulation and electrolaryngographic evidence for glottal constriction in vowel offsets before pre-glottalised sonorants, and glottal relaxation before pre-aspirated sonorants as forms of laryngeal feature-strengthening responsible for rendering the articulation of final sonorants silent. Rather than a "voiceless–voiced" analysis, our results support a "breathed–unbreathed" analysis of Mehri and Shehret laryngeal phonology. We conclude that in order to adequately fit these silently articulated sonorants into a typology of lenition, the concept of lenition may have to be extended to include the loosening, or weakening, of coordinative relations between the phonatory and articulatory components of speech production.

1 Introduction

Silent articulations, whereby we mean the absence of acoustic output while the active and passive articulators are in contact, of underlying sonorants have only

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rarely been reported as occurring systematically in the phonologies of languages. Two notable exceptions are Gick et al. (2012) who investigated utterance-final silent vowels in Oneida (Iroquoian) and Blackfoot (Algonquian), and the phenomenon of *išmām* in Classical Arabic in which utterance-final short vowels exhibit visible lip shape but are inaudible (Ibn Jinni 1993: vol. 1, 59; Sībawayh 2015: vol. 5, 485, cited in Al-Rumhi 2021: 183)[1] and show no acoustic signal. Another study of relevance, which we return to in Section 5, is Lawson et al. (2015) who report on the lenition of final /r/ in Scottish English.

In this chapter, we highlight a comparable phenomenon in Mehri and Śḥehrɛt (henceforth Shehret, also known in the literature as Jibbāli or Shahri) concerning utterance-final silent articulation of the plain sonorants /m, n, l, r, w, y/[2] and, in Shehret, of the pre-aspirated sonorants /ʰm, ʰn, ʰl, ʰr/ which only occur in the Central and Eastern dialects of the language and are restricted to word-final position in a closed set of words (Watson & Heselwood (2016), Watson et al. (2023)). The closed set includes function words: pronouns (e.g. *sɛʰn* 'they.F', *šuʰm* 'they.M'), demonstratives (e.g. *ḏaʰn* 'this.M', *ḏiʰn* 'this.F'), interrogatives (e.g. *muʰn* 'who') and adverbs (e.g. *būʰn* 'here', *ṭaʰn* 'like this') and a few nominal content words. Pre-aspirated sonorants and the sets of function and content words with final pre-aspirated sonorants are presented in Tables 3 and 4 in Section 2.

Our study of silent utterance-final sonorants came about from listening to normal rate narrative and careful rate elicited texts in Shehret and Mehri. Here expected singleton sonorants in the codas of utterance-final syllables were inaudible despite speakers' insistence that the sonorants were present. Preceding vowels also lacked the formant transitions found in utterance-medial tokens of these words, and, in many cases, nasalisation to signal final nasals. Utterance-final geminate sonorants were not affected, nor in many cases were utterance-final singleton sonorants in post-tonic syllables: for some speakers these sonorants were silent, for others they were not. This observation led us to suspect that segment length and stress may be an important factor, a point we return to in Section 5.

The sonorants investigated in this chapter are mentioned briefly in relation to Shehret by Johnstone (1981: xiv), Dufour (2016: 24–25) and Rubin (2014: 37–38) where they are described as "devoiced or lost". In relation to Mehri, some EPG evidence is presented in Watson & Heselwood (2016) and Heselwood & Watson (2018) to show that the sonorants are not in fact lost, and that silent articulations take place utterance finally. Apart from the utterance-final silent vowels

[1] The original works date back to the 8th CE. The works cited are edited versions. Note that <y> here is used instead of IPA /j/. Transcription conventions will be explained in Section 2.2.

[2] Consonant /w/ is no longer a synchronic phoneme in Central and Eastern Shehret.

reported in Gick et al. (2012) and in Ibn Jinni (1993) and Sībawayh (2015), we are not aware of the systematic occurrence of silently articulated sonorants in any languages outside the MSAL group.[3] Indeed, the notion of a silently articulated sonorant would seem to be a contradiction in terms from a phonetic point of view. Nevertheless, in Mehri and Shehret they occur systematically. Voiceless nasals, as reported for different languages in Bhaskararao & Ladefoged (1991), Gogoi & Wayland (2018) and others, contrast with our silently articulated sonorants in that they do not lack acoustic output.

From a typological perspective, it seems appropriate to situate utterance-final silent articulations in the wider cross-linguistic context of consonant lenition (Kirchner 1998), although lenition is not often discussed in relation to sonorant consonants and, as we discuss in Section 5, our data do not show the typical characteristics of lenition as presented in the literature. Justification for the description "silent articulation" comes from the observation that, apart from some whispered realisations by one speaker in our data, there is no acoustic output during the articulation of the target sonorant. Furthermore, as described in Section 4, there is no obvious evidence of any acoustic cueing of these sonorants through place-specific coarticulatory effects, although we cannot rule out the presence of subtle cues, including visual ones, that may enable listeners to detect them at least some of the time. Articulatory reduction is evident in some tokens in the form of a reduced area of articulatory contact, but articulatory reduction is also observed in some sounded utterance-initial and utterance-medial realisations.

1.1 Structure of the chapter

In Section 2, we provide a background to the languages, consonant inventories, pre-aspirated sonorants, vowel inventories, word stress, and our terminology.

In Section 3, we present the rationale for the study, research questions, materials and details of the speakers who provided speech data for this study.

In Section 4, we present our results. Section 4.1 and Section 4.2 present the results of our non-instrumental studies: Section 4.1 reports the results of auditory-acoustic analysis from listening by Watson and Heselwood to the recordings made for the electropalatographic (EPG), electrolaryngographic (ELG) and audio-visual analyses. Section 4.2 presents still images and Praat drawings taken from

[3] However, this could be a regional feature: in San'ani Arabic (Jastrow 1984; Naïm-Sanbar 1994: Naïm 2009: 27–28; Watson & Heselwood 2016: 15–16), Yemeni Arabic dialects of the central northern Yemeni plateau (Behnstedt 1985: 58), and Rijāl Alma' in south-west Saudi Arabia (Watson & Asiri 2008), C in utterance-final -*v̄C* is typically glottalised and, from impressionistic analysis, is reported to result in inaudibility in the case of final sonorants. Whether the final sonorant in these varieties is articulated or not has not yet been investigated.

our audio-visual data to show silent articulations of the labials /m/ and /w/, sounds that cannot be captured through EPG, as palates only show tongue–palate contact. Section 4.3 presents the results of our EPG study showing that the coronal sonorants /l, n/ and, less commonly, /r/ are realised with silent articulations in utterance-final position in both Mehri and Shehret.[4] Utterance-final /r/ is not always completely silent in either language; its realisation varies between tap and trill, and it is not possible to execute the articulation of a trill silently because of the nature of aerodynamic-myoelastic action (Ladefoged & Maddieson 1996: 217–218). We present further EPG data to show that the pre-aspirated sonorants /ʰl, ʰn, ʰr/ in Shehret, themselves typologically rare (Maddieson 1984: 65, 74) and phonotactically highly restricted (Berkson 2016, 2019), are also realised with silent articulations utterance-finally.

Section 4.4 presents the results of our ELG study that show increasing glottal constriction in vowels preceding silently articulated plain sonorants, /l, m, n, r/, and decreasing glottal constriction in vowels preceding silently articulated pre-aspirated sonorants, /ʰl, ʰm, ʰn, ʰr/.

In Section 5, we summarise our results, then consider them in the context of laryngeal categories and lenition, proposing a tentative diachronic trajectory of how silently articulated sonorants may have come about. We conclude with suggestions for further research.

2 Background

This section provides a brief background to the languages, the segmental inventories of the languages, word stress, and a discussion of the terminology adopted in the chapter.

2.1 The languages

Mehri (ISO 639-3: gdq, Glottolog: mehr1241) and Shehret (ISO 639-3: shv, Glottolog: sheh1240) are two of six endangered Modern South Arabian languages (henceforth MSAL), Semitic languages spoken in the southern part of the Arabian Peninsula. The MSAL are spoken in Dhofar in southern Oman, eastern Yemen, the island of Soqotra and the southern edge of Saudi Arabia, an area where Arabic is the dominant and majority language. The other MSAL are Ḥarsūsi, Soqoṭri,

[4]The sound /r/ is classed phonologically as a sonorant consonant (Kenstowicz 1994: 36), but it often has obstruent-like variants, including taps and trills, as pointed out by Lindau (1980); see Howson & Monahan (2019) for possible acoustic-perceptual affinities between trill and approximant variants.

Baṭḥari and Hobyōt which have not so far been investigated for silent sonorant articulations, although Hammal al-Balushi (p.c.) has observed them in Ḥarsūsi.

Mehri, with approximately 200,000 speakers, is spoken in Dhofar in southern Oman, in al-Mahrah in eastern Yemen, and in parts of southern and eastern Saudi Arabia. Shehret, with approximately 50,000 speakers, is restricted to Dhofar and spoken in the mountain ranges parallel to the coast of Dhofar and in settlements along the Dhofari coastline.

2.2 Consonant inventories

2.2.1 Introduction

In this chapter, the symbols used for the phonemes of Mehri and Shehret (Tables 1 and 2), and for spelling words in these languages, are those advocated for Semitic languages by the *Encyclopedia of Arabic Language and Linguistics* and used by the *Journal of Semitic Studies*. The haček symbol over ‘s’, ‘z’ denotes palato-alveolar articulation in /š, ž/; the tilde over ‘s’, ‘z’ denotes alveo-palatal articulation in /s̃, z̃, ṣ̃/; a subscript line denotes interdental articulation in /ḏ, ṯ, ṯ̣/; a subscript dot denotes emphasis in /ṭ, ṣ, ṣ̌, ṣ̃, ṣ́, ṯ̣/ and also denotes the pharyngeal fricative /ḥ/; a superscript dot over /ġ/ denotes a uvular fricative. International Phonetic Alphabet (IPA), Extensions to the IPA (ExtIPA) symbols (Ball, Howard, et al. 2018) and Voice Quality Symbols (VoQS) (Ball, Esling, et al. 2018) are used for transcribing the phonetic realisations of phonemes in figures and are given in square brackets. Following Ball, Esling, et al. (2018), silent articulations are given in parentheses, e.g. (n) denotes a silently articulated realisation of /n/.

The consonantal inventories of Mehri (Watson et al. 2020) and Shehret are given in Tables 1 and 2 below. Like many Semitic languages, the MSAL have triads of voiceless–voiced–emphatic obstruents, e.g. /t–d–ṭ/. Emphatic obstruents in MSAL involve a secondary articulation in the back of the vocal tract, inducing backing or glottalisation (Bellem 2007). In Mehri and Shehret, emphatics can be phonetically voiceless or voiced, and can also be realised as ejectives depending on speaker and context, as can voiced obstruents. Within a cell in the tables, voiceless consonants are given on the left, voiced consonants in the centre, and emphatic consonants on the right. In Mehri, all consonants barring marginal /ʔ/ can be realised as singletons or long consonants (geminates) in word-medial or word-final position.

In contrast to Mehri, Central and Eastern Shehret has a set of pre-aspirated sonorants which occur word-finally in a closed set of words and contrast with non-aspirated singleton sonorants in this position. While all consonants barring

Table 1: Mehri consonantal phoneme table

	labial	dental	alveolar	post-alveolar	palatal	velar	uvular	pharyngeal	glottal
plos	b		t, d, ṭ			k, g, ḳ			
fric	f	ṯ, ḏ, ṯ̣	s, z, ṣ	š, ž, ṣ̌			x, ġ	ḥ, ʕ	h, ʔ
lat fric			ś, ṣ́						
lat son			l						
nasal	m		n						
rhot			r						
glide	w				y				

marginal /ʔ/ can be realised as singletons and word-internally as geminates, contrasting with singleton consonants in this position, geminate consonants are never realised word-finally in Shehret. Pre-aspirated sonorants are never geminated. In the Central and Eastern varieties examined here, Shehret lacks synchronic /w/.

Table 2: Shehret consonantal phoneme table for Central and Eastern dialects

	labial	dental	alveolar	post-alveolar	alv-palatal	palatal	velar	uvular	pharyngeal	glottal
plos	b		t, d, ṭ				k, g, ḳ			
fric	f	ṯ, ḏ, ṯ̣	s, z, ṣ	š	s̃, z̃, ṣ̃			x, ġ	ḥ, ʕ	h, ʔ
lat fric			ś, ź, ṣ́							
lat son			^{h}l, l							
nasal	^{h}m, m		^{h}n, n							
rhotic			^{h}r, r							
glide						y				

2.2.2 Pre-aspirated sonorants

Pre-aspirated sonorants are attested in Central and Eastern Shehret, but not in Mehri. Where words ending in pre-aspirated sonorants have similar cognates in Mehri, the Mehri word has a plain sonorant: *sēn* 'they.F' in Mehri, *sε*^{h}*n* in Shehret; *śḥayr* 'green mountains' in Mehri, *śḥe*^{h}*r* in Shehret; *ḳōn* 'horn' in Mehri, *ḳu*^{h}*n* in Shehret; *yōm* 'day' in Mehri, *yu*^{h}*m* in Shehret; *mġār* 'frankincense trees' in Mehri, *mġe*^{h}*r* in Shehret.

Shehret final pre-aspirated sonorants contrast with sequences of /h/ plus sonorant, as in *ḏahn* 'mind', realised with an epenthetic vowel after /h/, versus *ḏa*^{h}*n* 'this.M', realised without an epenthetic vowel. Where two Shehret words differ in one ending in /h/ and the other in a pre-aspirated sonorant, there appears to be no perceptible acoustic difference: thus, *sεh* 'she', *sε*^{h}*n* 'they.F' and *sɛʰm* 'poison' are distinguishable only by context or by the speaker facing the listener. There is dialect variation in the lexical distribution of pre-aspirated sonorants: the function and content words in Tables 3 and 4 below are realised with pre-aspirated final sonorants in Eastern dialects; function words and a sub-set of the content words attested in the Eastern dialects, which may vary by individual, are realised with pre-aspirated final sonorants in Central dialects; Western dialects, however, appear to lack "breathed" sonorants altogether (Al-Maˤšanī 2014).[5] There is also a productive morpheme *-úʰn* which can be suffixed to any imperative to reinforce the command,[6] as in: *uss* 'shut up!' versus *ussúʰn* 'shut up!!', *ġalíḳ* 'look!F.SG' versus *ġaliḳúʰn* 'look!!F.SG', *skif* 'sit!F.SG' versus *skifúʰn* 'sit!!F.SG', but a final pre-aspirated sonorant is never attested as the final root consonant of any verb stem. Words with pre-aspirated sonorants always take final stress, the correlates of which in Shehret are higher F0 and intensity, and are predominantly mono- or disyllabic, with a few trisyllabic function words.

2.3 Vowel inventories

The Mehri vowel system includes short and long monophthongs and two diphthongs, /ay, aw/. The short vowels are /a, e, ɛ, i, o, u, ə/. Of these, only /a, ə/ occur in word-initial and word-medial position; /ə/ never occurs in word-final position; /e, o/ are restricted to word-final position followed by /h/; /ɛ/ is restricted to word-final position followed by /ʔ/ (Watson et al. 2020). The long vowels are /ā, ē, ɛ̄, ō, ū/ and the diphthongs /ay, aw/.

The Shehret vowel system includes full short monophthongs, the unstressed vowel /ə/ and long monophthongs that result principally from intervocalic elision of /y, m, b/ (Rubin 2014; Dufour 2016; Watson & al-Kathiri 2022). The full vowels are /a, e, ɛ, i, o, u/. The long vowels are /ā, ē, ɛ̄, ī, ō, ɔ̄/. Long vowels resulting from the intervocalic elision of /m/ are nasalised.

2.4 Word stress

Word stress in both Mehri and Shehret has some complications, which we simplify in this section as our interest is restricted to when word-final sonorant-final syllables take word stress.

With a few exceptions (Watson et al. 2020), word stress in Mehri is assigned to a final syllable ending in *-Vh* or *-ɛʔ*, as in: *ūṭóh* 'like that', *əmšéh* 'yesterday',

[5] A claim that needs to be verified in the field.

[6] As pointed out by a reviewer, this is reminiscent of emphatic aspiration in Polish (Waniek-Klimczak 2011).

Table 3: Shehret function words with final pre-aspirated sonorants

Words	Gloss
aġá^{h}l	'below'
bū^{h}n	'here'
ḏa^{h}n~ḏo^{h}n~ḏohú^{h}n	'this.M'
ḏi^{h}n~ḏihú^{h}n	'this.F'
ḏokú^{h}n	'that.M'
elohú^{h}n	'over there'
hu^{h}n	'there'
iźá^{h}n~iźó^{h}n~iźohú^{h}n	'these'
iźokú^{h}n	'these'
lḥokú^{h}n	'there'
mu^{h}n	'who'
nḥa^{h}n	'we'
sɛ^{h}n	'they.F'
šu^{h}m	'they.M'
tɛ^{h}n	'you.F.PL'
tu^{h}m	'you.M.PL'
ṭa^{h}n	'like this'

Table 4: Shehret content words with final pre-aspirated sonorants

Words	Gloss
ʕi^{h}n	'eye; source'
bi^{h}l	'owners'
dʕi^{h}n	'piles of rocks'
ḏo^{h}r	'blood'
egmí^{h}l	'the camels'
ɛ̄^{h}r	'land (as opposed to sea)'
ḥa^{h}l	'time; pressed oil'
ḳu^{h}n	'horn; mountain peak'
mġe^{h}r	'frankincense trees'
ri^{h}m	'tall; long'
sɛ^{h}m	'poison'
ṣi^{h}n	'China [place name]'
ṣo^{h}r	'Sur [place name]'
śḥɛ^{h}r	'green mountains'
ṯi^{h}m	'garlic'
yu^{h}m	'day; sun'

yətáh 'he eats.SUBJ', *həḳśɛʔ* 'to dry something', *hīlɛʔ* 'shadows'. Otherwise stress is assigned to the head of the right-most bimoraic trochaic foot: final CVV(C) or CVCC, as in: *dīwṓl* 'old M.PL', *nṣī́* 'split heel', *śəll* 'to take'; or the right-most non-final heavy (CVV or CVC) syllable, as in: *hɛ̄́ṣər* 'green/blue/yellow', *rəddən* 'we returned', *wátxəf* 'to be in the evening'; if there is no heavy syllable in the word, stress is assigned to the left-most light (CV) syllable, as in: *kábu* 'cold wind with rain drops', *híki* 'for you/us dual'. Where a word has two long vowels, the left-most long vowel is assigned secondary stress.

Word stress in Shehret is assigned to the right-most full vowel (not ə) followed by a consonant, as in: *šóṭər* 'female kid goat', *šiṭár* 'female kid goats', *nṣīníti* 'small.F.PL', *nīṣán* 'small.M'. Full vowels to the left of the primary stressed vowel take secondary stress.

2.5 Terminology

In this chapter, we follow our previous work on laryngeal categories and glottal states in Mehri and Shehret (e.g. Watson & Heselwood 2016; Watson et al. 2020) in adopting the laryngeal categories "breathed" ([breθt]) and "unbreathed".[7] The use of these terms goes back to the work of the early Arab grammarians, where Sībawayh adopts *mahmūs* "with breath" and *majhūr* "without breath" to describe the laryngeal categories of Early Arabic (Heselwood & Maghrabi 2015). "Breathed" denotes consonants traditionally described as "voiceless", including Shehret pre-aspirated sonorants, while "unbreathed" denotes both segments that are canonically voiced and the emphatic obstruents that canonically lack both voicing and audible breath on release. The adoption of the terminology for Mehri and Shehret emerges from the phonetics and from the phonological and morphological patterning of consonants in the languages, listed below.

1. "Breathed" consonants exhibit aspiration on release and degrees of pre-aspiration, which "unbreathed" consonants lack. Even when voiced in intersonorant position, "breathed" fricatives maintain breathiness and, from our electrolaryngographic work on Shehret (see Figure 18), and impressionistic work on Mehri, exhibit an abducted glottis typical of their canonical "voiceless" form (Heselwood et al. 2022).

2. In utterance-final position, "unbreathed" consonants exhibit pre-glottalisation and, in the case of obstruents, frequent post-glottalisation, which "breathed" consonants lack.

3. Morpho-phonologically, "unbreathed" emphatic and plain consonants pattern together in taking initial vowels when heading a defined nominal and heading certain derived verb forms, while "breathed" consonants are typically geminated in this position (Watson & Heselwood 2016: 8–13).

Henceforth we refer to the plain sonorants as "unbreathed" and the Shehret pre-aspirated sonorants as "breathed".

3 Rationale and research questions

This section examines the rationale behind the study, and then provides our research questions.

[7] In Watson & Heselwood (2016), we adopt the features [open] and [closed] following Morén's (2003) parsimonious feature geometry model.

3.1 Rationale for the study

Our study of silent utterance-final sonorants was motivated by listening to narrative texts in Shehret and Mehri, which exhibited inaudible sonorants in utterance-final position, particularly, but not exclusively, where a singleton closes a final stressed syllable. By utterance, here, we mean a stretch of speech followed by a measurable pause. Mehri *ṭwayl* 'long' typically lacks audible /l/ in utterance-final position but maintains fully voiced, audible /l/ in utterance-medial position. Compare inaudible utterance-final /l/ in *ṭwayl* 'long' in Figure 1 (denoted on tier 3 of the Praat TextGrid as S = 'silent', silent /l/ placed in round brackets on tier 2) with sounded utterance-medial /l/ in *ṭwayl əḳayd* 'the cord is long' in Figure 2 (denoted on tier 3 as V = "voiced"). Note "sf" on tier 4 denotes a stressed foot.

It is notable that the second formant does not deflect down towards a formant pattern for utterance-final /l/ in Figure 1, suggesting that the tongue is not making a coarticulated gesture for the utterance-final lateral consonant. By contrast, it does in Figure 2, where word-final /l/ occurs in utterance-medial position.

In utterance-final position, the final consonant in Shehret *ḥa*^{h}*l* 'pressed oil; time' is preceded by a period of breathy voice (denoted as BV on tier 3) followed by aperiodic noise (N) with no visible acoustic landmarks for the sonorant (Figure 3).

In utterance-medial position, by contrast, the word-final consonant is realised as fully modal-voiced, non-aspirated /l/ (denoted as V on tier 3 in Figure 4).

Previous researchers of MSAL have impressionistically described utterance-final sonorants as "devoiced" in the codas of stressed syllables, implying that they are "voiced" in the codas of unstressed syllables (e.g. Fabio Gasparini p.c. for Bathari). Rubin (2014: 37) claims Shehret nasals are "often devoiced or lost" at the end of a word when "preceded by a full vowel (not *ə*)". In our data, utterance-final singleton sonorants are almost invariably "devoiced" in both languages, even following unstressed /ə/ (see Figures 4 and 6, for example, where silence is denoted on tier 3 by S); whether they are audible in utterance-final unstressed syllable codas, however, appears to be speaker dependent. Some of our speakers, for example, M004, a monolingual Mehri speaker born around 1950 from the desert village of Rabkut, produce inaudible utterance-final sonorants in the codas of stressed syllables, but audible and sometimes partially voiced utterance-final sonorants in the codas of unstressed syllables, as seen for final /n/ in *lēbən* 'white.PL' in Figure 5.

Other speakers produce completely inaudible utterance-final sonorants irrespective of the prosody of the syllable in which they fall. Compare utterance-final /n/ in Mehri *lēbən* 'white.PL' in Figure 5 with the totally silent utterance-final /n/ in Mehri *rəddən* 'we returned' produced by J003, a bilingual speaker of Mehri and Shehret born in 1964 from Gabgabt in the central mountains of Dhofar (Figure 6).

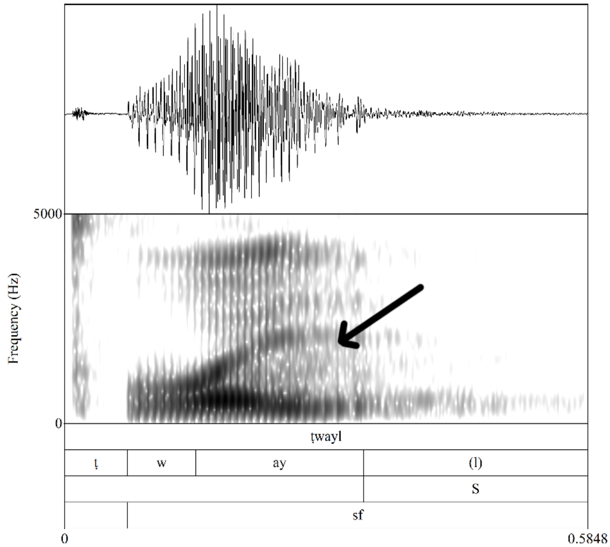


Figure 1: M001 *ṭwayl* 'long' (Mehri) with F2 transition arrowed

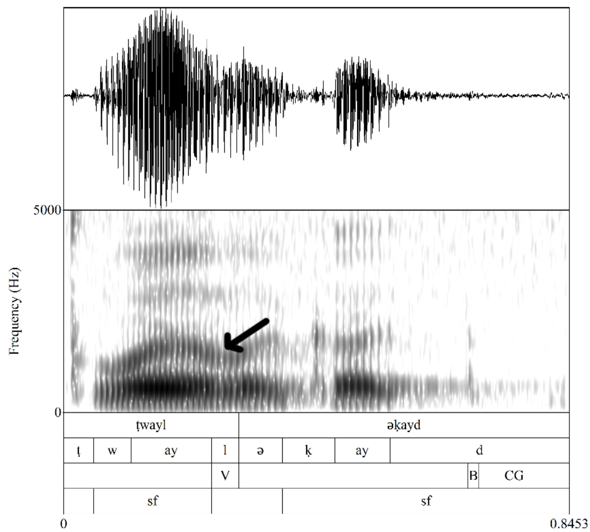


Figure 2: M001 *ṭwayl əḳayd* 'the cord is long' (Mehri) with F2 arrowed

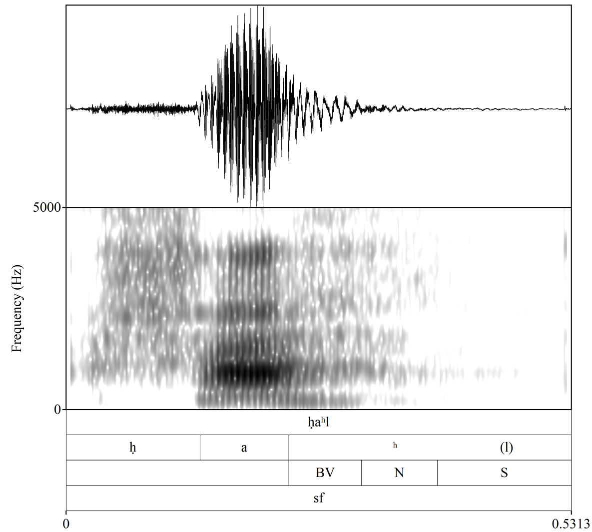


Figure 3: J028 *ḥa^{h}l* ‘pressed oil; time’ (Shehret)

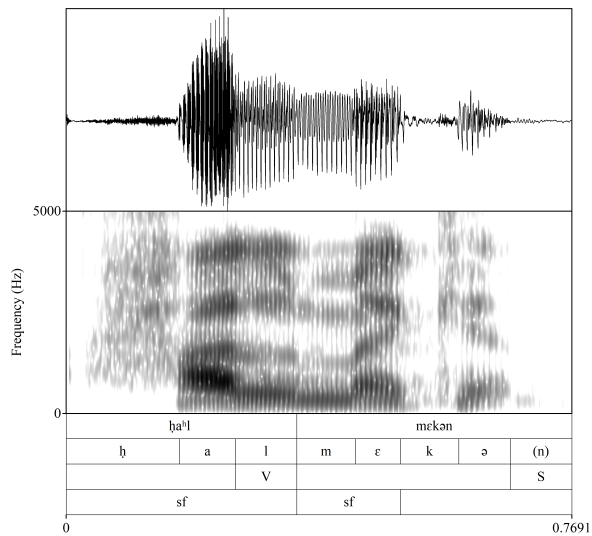


Figure 4: J028 *ḥa^{h}l mɛkən* ‘lots of pressed oil’ (Shehret)

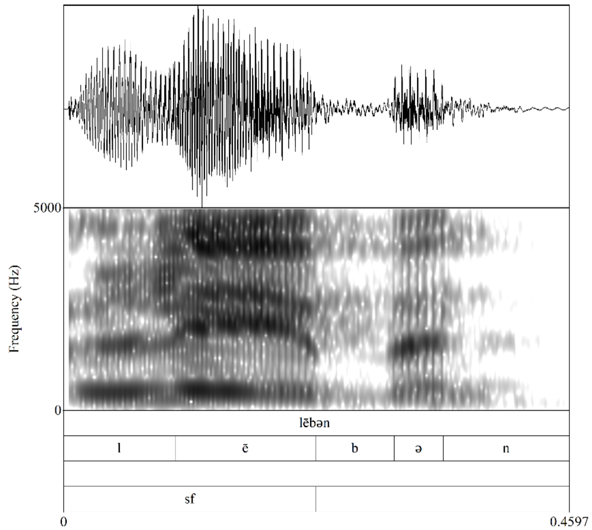


Figure 5: M004 *lēbən* 'white.PL' (Mehri)

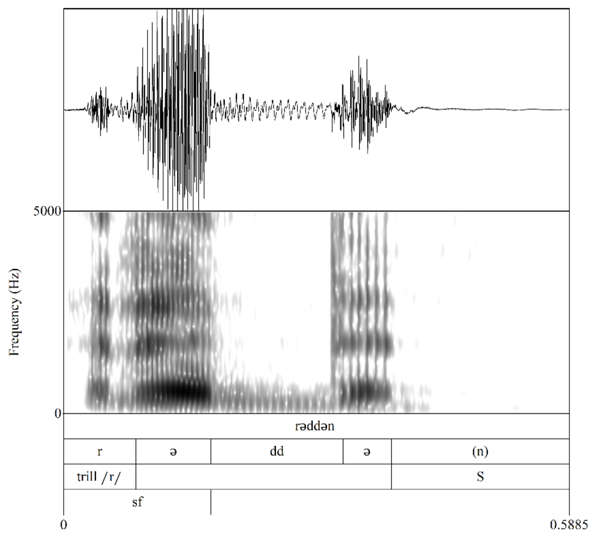


Figure 6: J003 *rəddən* 'we returned' (Mehri)

3.2 Research questions

We assume that utterance-final sonorants are more likely to be silent in fast, casual speech than in careful speech, as for other forms of lenition (e.g. Kirchner 1998, 2001; Warner 2011; Melero-Garcia 2021). Having observed utterance-final silent sonorants from acoustic narrative data, we recorded word-list data to examine the extent to which the production of utterance-final inaudible sonorants was attested in careful speech. We employed a holistic approach examining auditory-acoustic, visual, articulatory and electrolaryngographic data. The three research questions for the study are listed below.

1. Are utterance-final sonorants acoustically silent[8] in careful speech?
2. Are silent utterance-final sonorants articulated?
3. Does the larynx behave differently before silent utterance-final breathed sonorants than before silent utterance-final unbreathed sonorants?

3.3 Materials

For Shehret, the target phonemes were four "unbreathed" sonorants /l, m, n, r/ and four "breathed" sonorants /^{h}l, ^{h}m, ^{h}n, ^{h}r/ in utterance-final position preceded by a vowel. For Mehri, the target phonemes were 11 sonorants /l, ll, m, mm, n, nn, r, rr, w, y/ in utterance-final position preceded by a vowel.

Lists of individual words and words occurring at the end of two-word phrases, such as *ḥa^{h}l rḥím* 'good pressed oil', were produced for this study and presented to participants in the Arabic-based orthography designed in January 2013 at the start of the Leverhulme-funded project *Documentation and Ethnolinguistic Analysis of Modern South Arabian* (DEAMSA). Speakers were instructed to produce each word or phrase at normal speed between three and six times, leaving a clear gap between each word or phrase token. The words were recorded through electropalatography (EPG), electrolaryngography (ELG), and video, each with an accompanying acoustic file. The acoustic data extracted from the EPG and ELG files and our auditory-acoustic study were analysed to answer RQ 1. EPG and video data were analysed to answer RQ 2; ELG data were analysed to answer RQ 3. The methodology for each of these techniques is described in detail in Section 4.1 (auditory-acoustic), Section 4.2 (audio-visual), Section 4.3.1 (EPG), Section 4.4.1 (ELG). Audio-visual data were collected in Leeds in 2018, in Uppsala

[8] i.e. lacking any acoustic output.

in 2018, and in the field in Dhofar in 2021. EPG data were collected in the University of Leeds phonetics laboratory in 2012, 2015, 2017 and 2018. ELG data were collected both in the field in 2014, 2017, 2020 and 2021 and at the University of Leeds in 2015, 2017 and 2018.

3.4 Participants

All our participants come from Dhofar in southern Oman.[9] For Mehri, six speakers from Dhofar provided ELG data, three of whom also provided EPG data separately. Audio-visual data were provided by one speaker. All the Mehri speakers are also speakers of Arabic acquired as a second language through school.

For Shehret, seven speakers from Central and Eastern Dhofar provided ELG data separately, three of whom also provided EPG data separately. Audio-visual data were provided by two speakers. All the Shehret speakers are also speakers of Arabic acquired as a second language through school.

Three speakers (M026, J001, adn J002) are symmetrically bilingual in Mehri and Shehret. They speak both languages at home and in the community.

None of the speakers reported speaking or hearing difficulties and the speech of all was considered by other Mehri and Shehret speakers, including the native-speaker authors, to be representative of the language varieties investigated.

Speaker information in terms of language spoken and types of data provided is given in Table 5.[10]

4 Results

This section presents the auditory-acoustic, the audio-visual, and the instrumental phonetic studies. Section 4.1 examines the results of our auditory-acoustic study, Section 4.2 the results of our audio-visual study, Section 4.3 the results of our EPG study, and Section 4.4 the results of our ELG study. The media files and some additional phonetic material are provided in supplementary material, available at https://doi.org/10.5683/SP3/VPH6HH.

[9]Ethical approval was obtained from the Arts, Humanities and Cultures Faculty Ethics Committee at the University of Leeds (FAHC 19-046).

[10]Due to cultural considerations, it is considerably more difficult to record women than men in southern Oman. Two women were recorded using ELG; however, the ELG data of one of the women, recorded on three separate occasions, had to be rejected due to poor CQ traces. Her acoustic material extracted from the recordings showed utterance-final unbreathed and breathed sonorants to be silent.

Table 5: Speaker information; languages spoken (M = Mehri, S = Shehret), sex, age, region within Dhofar where born and brought up (C = central, E = eastern, C-W = central west, W = west)

	Language spoken	Sex	Birth year	Region	ELG	EPG	Video
J001	M, S	M	1984	C	✓	✓	✓
J002	M, S	M	1987	C	✓		
J028	S	M	1987	E	✓		
J043	S	M	1983	E	✓	✓	
J116	S	M	1996	C-W	✓		✓
J117	S	F	1973	C-W	✓		
M001	M	M	1993	C	✓	✓	✓
M026	M, S	M	1975	C	✓	✓	
M028	M	M	1964	W	✓		
M068	M	M	1997	C	✓		
M079	M	M	1989	C	✓		

4.1 Auditory-acoustic study

The auditory-acoustic study was designed to answer RQ 1:

1. Are utterance-final sonorants acoustically silent in careful speech?

The audio files from the EPG and ELG recordings of all speakers were listened to by two of the authors (Watson and Heselwood) independently. Watson speaks Mehri fluently as a non-native speaker and has communicative competence in Shehret. Heselwood is an instrumental phonetician and speaks neither language. Listening was done along with visual inspection of the spectrograms. Excluding the rhotics /r/ and /ʰr/ which are often realised in these languages as devoiced taps or trills (see Figure 18), all speakers except J001 produced their final sonorants inaudibly with pre-glottalisation, in the case of unbreathed sonorants (e.g. Figures 1, 13, 19), and pre-aspiration (e.g. Figures 3, 14, 24), in the case of breathed sonorants.

One of the bilingual speakers, J001, produced some final sonorants with audible whisper phonation. Thus, in addition to his 50 EPG and 40 ELG tokens, we listened to a further 110 audio tokens recorded by this speaker to get a better idea of how often he produced final sonorants audibly. In total, 18% (36/200) of his tokens were realised with audible whisper phonation (see Figure 12) identified by both listeners, which enabled us to hear and correctly identify the sonorant. Audible whisper realisations of J001's material all involved unbreathed sonorants in both languages. All of J001's breathed Shehret final sonorants were pre-aspirated with no acoustic trace of the sonorant. We do not know how many other speakers might employ whispered variants of utterance-final singleton sonorants.

Across all speakers and both languages, final silently articulated nasals in approximately 30% of the unbreathed data induced audible nasalisation in the preceding vowel.[11] Nasalisation was not detectable in vowels before any of the breathed nasals. It was also possible in almost all instances of Shehret final sonorants to hear whether it was unbreathed or breathed. The auditory cues that were detected, therefore, were:

- slight nasalisation of the preceding vowel, cueing nasals /m, n/ in contrast to non-nasal /l/ (and /w/ in Mehri).
- breathy voice followed by aspiration in Shehret, cueing breathed sonorants in contrast to unbreathed sonorants.

Occasionally one or both listeners thought they may have heard place-of-articulation cues, but they were not confident about that, and no clear evidence of place-appropriate F2 transitions could be seen on the spectrograms. With the caveat that some speakers (based on evidence from J001) may employ some whisper phonation, the results of the auditory-acoustic study thus answer RQ 1 positively: utterance-final sonorants are silent in careful speech.

4.2 Audio-visual study

In anticipation of our EPG study, as EPG palates do not extend to the lips, we recorded audio-visual data to establish whether utterance-final /m/ and /w/ are articulated or not, as conducted by Storto & Demolin (2002: 492-493) for the investigation of unreleased word-final [p̚] and [m̚] in Karitiana. The audio-visual study thus seeks to answer RQ 2 in relation to labial sonorants:

2. Are silent utterance-final sonorants articulated?

[11] One reviewer asked why we did not study nasalisation. First, the chapter is primarily presenting evidence for the silent articulation of utterance-final sonorants, rather than whether they can be perceived through other cues. Second, a proper study of nasalisation would require a nasal accelerometer or some other kind of nasometry, which would be difficult to operate in the field. The acoustic measure of nasality is not as valid, because it has been shown that laryngopharyngeal constrictions can result in the same acoustic effects (Laver 1980).

Audio-visual data were recorded in MTS format on a Canon XA20 camcorder with an Audio-technica AT2022 stereo microphone. The acoustic file was extracted from the video to .wav format 44KHz, 16 bit through Switch Sound File Converter by NCH Software. Words with final labial sonorants in utterance-final position were recorded from one Mehri speaker (M001) and two Shehret speakers (J001 and J116). Figures 7 and 9 are taken from the Mehri speaker M001, and show lip-closure and slight pouting, in the mid-point of /m/, and lip-rounding, in the mid-point of /w/. The Praat TextGrids below each image (Figures 8 and 10) show the whole word, the position in the file where lip closure (LC) or lip rounding (LR) occurs, and demonstrate the inaudibility of the respective sonorants. There are no formant transitions indicating labial coarticulation in the final vowel in the figures below. The second formant (F2), in particular, would be expected to show a downward movement in anticipation of /m/ or /w/. F2 is arrowed in Figures 8 and 10. There is also no visible trace of nasalisation in the preceding vowel in this token. In the case of our Shehret speakers, utterance-final /m/[12] similarly involved clear lip closure and was inaudible. Thus, the audio-visual study answers RQ 2 positively, filling in information about labial sonorants that was could not have been provided by the EPG study: silent utterance-final labial sonorants are articulated.

4.3 Electropalatographic study

This section examines collection and analysis methods of the EPG data, and then focuses on the analysis of three types of utterance-final segments: Mehri unbreathed sonorants, Shehret unbreathed sonorants, and Shehret breathed sonorants. The EPG study was designed to answer RQ2 in relation to lingual sonorants:

2. Are silent utterance-final sonorants articulated?

4.3.1 Data collection and analysis

EPG data were collected in the University of Leeds Phonetics Laboratory through Articulate Assistant, version 1.18, in 2012 (J001), 2015 (J043, M001), 2017 (M026) and 2018 (M001). EPG palates for all four speakers were the Articulate style palates produced by Bristol Dental Hospital. EPG data was sampled at 100Hz generating one frame every 10 ms. Four male speakers were recorded producing the wordlists. Two of the bilingual speakers (M026 and J001) recorded Mehri and Shehret wordlists. M001 speaks Mehri but not Shehret, and J043 speaks Shehret

[12]As noted above, /w/ is not a synchronic phoneme in Central and Eastern Shehret.

Figure 7: M001 final /m/ in *kərmaym* ‘hill’ (Mehri)

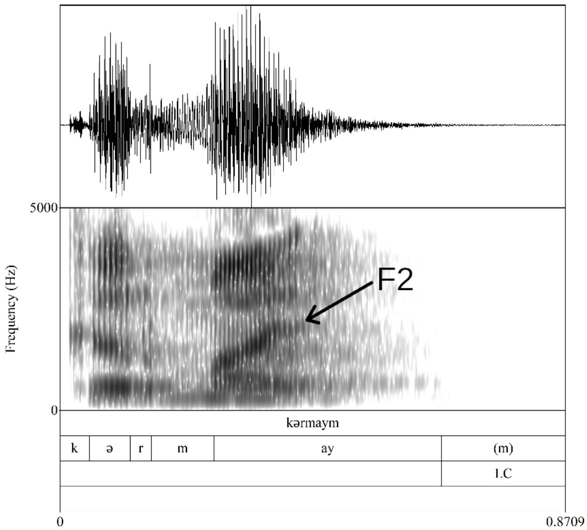


Figure 8: M001 *kərmaym* ‘hill’ with F2 arrowed (Mehri)

Figure 9: M001 final /w/ in *yəṭayw* 'he comes at night' (Mehri)

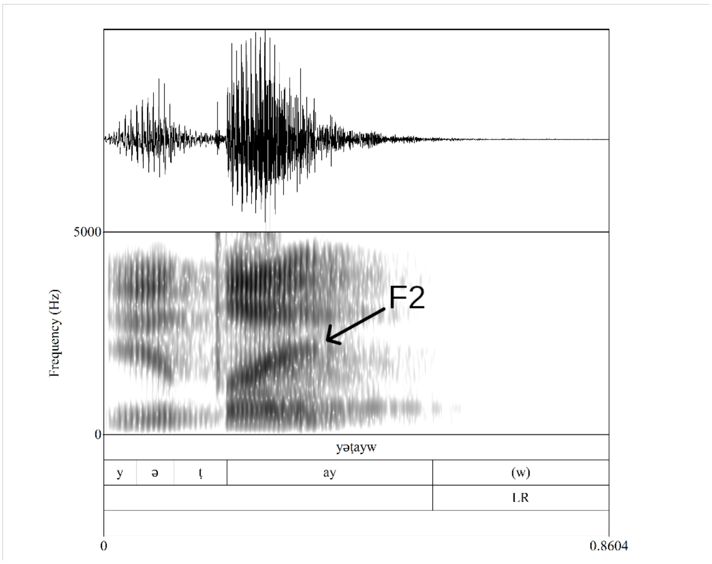


Figure 10: M001 *yəṭayw* 'he comes at night' with F2 arrowed (Mehri)

but not Mehri. Only two speakers recorded the Shehret breathed sonorants electropalatographically (M026 and J043). Table 6 shows the number of tokens of final sonorants produced by each participant.[13]

Table 6: Number of utterance-final silent sonorant tokens of each language by speaker for EPG analysis (M = Mehri, S = Shehret)

	M	M001	M026	J001	**S**	J043	M026	J001
Unbreathed								
/l/	**45**	18	15	12	**41**	20	12	9
/n/	**45**	18	15	12	**51**	25	18	8
/r/	**36**	18	12	6	**42**	27	12	5
Total	**126**	**54**	**42**	**30**	**134**	**72**	**42**	**20**
Breathed								
/ʰl/	n/a				**15**	12	3	0
/ʰn/	n/a				**51**	38	14	0
/ʰr/	n/a				**14**	12	6	0
Total					**85**	**62**	**23**	**0**

Analysis of the EPG data comprised the following numbered measurement procedures. Of these, Nr 1 measures the duration of delay between vowel and articulation to establish whether glottalisation or pre-aspiration results in onset delay. Nrs 2–4 measure contact and duration to establish whether silent articulations are similar in duration to sounded articulations. Nr 5 establishes whether silent articulations are similar to sounded articulations in degree and quality of contact.

1. Duration in milliseconds (ms) of any delay between the final voicing pulse of the preceding vowel and the onset of the articulation of the sonorant ("ONSET") as identified by the first palate frame showing more contact than for the preceding vowel; this duration is referred to as "ONSET DELAY". This measure shows whether the articulation of the sonorant follows on with or without hiatus from the articulation of the vowel. An intervening hiatus is expected to block, or severely weaken, coarticulatory influences.

[13] The imbalances in the number of tokens are due to the availability of the different speakers at different stages in the research, which was later interrupted by travel restrictions due to the Covid-19 pandemic.

2. Time between ONSET and first palate frame of maximum articulatory contact ("MAX"), referred to as "ONSET-MAX" to nearest 10ms (due to 100Hz sampling rate generating 1 frame every 10ms). This measure shows whether the dynamics of a silent articulation are similar to the dynamics of a sounded articulation.

3. Time to nearest 10 ms from MAX to first frame showing a breaking of the articulatory closure ("OFFSET"), referred to as "MAX-OFFSET". Because speakers often keep the active articulator in place indefinitely after finishing an utterance, the significance of this measure is not so great in itself. However, it is another parameter for comparison with sounded realisations of utterance-final non-sonorants (such comparison is, however, beyond the scope of this account).

4. Time between ONSET and OFFSET, referred to as "ONSET-OFFSET". This measure shows the total duration of articulatory contact.

5. Qualitative comparison between area of articulatory contact for silent articulations and sounded articulations of the same sonorant in non-final contexts.

The landmarks for taking the ONSET DELAY, ONSET-MAX, and MAX-OFFSET measurements are shown in Figures 11(b), 12(b), 13(b), and 14(b).

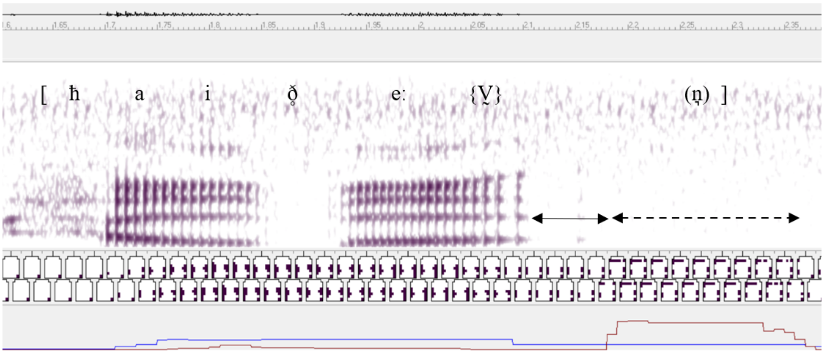
4.3.2 Mehri unbreathed sonorants

All Mehri sonorants are of the unbreathed type. Our Mehri data set for utterance-final singleton sonorants following long vowels contained 126 tokens from three speakers (M026, M001, J001). The mean ONSET DELAY, ONSET-MAX, MAX-OFFSET and ONSET-OFFSET duration values with their ranges and standard deviations are given in Table 7 separately for /l/, /n/ and /r/. Onset delays in these cases are due to glottalisation. Of the 126 tokens, one token each of /l/, /n/ and /r/ show no onset delay. The remainder show onset delays of 50 ms or more in the majority of cases: 86% of tokens in the case of /l/ (mean onset delay 79 ms), 77% for /n/ (mean onset delay 73 ms), 64% for /r/ (mean onset delay 108 ms), with delays of 100 ms or more being quite common: 29% of tokens in the case of /l/, 21% for /n/, rising to 61% for /r/.

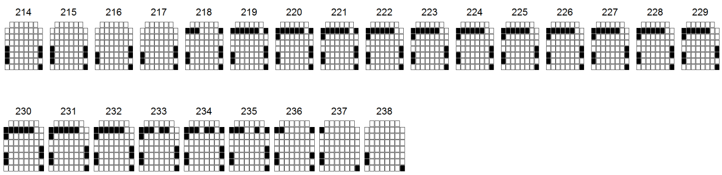
Figure 11(a) presents the synchronised waveform, spectrogram, palatogram and dynamic tongue-palate contact profile of an utterance-final /n/ in Mehri realised with a silent alveolar articulation. The lines below the palatogram show

Table 7: Duration values for ONSET DELAY, ONSET-MAX and MAX-OFFSET for Mehri /l, n, r/ (in ms); M=mean, SD=standard deviation, R=range

	ONSET DELAY			ONSET-MAX			MAX-OFFSET		
	M	SD	R	M	SD	R	M	SD	R
/l/	79.45	43.69	0-192	44.33	36.26	0-150	151.45	73.12	50-370
/n/	72.94	38.10	0-165	31.09	35.94	0-170	158.72	62.85	40-300
/r/	107.66	44.17	0-182	24.00	21.17	0-90	48.64	44.11	10-170



(a) M001 *ḥayḏēn* ‘the ear’ (Mehri) with aligned phonetic transcription; silent articulation and dynamic tongue-palate contact profile circled on palatogram; ONSET DELAY (86 ms) identified by double-headed arrow, ONSET-OFFSET (180 ms) by dashed double-headed arrow



(b) Enlarged image of palates circled in Figure 11(a); measurement landmarks ONSET (frame 218), MAX (frame 220) and OFFSET (frame 236)

Figure 11: M001 *ḥayḏēn* ‘the ear’ (Mehri)

alveolar contact (red line) and velar contact (blue line). The tongue-palate contact for the realisation of the /n/ begins 86 ms after the end of the speaker’s final voice pulse. There is no evidence of any sound output during the time of the articulatory contact for the /n/, i.e. the ONSET-OFFSET duration.

An enlarged image of the circled palate frames is given in Figure 11(b), enabling the reader to see the first contact of the tongue against the palate (frame 218), the maximum contact (frame 220), and the last contact before the articulation comes to an end (frame 236). Enlarged images of circled palate frames are also given for Figures 12–14 below. Filled squares on the EPG palate frames represent areas of tongue contact; the top three rows represent the alveolar area, rows four and five the palatal area, and rows six to eight the velar area.

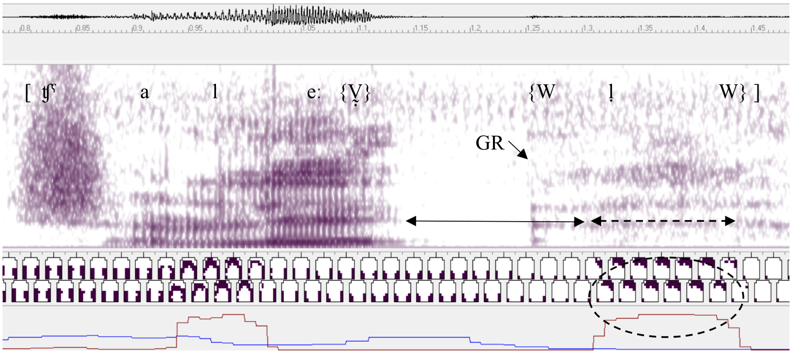
One bilingual speaker, J001, sometimes realises a final sonorant with voiceless noise which we take to be produced by a whisper setting, marked in the transcription as {W}. Figure 12 presents an example in which the vowel terminates in whispery-creak (marked as {{V̰̣}) and glottal closure, with whisper starting when the glottal closure is released (release marked with an arrow on the spectrogram). The lateral articulation for the final /l/ takes place during the whisper which has formant resonances approximately matching those of the sounded /l/; the auditory impression is of a whispered [ḷ].

4.3.3 Shehret unbreathed sonorants

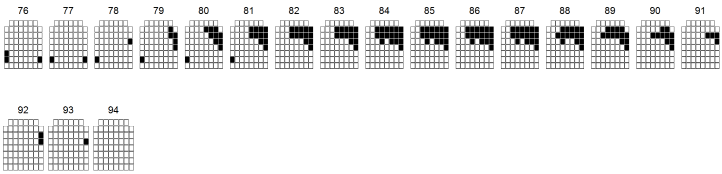
Our Shehret data set for utterance-final unbreathed sonorants in stressed syllables contained 134 tokens from three speakers (M026, J043, J001). The mean onset delay, onset-max, max-offset and onset-offset duration values with their ranges and standard deviations are given in Table 8 separately for /l/, /n/ and /r/. Of the 134 tokens, three tokens of /l/ and 2 of /n/ show no onset delay. The remainder show delays of 50 ms or more in the majority of cases: 63% of tokens in the case of /l/ (mean onset delay 74 ms), 78% for /n/ (mean onset delay 90 ms), 84% for /r/ (mean onset delay 76 ms), with delays of 100 ms or more not uncommon: 26% of tokens in the case of /l/, 39% for /n/, and 23% for /r/. These delay distributions are very similar to those for Mehri, except for /r/ which has many more tokens of 100 ms or more in Mehri than in Shehret.

The values are comparable to those in Table 7 for Mehri. Also comparable with Mehri is the extent and nature of variation within and across speakers with regard to the duration measures and the extent and location of articulatory contact during the silent realisations of the utterance-final sonorants, as can be seen in the figures below and in supplementary material.

As with the Mehri silent final /l/ shown in Figure 1, there is no acoustic output during the articulatory contact for final /l/ in the Shehret word *ṣ́ɛ̄l* in Figure 13, nor is there any evidence of formant transitions in the vowel appropriate for a following alveolar consonant. Note that the articulatory contact is slightly re-



(a) J001 *šlēl* 'cross-eyed' (Mehri) with aligned phonetic transcription; final /l/-articulation and dynamic tongue-palate contact profile circled on palatogram, glottal stop release arrowed on spectrogram; ONSET DELAY (143 ms) identified by double-headed arrow, ONSET-OFFSET (120 ms) by dashed double-headed arrow

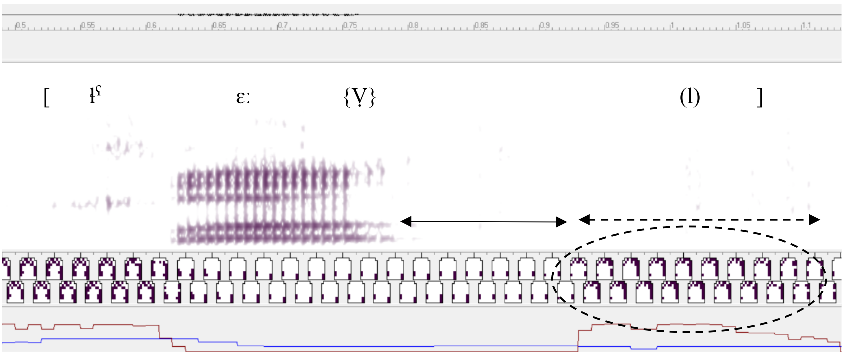


(b) Enlarged image of palates circled in Figure 12(a); measurement landmarks ONSET (frame 78), MAX (frame 84) and OFFSET (frame 90)

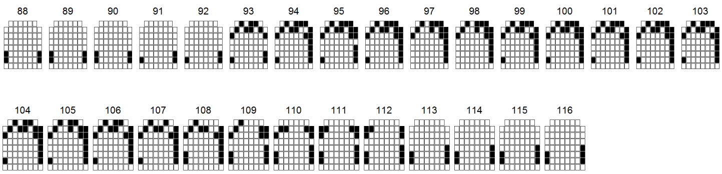
Figure 12: J001 *šlēl* 'cross-eyed' (Mehri)

Table 8: Duration values for ONSET DELAY, ONSET-MAX and MAX-OFFSET for Shehret /l, n, r/; M=mean, SD=standard deviation, R=range

	ONSET DELAY			ONSET-MAX			MAX-OFFSET		
	M	SD	R	M	SD	R	M	SD	R
/l/	74.13	46.95	0-170	35.53	27.28	0-90	154.21	70.47	30-320
/n/	90.14	57.68	0-261	45.49	36.84	0-180	158.04	68.03	40-330
/r/	75.7	29.23	17-142	20.91	23.21	0-110	37.27	25.09	10-100



(a) J043 *ṣ́ēl* ‘cold’ (Shehret) with aligned phonetic transcription; silent articulation and dynamic tongue-palate contact profile circled on palatogram; ONSET DELAY (141 ms) identified by double-headed arrow, ONSET-OFFSET (160 MS) by dashed double-headed arrow



(b) Enlarged image of palates circled in Figure 13(a); measurement landmarks ONSET (frame 93), MAX (frame 96) and OFFSET (frame 109)

Figure 13: J043 *ṣ́ēl* ‘cold’ (Shehret)

Table 9: Duration values for ONSET DELAY, ONSET-MAX and MAX-OFFSET for Shehret /^{h}l, ^{h}n, ^{h}r/; M=mean, SD=standard deviation, R=range

	ONSET DELAY			ONSET-MAX			MAX-OFFSET		
	M	SD	R	M	SD	R	M	SD	R
/^{h}l/	81.6	56.5	12-210	21.33	17.27	0-60	51.47	27.8	150-240
/^{h}n/	141.31	76.47	21-470	51.37	55.32	0-320	110.0	66.16	40-280
/^{h}r/	92.07	45.1	37-140	12.86	7.26	0-30	38.57	21.07	10-70

tracted and less extensive along the lateral margins for the silent /l/ than for the word-initial emphatic lateral fricative /ṣ́/.

4.3.4 Shehret breathed sonorants

Our Shehret data set for utterance-final breathed sonorants contained 85 tokens from two speakers (M026, J043). The mean onset delay, onset-max, max-offset and onset-offset duration values with their ranges and standard deviations are given in Table 9 separately for /^{h}l/, /^{h}n/ and /^{h}r/. All tokens showed an onset delay which in the majority of cases reached 50 ms or more: 67% of tokens in the case of /^{h}l/ (mean onset delay 82 ms), 96% for /^{h}n/ (mean onset delay 141 ms), 71% for /^{h}r/ (mean onset delay 92 ms). Delays of 100 ms or more are very common across all sonorants: 40% of tokens in the case of /^{h}l/, 73% for /^{h}n/, 57% for /^{h}r/.

The situation with respect to the breathed sonorants in Shehret is essentially the same as for the unbreathed sonorants, except that the vowel offset is marked by breathy voice (transcribed as {V̤}) and the onset delay typically contains some aspiration noise, shown by ^{h} in Figure 14(a).

4.3.5 Summary of EPG results

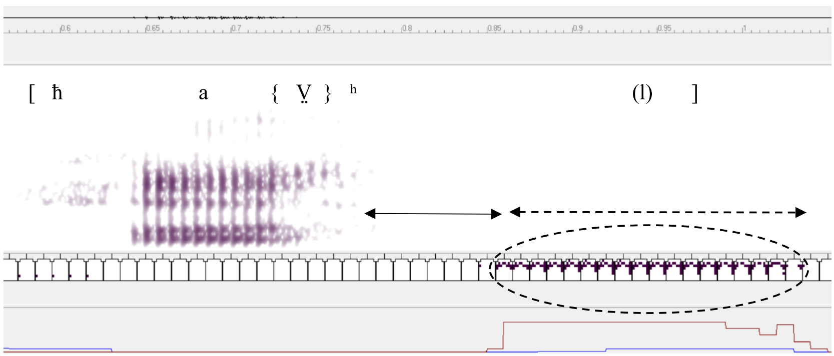
EPG methods were used to address RQs 1 and 2:

1. Are utterance-final sonorants silent in careful speech?

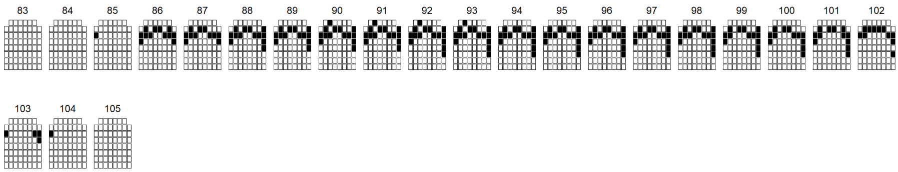
2. Are silent utterance-final sonorants articulated?

Both of these questions are answered positively: lingual sonorants in utterance-final position following a long vowel in Mehri and a full vowel in Shehret are all articulated with a gesture appropriate to the target sound and, with few exceptions, lack any accompanying acoustic signal. The non-silent exceptions are a few cases of /r/, and fewer of /^{h}r/, due to the inherent nature of trilled articulation, and speaker J001's whispered realisations. The lack of formant transitions in the preceding vowel and the lack of evidence of articulator activity during the onset delay provide justification for describing these sonorants as truly silent, a description corroborated by the informal test described in Section 5.3 in which a listener was unable to identify the final sonorant when the speaker's back was turned.

Three phases can be identified in the time course of silent sonorants: the vowel offset, the onset delay, and the articulatory contact itself. The onset delay phase in the utterance-final sonorant data varies considerably in duration with a few tokens showing no delay but most showing delays of well over 50 ms, often extending to over 100 ms.



(a) J043 *ḥa^{h}l* ‘pressed oil’ (Shehret) with aligned phonetic transcription; silent articulation and dynamic tongue-palate contact profile circled on palatogram; ONSET DELAY (57 ms) identified by double-headed arrow, ONSET-OFFSET (180 ms) by dashed double-headed arrow



(b) Enlarged image of palates circled in Figure 14(a); measurement landmarks ONSET (frame 85), MAX (frame 92) and OFFSET (frame 103)

Figure 14: J043 *ḥa^{h}l* ‘pressed oil’ (Shehret)

The articulatory contact phase also varies considerably both in how long it takes to form maximum articulatory contact (the ONSET-MAX measure), and in how long the contact remains in place (the MAX-OFFSET measure), although the latter will be affected by the general phenomenon of pre-boundary lengthening whereby segments immediately before certain boundaries are longer than those earlier in the utterance (Gussenhoven & Rietveld 1992). MAX-OFFSET values for /r/ and /^{h}r/ are lower due to the prevalence of tap and trill realisations; these realisations also sometimes exhibit some brief voiceless turbulence.

In the case of unbreathed sonorants in both languages, the vowel offset is marked by creaky phonation; in the case of the Shehret breathed sonorants, it is marked by breathy voice. The onset delay phase is marked by silence in the case of pre-glottalised sonorants, but by aspiration in the case of the pre-aspirated ones. The vowel offset phase is explored further in Section 4.4.

4.4 Electrolaryngographic study

This section examines collection and analysis methods of the ELG data, and then focuses on the analysis of three types of utterance-final segments: Mehri unbreathed sonorants, Shehret unbreathed sonorants, and Shehret breathed sonorants. The ELG study was designed to answer RQ 3:

3. Does the larynx behave differently before silent utterance-final breathed sonorants than before silent utterance-final unbreathed sonorants?

4.4.1 Data collection and analysis

ELG were recorded on a Laryngograph EGG-D200 microprocessor with an ECM 500L/SK lapel microphone both in the field in Dhofar between 2014 and 2021 and at the University of Leeds in 2015, 2017 and 2018. Closed quotient (CQ) values were taken at the mid-point and offset of the vowel preceding the utterance-final sonorant in a total of 781 tokens: 226 Mehri unbreathed sonorants, 226 Shehret unbreathed sonorants, 226 Shehret breathed sonorants, and 103 more Mehri tokens collected from speaker M001 whose results are presented separately in Section 4.4.6 due to their atypicality. In contrast to our EPG study, we are not investigating different places of articulation in the ELG study. We therefore present the data in Table 10 according to the number of unbreathed and breathed tokens recorded for each speaker rather than the number of individual segment tokens.

Table 10: Number of utterance-final silent sonorant tokens of each language by speaker for ELG analysis

Mehri	Unbreathed	Shehret	Unbreathed	Breathed
M001	103	J001	24	30
M026	13	J002	12	0
M028	58	J116	27	48
M068	69	J117	24	19
M079	70	J028	27	48
J001	16	J043	95	63
		M026	17	18
Total	329	Total	226	226

The closed quotient (CQ) of a glottal voicing cycle is the proportion of the cycle during which the vocal folds are in contact, expressed as a percentage of the whole cycle (Abberton et al. 1989: 290). The lower the CQ value of a cycle, the more air is free to flow through the glottis. There is thus an inverse relation between CQ and transglottal airflow, with values below about 40% tending to sound increasingly breathy (Heselwood & Maghrabi 2015: 153–154; Wright et al. 2019 give 34% as typifying breathy voice). The voice quality of a vowel typically shows coarticulatory effects depending on the glottal state of the adjacent consonant (Gobl & Ní Chasaide 1999). Open-glottis consonants prompt lower CQ values at vowel edges in contrast to voiced consonants and consonants with the glottis in what Esling & Harris (2005: 356) call a constricted "prephonation" state as found, for example, at the release of unaspirated stops. By taking CQ values at the offsets of vowels we can therefore gain information about the relative size of the glottal opening at the start of the following consonant and the extent to which it impedes or facilitates transglottal airflow. Comparison with the CQ value at the vowel's mid-point reveals whether the glottis is becoming increasingly unconstructed, and hence increasingly open, as the vowel approaches the following consonant or not. Aspirated (breathed) segments are produced with an open glottis, while unaspirated (unbreathed) are produced with a more closed glottis. We therefore predict that Shehret breathed sonorants will exhibit CQ values below 40% and Mehri and Shehret unbreathed sonorants will exhibit CQ values above 40%.

The two measurement CQ landmarks are the glottal cycle at the mid-point of the vowel, which we take to be half-way along the train of glottal pulses,[14] and the final regular glottal cycle at the vowel offset. Irregular cycles were excluded because of the risk of inaccuracies due to double pulsing and very long glottal closed phases.

CQ values were assigned to bins on a 0–100% scale, as given in Figures 15, 19, and 22. The significant divide is at around 40%.

4.4.2 Mehri unbreathed sonorants

Figure 15 presents the distribution of CQ values for vowel offsets in Mehri (excluding atypical speaker M001) before silent sonorants. 80% of values are in the 45%+ range, with only 4% falling below 40%. From this we can conclude that the glottis does not begin to open during the final part of the vowel, a conclusion consistent with the creaky phonation seen in the spectrograms below and in Section 4.1. Figure 16 shows that averaged across all tokens there is virtually

[14]We measure half-way along the train of glottal pulses rather than the mid-point of the vowel, as the number of glottal pulses is less arbitrary than an estimate of vowel duration.

no change in CQ value from vowel mid-point to vowel offset, the slope being almost level.

The following figures present examples of the sonorant consonants /l, r/ in Mehri. Figures presenting examples of /n, m/ are provided in supplementary material. The figures show little change in CQ value from the vowel mid-point to vowel offset, closely replicating the slope of the averaged values in Figure 16. Figure 17 shows synchronized spectrogram, audio waveform (blue), larynx waveform (green) and CQ trace (pink line) for the second syllable of *ṯīḳōl.* The larynx waveform represents the alternate closing and opening of the vocal folds during voicing: the waveform peaks represent maximum closure, the valleys represent

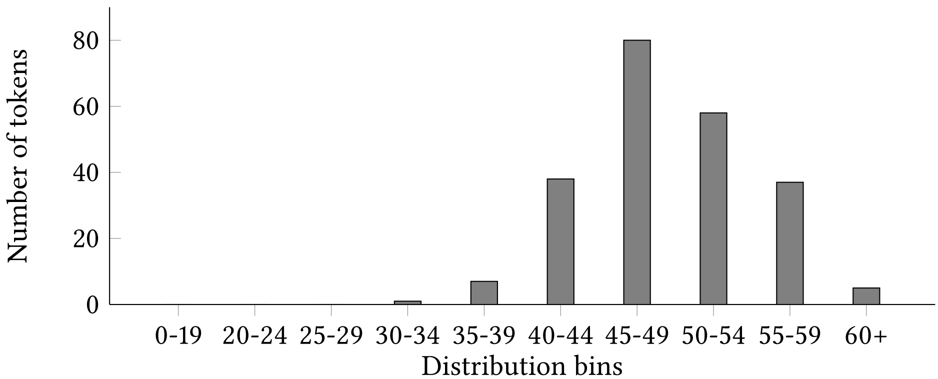


Figure 15: Distribution of CQ values at vowel offset before final silent sonorants in Mehri

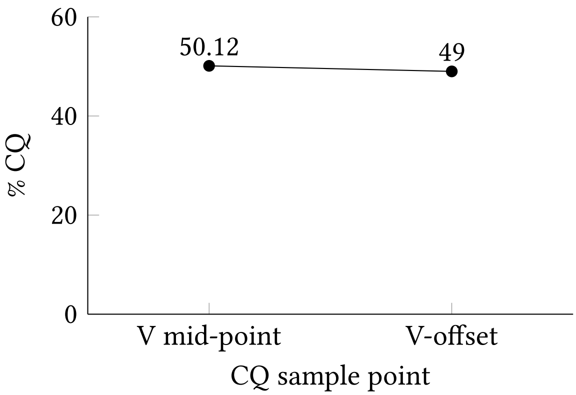


Figure 16: Averaged CQ slope from vowel mid-point to vowel offset before final silent sonorants in Mehri

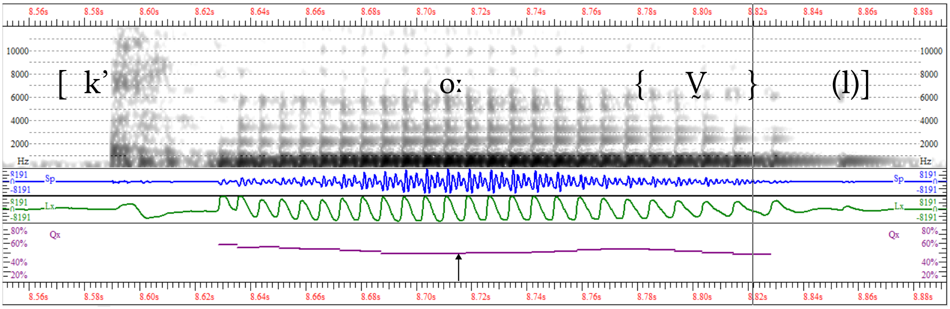


Figure 17: M028 *(ṯī)ḳōl* ‘heavy.M.PL’ with aligned phonetic transcription; CQ at mid-point = 48% (arrowed), CQ at offset = 48% (at cursor)

maximum opening. In this figure, the CQ slope remains relatively flat during the vowel in the 45–49% range with the final few pulses showing evidence of creaky phonation. The final /l/ is silent.

In Figure 18, the CQ value rises from 50% at vowel mid-point to 55% at the offset of the vowel preceding final /r/ in Mehri *āfōr* ‘clouds’. Note that /r/ is realised as a two-beat devoiced trill after a silent onset delay of 162 ms.[15]

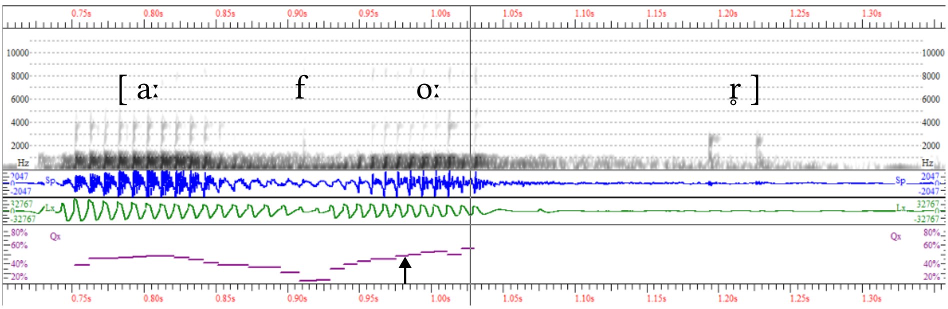


Figure 18: M068 *āfōr* ‘clouds’ (Mehri) with aligned phonetic transcription; CQ=50% at mid-point (arrowed), 55% at offset (at cursor)

4.4.3 Shehret unbreathed sonorants

Figure 19 presents the distribution of CQ values for vowel offsets in Shehret before silent unbreathed sonorants. The values are more spread out than they

[15]Also worthy of note is that /f/ is realised with breathy voice with a CQ value reaching as low as 21% in this instance; that is to say, it is phonetically voiced while remaining phonologically “breathed”.

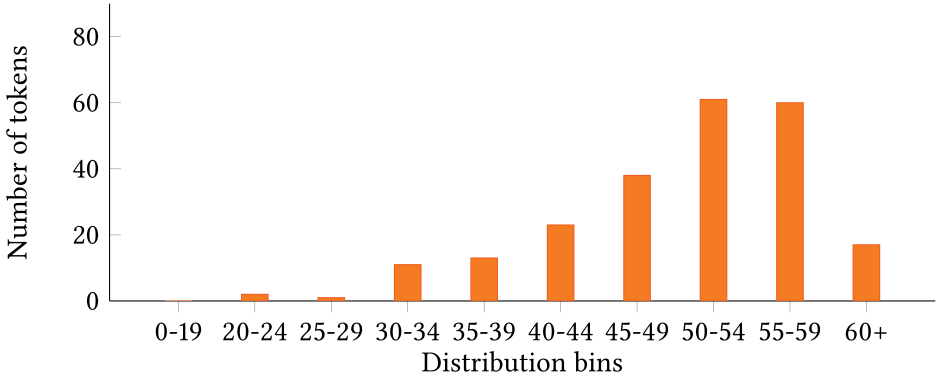


Figure 19: Distribution of CQ values at vowel offset before final silent unbreathed sonorants in Shehret

are in Mehri, although the general pattern is similar, with 12% exhibiting CQ values below 40%. Of the rest, 78% have CQs of 45% or above. Figure 20 shows on average the CQ slope is almost flat, however, as was the case in the Mehri data.

Figure 21 presents the spectrogram, audio waveform, larynx waveform and CQ trace of final unbreathed /l/ in Shehret. Figures in supplementary material present examples for each of the other unbreathed sonorants /m, n, r/. As with the Mehri examples, the CQ slopes in some remain relatively flat, while they rise slightly in others.

4.4.4 Shehret breathed sonorants

The distribution of CQ values for vowel offsets in Shehret before silent breathed sonorants is presented in Figure 22. Only five tokens (2%) had a CQ of 40% or more, and 79% had CQ values below 30%, well within the range for breathy voice phonation. In marked contrast to the vowels before the unbreathed sonorants in both Shehret and Mehri, Figure 23 shows that, on average, the CQ slope of a vowel drops 23% before a breathed sonorant. The indication is, therefore, that the glottis becomes less constricted towards the end of the vowel in anticipation of its opening to allow voiceless air to flow through in the form of aspiration.

ELG data of the breathed sonorants /^{h}l, ^{h}m, ^{h}n, ^{h}r/ in Shehret show an average fall in the CQ slope from the vowel mid-point to a value below 30% at vowel offset. These falls are not observed in the data for the unbreathed sonorants in either Shehret or Mehri (although see Section 4.4.6). They indicate that the vocal folds are undergoing a progressive reduction in contact during subsequent cycles

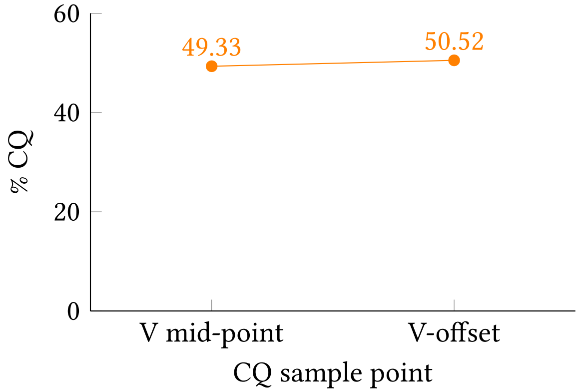


Figure 20: Averaged CQ slope from vowel mid-point to vowel offset before final silent unbreathed sonorants in Shehret

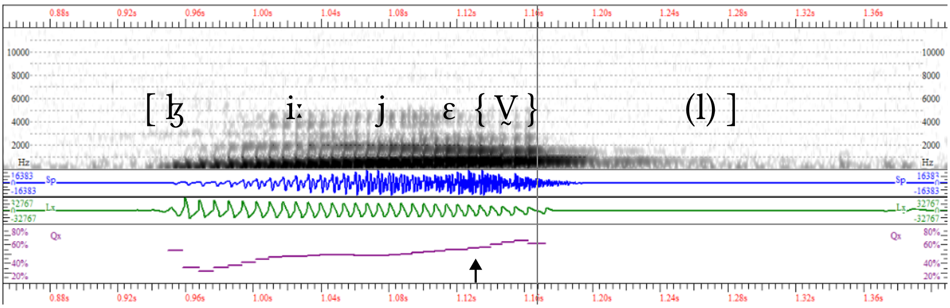


Figure 21: J043 *źīyɛl* 'camel herders' (Shehret) with aligned phonetic transcription; CQ=54% at mid-point (arrowed), 61% at offset (at cursor); position of silent /l/ very approximate

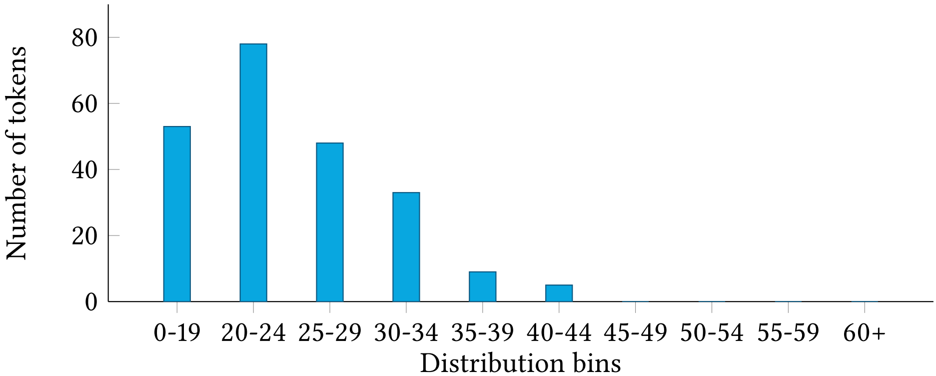


Figure 22: Distribution of CQ values at vowel offset before final silent breathed sonorants in Shehret

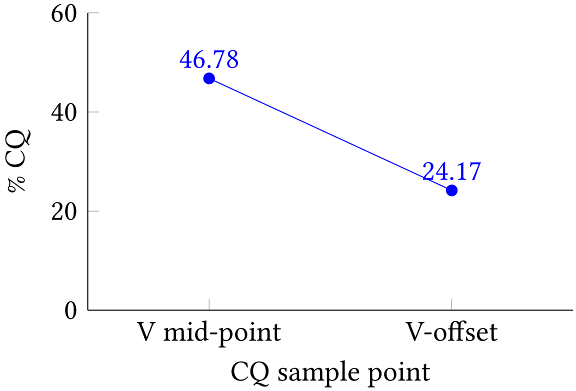


Figure 23: Averaged CQ slope from vowel mid-point to vowel offset before final silent breathed sonorants in Shehret

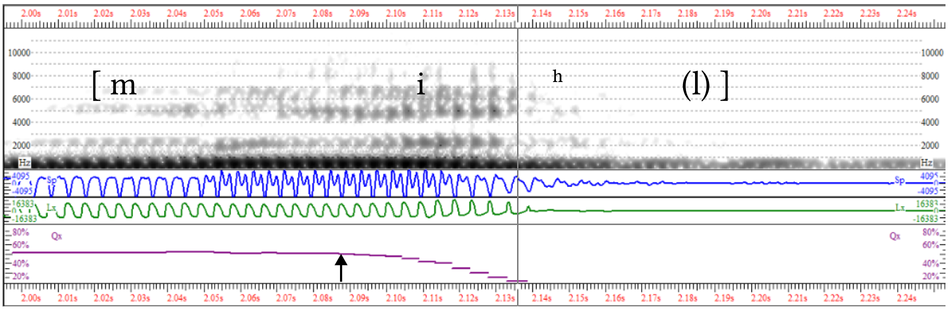


Figure 24: J001 (*eg*)*mi*^{h}*l* 'the camels' (Shehret) with aligned phonetic transcription; CQ=50% at mid-point (arrowed), 20% at offset (at cursor); position of silent /l/ very approximate

of voicing preparatory to the appearance of aspiration which can be seen on the spectrograms as soon as voicing ceases. Figure 24 provides an example of /^{h}l/, taking the final syllable from (*eg*)*mi*^{h}*l* 'the camels'. Further figures and discussion are available in the supplementary material.

4.4.5 Summary of ELG results

ELG methods were used to address RQ 3:

3. Does the larynx behave differently before utterance-final breathed sonorants than before utterance-final unbreathed sonorants?

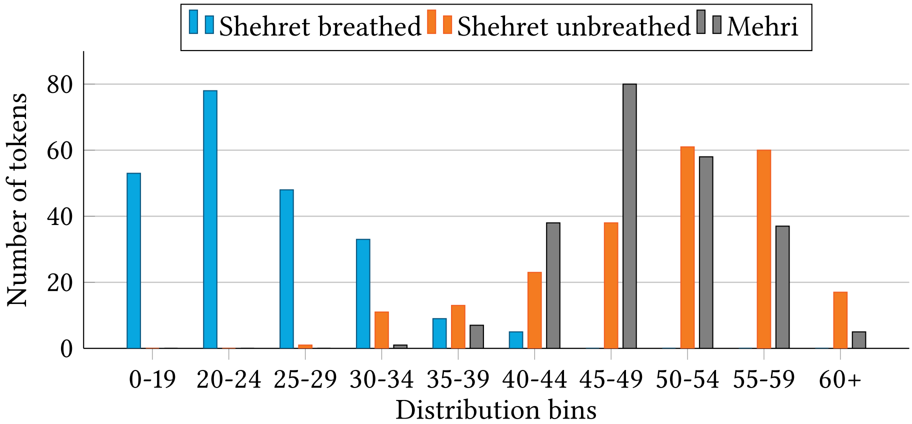


Figure 25: Comparison of distribution of CQ values at vowel offset before final silent sonorants in Mehri and Shehret

For convenience of comparison, Figures 15, 19 and 22 are combined in Figure 25 where it can easily be seen that vowel offset CQ values for Mehri and Shehret unbreathed sonorants have very similar distributions in clear contrast to those for Shehret breathed sonorants. Figures 16, 20 and 23 are combined in Figure 26 to show that on average CQ slopes remain almost level well above 40% for Mehri and Shehret unbreathed sonorants, but fall quite steeply to well below 30% for Shehret breathed sonorants.

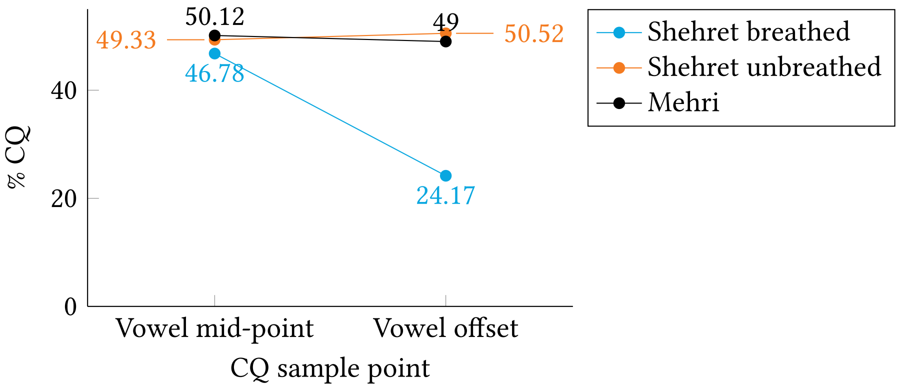


Figure 26: Comparison of averaged CQ slopes in Mehri and Shehret (Shehret unbreathed line partially obscured by Mehri line)

The ELG results answer RQ 3 positively: the larynx does behave differently before utterance-final breathed sonorants than before utterance-final unbreathed sonorants. The ELG results provide evidence of the behaviour of the glottis during the vowel offset phase of final silent sonorants in both languages, showing that the glottis is relatively constricted prior to the onset delay phase of unbreathed sonorants, but becomes increasingly unconstricted prior to the onset delay phase of the Shehret breathed sonorants. This difference in glottal constriction at vowel offset results in the onset delay phase being silent in unbreathed sonorants due to lack of transglottal airflow, but noisy for at least the first part of the onset delay phase in Shehret breathed sonorants due to transglottal airflow being facilitated.

4.4.6 Simultaneous pre-glottalisation and pre-aspiration

We have so far excluded one speaker (M001) in our Mehri data because of his atypically and exceptionally low CQ values for all vowel tokens at vowel offset. His CQ distribution is shown in Figure 27, his averaged CQ slope can be seen in Figure 28, and an example of his production of the word *yiṣ́lēl* in Figure 29. From these figures, it can be seen how similar his CQ values are to those associated with the breathed sonorants in Shehret.

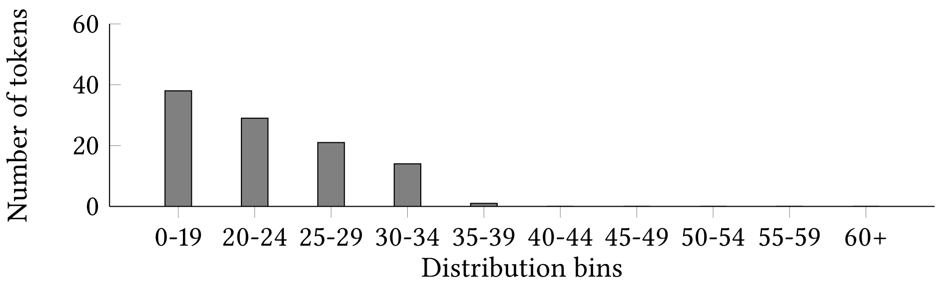


Figure 27: Distribution of speaker M001's CQ values at vowel offset before final silent sonorants in Mehri

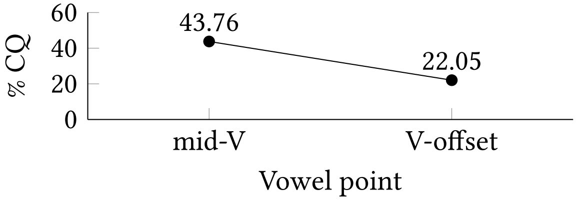


Figure 28: Averaged CQ slope from vowel mid-point to vowel offset before final silent sonorants in Mehri for speaker M001

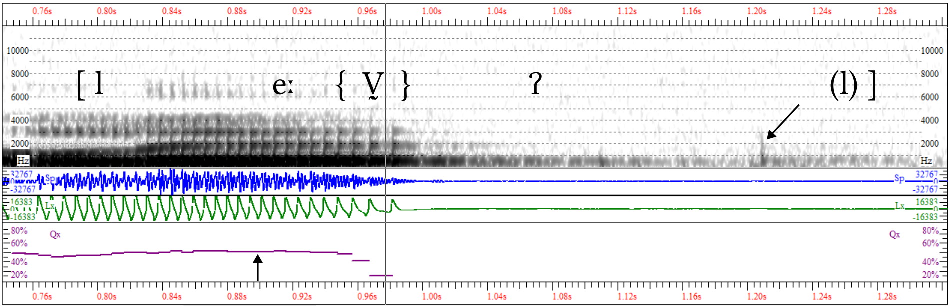


Figure 29: M001 (*yiṣ̂*)*lēl* 'he goes wrong' (Mehri) with aligned phonetic transcription; CQ=50% at mid-point (arrowed), 25% at offset (at cursor); glottal release arrowed; position of silent /l/ very approximate

The resemblance of M001's vowel offsets to those preceding pre-aspirated sonorants looks on the face of it to run counter to what the other Mehri speakers' CQ values lead us to expect in terms of glottal constriction, but closer inspection may provide an explanation. Hejná (2022, see also Hejná 2025 [this volume]) concludes from a study of Welsh-accented English that pre-glottalisation does not preclude pre-aspiration and that both can occur together manifesting as whispery creak. The creak pulses evident in the spectrogram in Figure 29 together with the falling CQ values suggest that M001 may be employing whispery creak phonation (marked on the transcription as {Ṿ̃}, with subscript dot beneath tilde) at the offset of vowels before final silent sonorants: the whisper is visible on the relevant spectrograms for this speaker; however, the auditory impression is of a glottal stop at the end of the vowel, and a glottal release can be seen on the spectrogram (arrowed). The posterior opening of the glottis for the whisper component of whispery creak (Catford 1977: 100) will be responsible for the low CQ values, and the anterior medial compression responsible for the creakiness. The whisperiness itself may result from sphinctering of the aryepiglottic folds (Esling & Harris 2005: 367; Moisik et al. 2019). It is also significant in view of our "breathed–unbreathed" analysis of Mehri and Shehret laryngeal phonology that airflow is lower during whisper settings than during breathy voice (Esling & Harris 2005: 368).

5 Discussion

This section is divided into a summary of results (Section 5.1), a discussion of laryngeal categories (Section 5.2), a discussion of how silently articulated sonorants can be incorporated into the literature on lenition (Section 5.3), and further research (Section 5.4).

5.1 Summary of results

In our EPG data, utterance-final singleton sonorant consonants in a stressed syllable are always realized with an articulation, which is typically silent, in both languages. In Mehri, utterance-final geminate sonorants are fully sounded with voicing in the initial portion without pre-glottalisation or pre-aspiration, as are many, but not all, singleton sonorants in post-tonic syllables. The absence of sound can be seen in almost all the examples we present in this chapter and in supplementary material, and is underscored by the comment from M001 that were a speaker to voice a singleton sonorant in an utterance-final stressed syllable listeners would find it comical. There may therefore be social pressure not to voice them. M001 was equally insistent that, despite its silence, the articulation of a final sonorant is always executed, a claim borne out by our data. One bilingual speaker, J001, however, realises his final unbreathed sonorants with whisper phonation in a minority of cases, an example of which is presented in Figure 12. Very occasionally, some light noise is evident after the offset of a silent articulation which we take to be turbulent air exiting through the channel opened by the articulatory release.

The atypical laryngeal behaviour of M001 discussed in Section 4.4.6, we believe, may be partly due to the fact that there is no contrast in Mehri between unbreathed and breathed sonorants; there is therefore less need for Mehri speakers than for Shehret speakers to produce significantly higher CQ values in this context providing there is some form of pre-glottalisation.

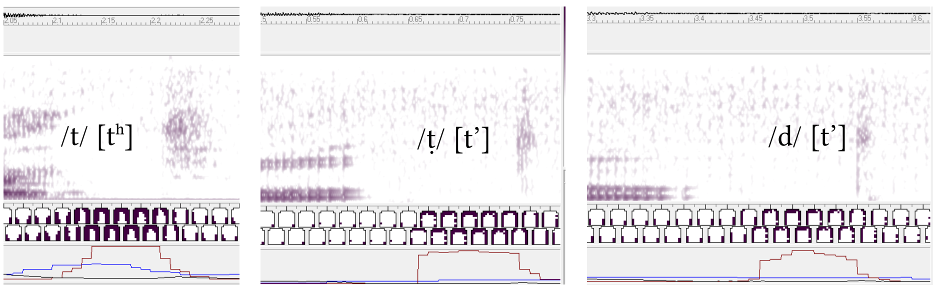
The phonatory component of final sonorants, however, is generally not completely silent if we take modulations to the offset of the preceding vowel as evidence of phonatory co-production. In the case of the unbreathed sonorants of Mehri and Shehret, this takes the form of creaky phonation. In the case of the breathed sonorants of Shehret, it takes the form of breathy voice followed by aperiodic noise. Whether or not these modulations function as perceptual cues is a question we have to leave open in the absence of experimental evidence. In some tokens, there is also a detectable manner-of-articulation cue in the form of degrees of nasalisation on a vowel preceding a silently articulated nasal.

5.2 Laryngeal categories

As discussed in Section 2.5, voiced and emphatic consonants share phonetic and morphophonological characteristics (Watson & Heselwood 2016), motivating the shared laryngeal feature "unbreathed" as opposed to "breathed" for voiceless consonants. As noted in Section 4.4.5, many tokens of utterance-final unbreathed sonorants show creaky phonation at vowel offset. These tokens, and many that do not show creaky phonation, give the auditory impression of terminating in a complete glottal closure. Evidence of glottal release occurring during the onset delay phase of final silent unbreathed sonorants from our EPG data can be seen in Figure 12, and from our ELG data in Figure 17 and Figure 29. The fact that unbreathed sonorants exhibit pre-glottalisation and relatively high CQ values in preceding vowel offsets, and that breathed sonorants exhibit pre-aspiration and much lower CQ values in preceding vowel offsets, supports the "unbreathed" vs. "breathed" analysis of their laryngeal behaviour referred to in Section 2.5. The terms of the analysis derive from focusing on the breath-controlling function of the glottis rather than the tone-generating function (Heselwood & Watson 2021). Further research into the behaviour of the larynx in Mehri and Shehret would benefit greatly from laryngoscopic and aerometric investigation.

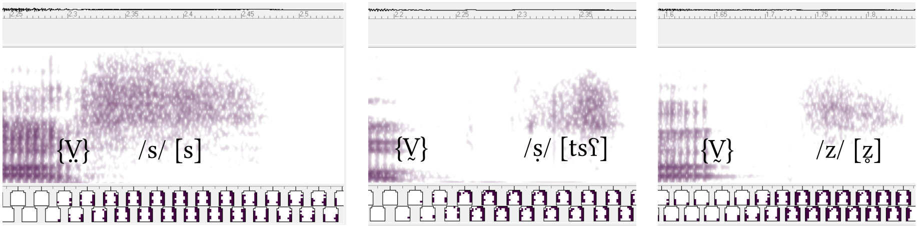
The glottalised vowel offset and silent onset delay before unbreathed sonorants is also observed in our EPG data before utterance-final emphatic and voiced obstruents in both languages.[16] Examples are shown in Figure 30 for the voiceless-emphatic-voiced triad of alveolar stops in Mehri, and in Figure 31 for the fricative voiceless-emphatic-voiced triad in Shehret. The lack of glottalisation or onset delay before voiceless consonants means that, in the case of fricatives, friction noise follows immediately on from the vowel thus paralleling the aspiration in pre-aspirated sonorants which also follows immediately on from the vowel. This similarity again justifies placing pre-aspirated sonorants in the same

[16]For Shehret, Heselwood et al. (2022) report mean gap durations of 60 ms before final emphatic fricatives, 109 ms before voiced fricatives, and no gap before voiceless fricatives.



(a) voiceless (b) emphatic (c) voiced

Figure 30: J001 utterance-final (a) voiceless, (b) emphatic and (c) voiced alveolar stops (Mehri); note the articulation onset delay in the emphatic and voiced stops but not the voiceless stop



(a) voiceless (b) emphatic (c) voiced

Figure 31: J043 utterance-final (a) voiceless, (b) emphatic and (c) voiced alveolar fricatives and their realisations (Shehret); note the glottalised offset, onset delay and acoustic gap in the emphatic and voiced fricatives, but not the voiceless fricative which has a breathy offset

laryngeal class as voiceless obstruents, and plain sonorants in the same class as emphatic and voiced obstruents.

Although place distinctions are lost acoustically among utterance-final sonorants, the stop–fricative–sonorant manner contrast is maintained by the respective phonetic exponents "burst"–"friction"–"silence".

5.3 Lenition

Sonorants have rarely been examined within the recent literature on lenition, one exception being the work of Lawson et al. (2015) on lenited final /r/ in Scottish English; however, final sonorants are prone to significant synchronic and diachronic instability, typically becoming more vowel-like and moving up the sonority scale. This includes vocalisation of /l/ and /r/ in varieties of English (Wells 1982 for *l*-vocalisation; Lutz 1994 for *r*-vocalisation), Romance and Germanic, a process which has resulted in the diachronic loss of /l/ in certain words in Dutch, as in *goud* 'gold' but *gulden* 'golden', and in French, as in *chaud* 'hot' from Vulgar Latin *caldu(m)*, *l*-vocalisation in Mehri (Rubin 2014; Watson et al. 2020) and Shehret (Rubin 2014), loss of nasals with nasalisation of the preceding vowel in French (Rochet 1976) and Portuguese (Cruz-Ferreira 1995), and anticipatory assimilation of sonorants in Arabic (Watson 2002).

We assume that utterance-final silent sonorants fall in the category of consonant lenition. Harris (1990: 265) describes lenition as "a reduction in the complexity of a segment", and this is indeed what we find in our data. Utterance-final position is one of the conditioning environments for lenition (Kirchner 1998: 8). The typical cline of lenition is given below (after Guravich 2011: 1564):

- degemination (e.g. t: to t);
- deaspiration (e.g. t^h to t);
- voicing (e.g. t to d);
- spirantisation, or reduction from a stop (or affricate) to a fricative continuant (e.g. t to θ, b to β);
- flapping (e.g. t to ɾ);
- debuccalisation, or reduction to a laryngeal consonant (e.g. t to h, s to h);
- gliding, or reduction of obstruent to a glide (e.g. b to w);
- loss, or complete elision (e.g. t to ∅);

Of these, debuccalisation and complete elision are most likely to occur in syllable coda or utterance-final position. The cline of lenition typically relates to acoustics rather than articulation, however, and silent articulations have, to the best of our knowledge, not been described within the literature on lenition. As the majority of work on lenition has focused on acoustics rather than articulation, it is also possible that some cases of complete loss, on the cline of lenition above, do involve some residual articulatory gesture.[17]

The literature on lenition typically describes two types. The first involves the consonant becoming more vowel-like and increasing in intensity while decreasing in degree of articulatory constriction. The second involves the consonant losing part of its melodic content (either its place of articulation or its laryngeal properties) and becoming more mutelike (Szigetvári et al. 2008). The terms for the two major lenition types vary across the literature: the first has been described as "vocalic lenition" or "sonorisation" (Szigetvári et al. 2008), and "continuity lenition" (Katz 2016); the second has been described as "consonantic lenition" (Szigetvári et al. 2008) and "loss lenition" (Katz 2016).

Silent sonorants, however, present a challenge to lenition theory. They have not become more vocalic (in fact, catastrophically less so), nor have they consistently decreased their degree of articulatory constriction compared to sounded

[17] For example, unreleased word-final stops, as attested systematically in Korean and Thai (Tsukada 2004) and in Karitiana, an endangered language of the Tupi stock (Storto & Demolin 2002). Browman & Goldstein (1987, 1989), taking the example *perfect memory*, show that even where /t/ of *perfect* fails to show any audible trace, there may still be a reduced articulatory gesture. We assume here that utterance-final silent articulations occupy the stage on the cline of lenition preceding debuccalisation.

sonorants. Our EPG results show that they have not lost their place of articulation, and it is problematic to say they have lost their laryngeal category. Although they have lost the phonation that normally accompanies the articulation of a sonorant, and have thus undeniably become "mutelike", our ELG results show the laryngeal contrast "breathed–unbreathed" is maintained through different distributions of CQ values at the offset of the preceding vowels, enhanced by pre-aspiration versus pre-glottalisation. Yet there is no acoustic signal during the articulation, barring the whispered realisations found in one speaker, and no evidence of coarticulatory effects in terms of formant transitions cueing their place of articulation (Delattre et al. 1955). If the term "lenition" is to be applied, it has to be applied to the acoustics of these sonorants not their articulation, with "loss lenition" (Katz 2016) interpreted to mean loss of acoustic signal only. It is difficult to fit this situation into the cross-linguistic cline of lenition processes above, which, except for the process of degemination, appears not to apply to sonorant consonants at all.

What we see, rather than loss of place of articulation or laryngeal category, is the separation of place of articulation and laryngeal category by an articulatory onset delay similar to that observed for final /r/ in Scottish English reported in Lawson et al. (2015). They found that final /r/ is either not perceived by listeners, or weakly perceived, when the relative timing of phonation and articulation shifts such that the articulatory gesture reaches its peak after phonation ceases, resulting in a partially or wholly devoiced /r/.

Piecing together the evidence, and supplementing it with speculation, the diachronic picture for utterance-final unbreathed sonorants may be something like this:[18]

1. Creaky realisation of sonorant with anticipatory vowel offset, e.g. [a̰n̰].
2. Devoicing of sonorant with whisper arising as carryover from the laryngeal constriction setting for glottalisation, e.g. [a̰ṇ].
3. Introduction of prolonged glottal closure creating an onset delay by shifting articulation rightward along with its whisper phonation, e.g. [a̰ʔːṇ].

[18] One reviewer objected that the usual "lenition" path of change would be from complete glottal closure to creaky voice, not vice versa. However, we believe it quite plausible that creaky voice could evolve into a sustained glottal closure. In utterance-final position speakers do not have to make any anticipatory adjustments to their articulation, hence the common phenomenon of keeping the articulator in place for a short while after finishing the utterance. As creak slows down, the glottis is closed for longer in each cycle until the speaker terminates it, and the most effective way to stop creaking is to close the glottis.

4. Loss of whisper rendering the sonorant silent, e.g. [a̰ʔː(n)] as seen in the figures in Sections 4.3 and 4.4.

In summary, the hypothesised stages are:

(1) [a̰n̰] > [a̰ṇ] > [a̰ʔːṇ] > [a̰ʔː(n)].

Speaker M001 exhibits a variant in which whisper may have appeared by leftward spread to the vowel offset in stage 2 resulting in whispery creak, e.g. [a̰̣ṇ], and in this speaker whisper has remained there through to stage 4.

Glottal closure in the onset delay phase of unbreathed sonorants is analogous to the glottal closure in unbreathed obstruents, which in the same context are commonly realised as ejectives (as in Figure 30 and Figure 31), i.e. maximally "unbreathed" due to closure in the larynx. That is to say, glottal closure is a process that strengthens the glottalisation gesture of unbreathed consonants in contrast to glottal opening and aspiration which strengthen the "breathed" feature in breathed consonants, including the breathed sonorants in Shehret.[19] It seems then that the proposed trajectory for the utterance-final unbreathed consonants involves strengthening, or fortition, of the laryngeal feature and weakening, or lenition, of the acoustic properties of the place feature, although the articulatory properties may disappear in the future. This analysis of laryngeal strengthening is only explanatory if the relevant laryngeal feature is "unbreathed" (or an equivalent term). A closure in the larynx completely shuts down airflow and is therefore the strongest phonetic exponent of "unbreathed". If the relevant feature is claimed to be "voiced", then far from being strengthened, it is in fact completely extinguished. In the case of breathed sonorants, the laryngeal feature "breathed" is strengthened by glottal opening and pre-aspiration.

The diachrony for silent breathed sonorants might be something like that outlined below.

1. Breathy voice realisation of sonorant with anticipatory vowel offset, e.g. [a̤n̤].

2. Devoicing of sonorant, e.g. [a̤n̥].

3. Introduction of prolonged glottal opening with aspiration creating an onset delay, e.g. [a̤ʰːn̥].

[19] It is interesting to note that the role pre-aspiration has in strengthening the phonological feature "breathed" has a morphosyntactic correlate in strengthening the category 'imperative' in verbs, as mentioned in Section 2.2.2.

4. Voiceless airflow becomes inaudible before the articulation, rendering the sonorant silent, e.g. [a̤ʰː(n)].

In summary, the hypothesised stages are:

(2) [a̤n̤] > [a̤n̥] > [a̤ʰːn̥] > [a̤ʰː(n)].

It is possible that this change could have happened very quickly once devoicing took place, perhaps even collapsing stages 2, 3, and 4.

We might interpret the asynchronous relation of articulation and phonation as a kind of lenition in the sense that the requirement for precise coordination is loosened, or weakened, in utterance-final position eventually unmooring the articulation of the sonorant from its original phonation and setting it adrift out of reach of coarticulatory effects and into eventual silence.

While we have encountered no tokens in either language in which the final sonorant fails to be articulated from our EPG and video data, an examination of a small set of Mehri cognates of Shehret function words with final breathed nasals may give us an idea that eventually word-final sonorants may be lost, while the laryngeal features remain and manifest as final /h/. Thus, Shehret *bū́ʰn* ‘here’ has the Mehri cognate *bóh*, Shehret *ṭáʰn* ‘like this’ the Mehri cognate *ūṭóh*, Shehret *ḏáʰn* ‘this.M’ the Mehri cognate *ḏáh* and Shehret *ḏíʰn* ‘this.F’ the Mehri cognate *ḏíh*. We know that these words are realized with final /h/ in Mehri because native speakers write them in the Arabic-based script in text messages with final /h/ (ه), while the Shehret words are written with final /hn/ (هن). In Mehri, none of the words above are realized with a nasal vowel. There are two words in Mehri with nasal vowels, however, both of which correspond to Shehret words with final breathed and unbreathed nasals respectively. Shehret *húʰn* ‘where’, with a final breathed nasal, has the Mehri cognate *ḥȭh*, ending in /h/, and Shehret *ahán* ‘yes’, with a final unbreathed nasal, has the Mehri cognate *ahã̄*, lacking final /h/.

As silent utterance-final sonorants are evident across generations, and, from Johnstone’s comments (1981: xiv) and Rubin’s (2014) work on some of Johnstone’s recordings, were already apparent among the Shehret speakers he worked with in the late 1960s and 1970s, one question we consider is how silent articulations continue to be passed across the generations.[20] The fact that word-final sonorants are maintained and typically fully voiced in utterance-medial position means that speakers are able to retrieve these sonorants lexically. However, the

[20] The maintenance of silent articulations over long periods of time is certainly not unprecedented: Gick et al. (2012) discuss reports of silent vowels dating to the 1880s in Oneida in Cooper (1885).

utterance-final lack of any acoustic signal accompanying the articulatory contact would suggest a diachronic trajectory in both languages towards total deletion of these sonorants in the relevant context, but this has not, as yet, occurred.

The failure to perceive utterance-final sonorants by native speakers is supported by fieldwork evidence where listeners frequently ask the speaker to repeat a new word and seek to view the speaker's face during articulation. We mention two anecdotes here. First, in 2018, M001 conducted an experiment whereby he turned his back to a native-speaker listener and produced final /w/ and /y/ words with and without producing the articulations for the final sonorant. Without being able to see the lips, the listener failed to identify pronunciations correctly on a higher than chance basis. Second, during fieldwork in late 2021, Watson asked about a Mehri word meaning 'lacking in salt'. Three speakers insisted the word was *ṣəḳḳawr* with final /r/, while their mother said the word was *ṣəḳḳawm* with final /m/. During her production of *ṣəḳḳawm*, her sons failed to hear the final sonorant, and even any nasalisation in the preceding vowel to signal the nasal, asking her to turn towards them so they could observe her lips during the articulation.

5.4 Further research

The silent sonorants in Mehri and Shehret are not only rare and unusual, but also prompt a critical look at notions of lenition, fortition, and devoicing. Singleton sonorants in the coda of word-final stressed syllables in Mehri and Shehret become silent utterance-finally, while those in post-tonic syllables usually do not. This appears to be due at least partly to stress conferring strength on laryngeal features which in both unbreathed and breathed sonorants puts the glottis in a state where it cannot provide sonorants with periodicity. Final geminates in Mehri are never silent despite occurring in the coda of a stressed syllable. The sounding of geminates in this position may be explained as gemination conferring strength on place features such that it overrides laryngeal strengthening. This is clearly an issue that requires further research and theorising.

Another question that has been raised is why speakers continue to articulate segments that have no acoustic output. The likelihood must be that they will suffer "loss lenition" and be lost altogether, but not via any previously described lenition trajectory. Watson, Tomé Lourido, and the native-speaker authors believe that visual cues ("visemes") in face-to-face interactions in languages, which until recently have been used solely in face-to-face communication, may play a role here. This hypothesis gains support from our anecdotal evidence of speakers requesting to see the speaker's lips and of listeners failing to perceive the final sonorant when the speaker's back is turned. The communicative effect of mobile phones on the articulation of utterance-final sonorants, a product of the twenty-first century in Dhofar, is yet to be examined. We presume that any loss of articulation will begin to be apparent in the speech of speakers born after 2000. Within a study on the effect of mobile phones, there is scope for an apparent-time study using EPG to investigate speakers who are both older and younger than the ones included here.

The analysis suggests two further areas of investigation with a larger speaker base:

1. In our EPG data, there appears to be a "same consonant" effect insofar as the onset delay tends to be shorter when the same consonant occurs in penultimate and ultimate positions. Further data from both languages is needed to establish how robust this tendency is.

2. From our speakers, only J001 produces whispered utterance-final sonorants and only M001 exhibits whispery creak in vowel offsets before utterance-final sonorants. Further data from both languages would establish how common these phenomena are in the population.

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Abbreviations

B	burst
BV	breathy voice
C	Central Dhofar
(C)	silent consonant
CG	closed glottis
CQ	closed quotient
C-W	Central-western Dhofar
DEAMSA	Documentation and Ethnolinguistic Analysis of Modern South Arabian
E	Eastern Dhofar
ELG	electrolaryngography, electrolaryngographic

EPG	electropalatography, electropalatographic
ExtIPA	extensions to the IPA
F	female; feminine; formant
fric	fricative
Hz	hertz
lat	lateral
LC	lip closure
LR	lip rounding
M	male; masculine; Mehri; mean
ms	milliseconds
MSAL	Modern South Arabian languages
N	aperiodic noise
Nr	number
pl.	plural
RQ	research question
sg.	singular
S	Shehret; silent articulation
SD	standard deviation
sf	stressed foot (primary stressed foot)
son	sonorant
R	range
V	voiced
{V̰}	creaky phonation
{V̤}	breathy voice
{V̰̣}	whispery creak phonation
VoQS	Voice Quality Symbols
W	Western Dhofar
{W}	whisper setting

Max	maximum articulatory contact
Max-offset	time between max and first frame showing break of articulatory contact
Offset	offset of articulatory contact
Onset	onset of articulatory contact
Onset delay	duration in ms of any delay between final voicing pulse of preceding vowel and onset of articulation of sonorant
Onset-max	time between onset and first palate frame of maximum articulatory contact
Onset-offset	time between onset and first palate frame showing break of articulatory contact

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Chapter 13

Aerodynamic and acoustic correlates of word-initial voiceless nasal geminates in Ikema Miyako Ryukyuan

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This study investigates the voiceless nasal sounds of the Ikema dialect of Miyako Ryukyuan, which is a severely endangered language spoken on the Miyako Islands in Japan. Miyako Ryukyuan exhibits a variety of geminate consonants, but Ikema is the only Miyako dialect that has developed voiceless nasal consonants as part of its word-initial geminate inventory. To investigate the voicing contrast of nasals, we explored aerodynamic and acoustic recordings from ten speakers. Acoustic measures (fundamental frequency and H1*-H2*) aimed to find voicing cues in the following vowel. Our results indicate that the airflow patterns of Ikema voiceless nasals are similar to those of Burmese, except that the voicing rate is higher in Ikema. Acoustic measures do not reveal any enhancing cue of the voicing feature. This result might be due to the longer voiced duration in the voiceless nasals, which our study also confirmed.

1 Background

1.1 Introduction to Ikema

Miyako Ryukyuan (Glottolog: miya1259) is spoken on the Miyako Islands of Japan on the East China Sea (Figure 1). It belongs to the Japonic language family

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along with Japanese (Pellard 2015). All Ryukyuan languages are recognised as endangered by UNESCO (Moseley 2009). The Ikema dialect of Miyako Ryukyuan is spoken in three areas of the Miyako Islands: Ikema Island, the Sarahama area on Irabu Island and the Nishihara area on the main Miyako Island. The dialect is spoken mainly by the elderly population over 60 years old. The current number of Ikema speakers is estimated to be circa 1,300 people (Nakama et al. 2022).

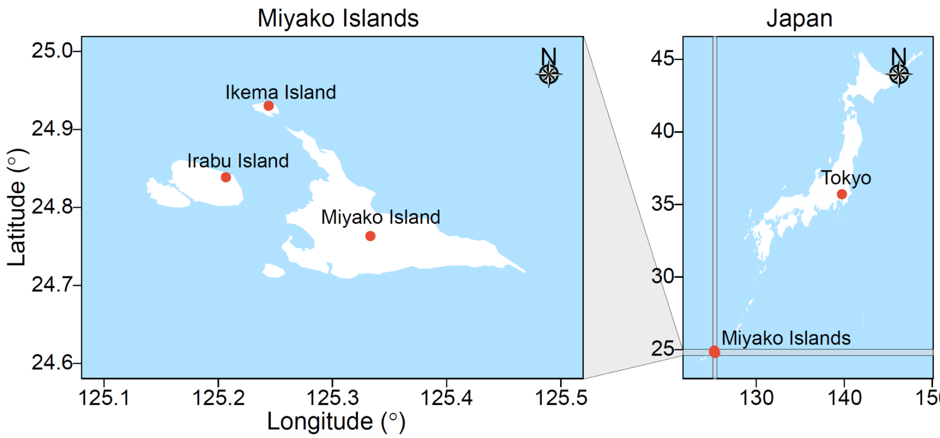


Figure 1: Location of the places where the Ikema dialect of Miyako Ryukyuan is spoken

Miyako Ryukyuan language has a wide range of word-initial and word-medial geminate consonants, but only the Ikema dialect has voiceless nasal consonants in its word-initial geminate inventory (Pellard & Hayashi 2012, Table 3).

Our purpose is twofold:

(1) to assess the contrast between voiceless and voiced nasals in Ikema through phonetic investigation;

(2) to determine whether the voiceless nasals in Ikema can be classified among the previously identified similar sounds.

To achieve these goals, we have explored airflow and acoustic data from ten speakers of the Ikema dialect of Miyako Ryukyuan recorded in 2018. Additionally, we discuss the rarity of voiceless nasal geminates from the perspective of their evolutionary path.

The remaining parts of this section subsequently present Ikema phonology and phonetics from synchronic and diachronic perspectives and give an overview of the typology of voiceless nasals in a cross-linguistic context. Section 2 introduces relevant phonetic studies and our hypotheses for Ikema. Section 3 outlines the methods and procedures used in the current study. Section 4 presents the key findings of the study. Finally, Section 5 discusses our results and their implications for the typology of voiceless nasals.

1.2 Ikema segmental phonology: synchrony

Ikema features four basic vowel segments (Table 1): /a/ (relatively open and central), /i/ (closed and front), /u/ (closed, back and rounded), and /I/ ([z̞] or [s]),[1] a closed unrounded vowel where the main constriction is located at the alveolar ridge, creating weak frication noise in some cases and the second formant of which is found between [i] and [u] (Fujimoto & Shinohara 2018).[2] This vowel occurs only after one of the homorganic consonants [s, ts, z] in Ikema. Additionally, two more vowel segments are used in a limited number of lexical items: /e/ (front mid-open) and /o/ (back mid-open), such as in /do/ ‘a sentence-final particle’ or /sjensjee/ [ɕeẽɕe:] ‘teacher,’ which is borrowed from Japanese.

Table 1: Ikema vowels

Front			Back
Close	i	I	u
	(e)		(o)
Open		a	

The consonant segments occuring in Ikema are given in Table 2.

In Ikema, segmental length (quantity) is contrastive, as it is in the majority of Japonic dialects (e.g., in Tokyo Japanese). Vowels contrast in length, except in underlyingly monomoraic words (see below). Consonants also exhibit length contrast manifested by gemination and represented in this chapter by double consonants.

Gemination occurs in certain consonants in word-initial and word-medial positions in Ikema. For example, the words /bada/ ‘gutter’ and /badda/ ‘side’ are differentiated solely by the length of the word-medial consonant. Some geminates

[1]The diacritic mark in [z̞] indicates an open articulation. The voiceless phone appears when the vowel occurs between two voiceless obstruents.

[2]In Miyako and southern Ryukyuans, a similar vowel has been described in different ways depending on the perspective. From an articulatory point of view, it has been labelled as an “apical” vowel /ɿ/ (e.g., Sakiyama 1963), while from an auditory point of view, it has been described as a central vowel /ï/ (e.g., Uchima 1984) or /ɨ/ (e.g., Hayashi 2010). A summary of the debate is found in Oono et al. (2000) and Pellard & Hayashi (2012). Fujimoto & Shinohara (2018) investigated its place of articulation in Ikema using real-time magnetic resonance imaging and acoustic quality through formant frequencies. See van Hugte et al. (2025 [this volume]) on the typology of fricative vowels.

Table 2: Consonant inventory of Ikema

	Labial (Labio-velar)	Alveolar	Alveolo-palatal	Palatal	Velar	Glottal
Plosive	(p)[a], b	t, d			k, g	
	pp	tt, dd			kk	
Fricative	f	s, z	ɕ, ʑ	ç		h
	ff, vv	ss, zz	ɕɕ			
Affricate		ts, dz	tɕ, dʑ			
		tts	ttɕ, ddʑ			
Nasal	m	n				
	m̥m, mm	n̥n, nn				
Approximant	(w)			j		
Liquid		ɾ				

[a]In the Nishihara variety of the Ikema dialect, singleton /p/ is used by some speakers; however, this is not the case in the Ikema variety. The Ikema dictionary based on the Nishihara variety includes words with /p/ (Nakama et al. 2022). Morphologically induced geminates may not all be included.

are lexical and contrast with a singleton consonant, as in this example. Alternatively, a segment may become a geminate through a morphological operation (e.g., /dusI/ 'friend' alternates with /duss-a/ 'friend.top').

Here is a summary of the syllable types, analysed in standard moraic theory (Hayes 1989) for Ikema (Table 3), except for some onset structures (see below). The syllable types in Ikema can be divided into two types: light and heavy syllables. Light syllables are composed of a short vowel with or without a simplex onset, cf. (a) in Table 3. Heavy syllables manifest several subtypes. Heavy syllables can contain a long vowel (b) or a short vowel closed by a coda segment. Coda consonants are restricted to a nasal (c) and the first half of a geminate consonant (d). Heavy syllables can also start with a geminate consonant (e) or a moraic nasal followed by an obstruent (f). In structure (f), only homorganic consonant sequences are allowed. A nasal consonant can also form a heavy syllable without a nucleus vowel (g), although only a few lexical items seem to involve this structure.[3]

In the moraic framework, the onset consonants are considered weightless. A word-medial geminate is treated as a single segment that affiliates with the

[3]The Ikema dictionary (Nakama et al. 2022) records two homophonous verbs, /n̥n/, which mean 'to ladle' and 'to step on.' The sound /n̥n/ is also present in some compound verbs, such as [n̥nta:] 'to trample.' As this dictionary is based on a single speaker, it is not possible to determine whether this structure represents a phonologically regular pattern.

Table 3: Surface syllable types of Ikema. C represents a consonant, V = a vowel, N = a moraic nasal, N: = a syllabic nasal. A dot marks the syllable boundary

Light syllable type (1 mora)	(C)V	(a) [sa.ba] ‘shark’
Heavy syllable types (2 moras)	(C)V:	(b) [na:] ‘name’
	(C)VN	(c) [in] ‘dog’
	(C)VC	(d) [maf.fa] ‘pillow’
	CCV	(e) [tta] ‘tongue’
	NCV	(f) [nta] ‘soil’
	N:	(g) [n:] ‘potato’

moraic coda position of one syllable and simultaneously with the onset position of the following syllable. Word-initial geminate consonants are less common cross-linguistically than those found in the word-medial position (Dmitrieva 2012, Hamzah et al. 2020, Kraehenmann 2001, Muller 2003, Thurgood 1993). The occurrence of geminates in the syllable onset positions poses a challenge to this theory. However, in some languages, onset consonants play a role in prosodic organisations such as stress or tone assignment, which indicates that they can bear prosodic weight (Davis 1999, Gordon 2004, Topintzi 2008, Shinohara & Fujimoto 2011). We also adopt the perspective that moraic segments can in principle appear in a syllable onset position.

Phonological evidence supports the moraicity of the initial geminates in Ikema. Monomoraic words always surface with two moras due to the bimoraic word minimality constraint. For example, /na/ ‘name’ and /ti/ ‘hand’ surface as [na:] and [ti:], respectively. This constraint is observed in many Ryukyuan dialects, including Ikema (Shimoji 2010, Pellard & Hayashi 2012). However, vowel lengthening does not occur in words such as /nna/ ‘spiral shell’ or /tta/ ‘tongue’. This indicates that the initial consonant is moraic, and so the overall output length of these words already satisfies the bimoraic word minimality constraint. The vowel does not lengthen in a monosyllabic word starting with a voiceless nasal (/n̥na/ [n̥na] ‘rope’) either, which shows the moraicity of this consonant.

Previous phonological analyses of Ikema have consistently considered the first half of the [m̥m] and [n̥n] sequences as moraic. However, these sequences have been treated as sequences of two nasals, as analysed in linear phonological models, rather than as single geminate consonants (Hirayama 1983, Uchima 1984, Hayashi 2007, 2010, Igarashi et al. 2011, Takubo 2021, Nakama et al. 2022). In contrast, Shinohara & Fujimoto (2018) have recognised these units as “half voiceless nasal geminates”. In this study, we refer to the sounds in question as “voiceless nasal geminates”. However, we continue to use the conventional and phonetically realistic transcription, i.e., a sequence of a devoiced nasal element followed by a plain nasal. “Voiceless nasals”, in turn, are used as a general term covering any voiceless nasal segments in any language regardless of their length.

The particularity of Ikema phonology lies in the richness of the subsystem of geminate consonants (a summary of which is provided in Table 4). Unlike other Japonic languages such as Okinawa or Yaeyama Ryukyuan, which have only voiceless geminate consonants, Ikema displays a variety of voiced and voiceless geminates. However, there are also numerous gaps in terms of both the types of segments and the types of positions in the distribution of geminates. For example, voiceless nasal geminates occur only in the morpheme-initial position. Hayashi (2010) noted that, among the obstruents, /tt, tts, kk, ff, ss, vv, zz/ can occur as initial geminates. Additionally, certain segments such as /m̥ , n̥ , p, v/ do not appear as singletons in any position and only occur as (or as part of) geminates. On the other hand, singletons /b/ and /g/ lack their respective geminate counterparts. Geminates /pp, kk/ are rare (e.g., /bappai/ ‘mistake in calculation’ and /kkunutsI/ ~ /kukunutsI/ ‘nine’).

Table 4: Voicing contrast in Ikema geminate consonants. A symbol “–” indicates a systematic gap

	Word-initial position	Word-medial position
Voiceless	*tta* ‘tongue’	*uttu* ‘brother’
	ttɕutsI ‘cicada’	*attɕa* ‘geta clogs’
	ffa ‘child’	*maffa* ‘pillow’
	ssa ‘grass’	*uss-a* ‘cow.TOP’
	m̥mu ‘cloud’	–
	n̥na ‘rope’	–
Voiced	–	*badda* ‘side’
	–	*tuddʑ-a* ‘wife.TOP’
	vva ‘you’	*avva* ‘oil’
	zza ‘father’	–
	mma ‘mother’	*haamma* ‘grandmother’
	nna ‘spiral shell’	*kannai* ‘thunder’

Ikema is a language that uses a three-way pitch-accent system, where lexical items are specified for one of the three abstract categories: A, B or C type. This terminology is used in the historical linguistics of Japonic languages, as described in Igarashi et al. (2011 et seq.). According to Igarashi et al. (2011 et seq.), bi- and trimoraic words in isolation neutralise pitch accents for A and B types. In trimoraic words, the first mora of all types can be either low- (L) or high- (H) toned. The pitch patterns for the two-mora words are HL (A and B types), LH or HH (C type), while those for the three-mora words are LHL or HHL (A and B types), and LHH or HHH (C type). Igarashi et al. (2018) discovered that a full distinction of the accent types is conditioned by the number of prosodic words in an utterance. Nevertheless, there are still numerous unresolved issues in the description of the pitch-accent system. As they are not directly relevant for the purposes of this chapter, we do not discuss them further.

1.3 Ikema segmental phonology: diachrony of voiceless nasal geminates

By comparing cognate words across different dialects, it is possible to trace the phonetic changes which have led to the occurrence of voiceless nasal geminates. We list some synchronic forms of three words with voiceless nasal geminates drawn from Kibe (2012) in Table 5. One key characteristic of the voiceless nasals is that they correspond to a voiceless obstruent accompanied by an element with frication noise in cognate words. This element can be a fricative consonant or the vowel represented by /I/ in our transcription. This vowel corresponds to /ɿ/ or /ï/ in Table 5. It occurs in wider consonantal contexts and preserves more frication noise in some other Miyako dialects, such as Karimata, Hirara or Bora among others, than in /I/ in Ikema (Kibe 2012). Pellard & Hayashi (2012: 50) posited that all initial geminate plosives in Miyako Ryukyuan have developed out of vowel elision. Among other things, they suggested that the initial nasal sequences found in Ikema likely result from the syncope of a high vowel (p. 47).

Table 5: Cognate forms in Miyako Ryukyuan dialects. Based on data from Kibe (2012)

	Ikema	Yonaha	Kugai	Kurima	Bora	Proto Miyako
‘cloud’	m̥mu	fʊm	fumu	fumu	fumu	*fumu
‘yesterday’	n̥nu	kˢɿ̥nʊ	ksïnu	ʦïno	kˢɿnuː	*kɿnuː
‘horn’	n̥nu	ʦɿnʊ	ʦïnu	ʦïnu	ʦɿnu	*tsɿnu

Phonetic explanations have been provided for the development of voiceless nasals in other languages, and they can be applied also to the case of Ikema. Ohala (1975) and Ohala & Ohala (1993) observed that voiceless nasals in Burmese have their origin in a sequence of [s] followed by a nasal stop, as depicted in the orthography of corresponding Tibetan words. Barry & Kunzel (1978) explicated the gradient nature of progressive partial devoicing of sonorants after a voiceless obstruent in German and English, in words like *small*. They argued that the nasal component is typically partially devoiced due to asynchrony in velum opening, a shift of oral constriction place and voicing coordination. The present study hypothesises that a gradient phonetic assimilation may result in a phonological change, particularly when incited by a shift in the prosodic structure. In cases where only one consonant slot remains in the prosodic template, one possible solution for segmental reduction is the use of a coalesced form to fill the slot. In the case of Ikema, the preservation of this consonant slot as moraic after vowel syncope may have saved the prosodic shape of a word intact even after a segmental change. As the pitch-accent location is determined by the mora count from the beginning of the word (Igarashi et al. 2011 et seq.), the loss of the first mora would have altered the prosodic shape of the word.

Ohala & Busà (1995) argued for the perceptual similarity between vowels adjacent to fricatives and to nasals from an aerodynamic perspective. This similarity has induced nasal loss in fricative contexts in sound changes in many unrelated languages, as seen in German *Gans* to English *goose* or Latin *mensis* to Italian *mese*. Less frequently, the similarity has also induced spontaneous nasalisation of vowels adjacent to a fricative or apparition of a nasal consonant such as in Sanskrit *sarpa* 'snake' > Hindi /sãp/, or Latin *bonaça*. bon- 'good' > Spanish *bonanza* [bonansa]. However, segments whose production requires high airflows, such as affricates or aspirated stops, do not promote nasal loss (Ohala & Busà 1995: 22). According to Ohala and Busà's theory, the fricative in Ikema's sequence, such as [fumu], could have resulted in a nasalised vowel as in inexistent *[ũmu]. But instead, the syllable is deleted leaving the voiceless and fricative features of the initial consonant. This sound change might have been incited by the already existing voicing contrast in initial geminates in the language (e.g., /ffa/ 'child' vs. /vva/ 'you' in Table 4). Indeed, the latter type of initial obstruent geminates are widespread across Miyako Ryukayun dialects, but Ikema is the only dialect which has developed voiceless nasals. [4] Therefore, we assume that the voiceless nasals developed later than the initial geminate obstruents.

[4]Uchima (1984) observed that voiceless bilabial and alveolar nasals are present in Karimata Miyako Ryukyuan and Kabira Yaeyama Ryukyuan. In Kabira Yaeyama Ryukyuan, voiceless singleton nasals occur in the context of sonorant devoicing, where a sonorant onset is devoiced

1.4 Typological comparanda for voiceless nasals

Cross-linguistically, contrastive voiceless nasals are rare, although partially or entirely devoiced nasals may occur as allophones of nasals. In some languages, nasal stops become partially devoiced when adjacent to a voiceless obstruent, which results in voiceless frication noise through the nasal cavity. Gimson (1980) provides the following examples of devoiced nasals in English: *topmost* [tɒpⁿm̥əʊst], *chutney* [ʧʌtⁿn̥ɪ]. Dell (1973) gives the following sequences in French as examples of non-distinctive voiceless sonorants: *cette natte* [sɛtⁿn̥at] 'this plait', *cette masse* [sɛtⁿm̥as] 'this volume', *vous semez* [vu sm̥e] 'you sow'. While voiced nasal stops are sonorants, the devoiced ones are phonetically fricatives, like any other sonorant consonants which become fricative sounds when devoiced. For instance, the devoiced [l] is a voiceless lateral fricative [ɬ].

Ohala & Ohala (1993) characterised voiceless nasal sounds as non-optimal speech sounds because the nasal cavity is not suitable for intense noise generation. Ohala (1975) noted that the place distinction for voiceless nasals would not be made because noise spectra of voiceless nasals are similar for any of the places of articulation. Therefore, the place distinction is only possible for the voiced portion of a voiceless nasal segment. He also predicted that voiceless nasals should be prone to deletion because of their low-intensity noise.

According to the geospatial distribution of the world's languages in PHOIBLE (Moran & McCloy 2019), which is the largest database of phonemic inventories, voiced nasal /m n/ are widely attested across languages (/m/ 96%, /n/ 78%). However, their voiceless counterparts /m̥ n̥/ are found only in 2% of the world's languages. The UCLA Phonological Segment Inventory Database (UPSID) (Maddieson & Precoda 1990) lists 18 languages (4%) among the 451 languages of the world that have voiceless nasals at least at one place of articulation. Non-contrastive voiceless nasals are not included in UPSID. A similar result is obtained in the Lyon-Albuquerque Phonological Systems Database (LAPSyD) (Maddieson et al. 2016). LAPSyD lists 31 (4.5%) out of 683 languages with at least one voiceless nasal and 19 languages (2.8%) having both bilabial and alveolar voiceless nasals. None of the aforementioned databases lists any Ryukyuan languages.

The Ikema language exhibits a unique feature in that its voiceless nasals only occur as word-initial geminates, a phenomenon not reported for any other known language to the best of our knowledge. Word-initial voiceless nasal geminates are expected to be very rare, because they present a combination of rare

when following a devoiced vowel (Kajiku 1984). This phenomenon is common across many Yaeyama Ryukyuan dialects, and the resulting voiceless nasals are not contrastive. With regard to the Karimata dialect, the data collected in 2011 by Kibe (2012) and the dialect study by Kinuhata & Hayashi (2014) do not provide evidence for voiceless nasal sounds.

factors. First, voiceless nasals in themselves are rare, as previously illustrated. Additionally, geminates are rarer than singletons, as all languages possess singleton consonants but only some possess geminate consonants. Finally, initial geminates are typologically rarer than intervocalic geminates, as noted in previous studies (Thurgood 1993, Dmitrieva 2012). Of all segmental types, voiceless plosives and nasal stops are the most common segments for gemination in word-medial position, according to studies by Jaeger (1978), Kirchner (2001), Podesva (2002) and Maddieson (2008). In word-initial position, nasal geminates have been found in 22 languages out of 28 surveyed for initial geminates (Muller 2001: Appendix), although none of these languages has voicing contrasts in nasal geminates.

2 Previous studies on voiceless nasals and hypotheses for Ikema

This section begins by reviewing aerodynamic studies of voiceless nasals in other languages Section 2.1. We then show that timing patterns of voicing are essential for the characterisation of voiceless nasals. Because of this, we provide additional details on the durational correlates of voiceless nasals in Section 2.2. In Section 2.3, we review non-temporal acoustic studies on voiceless nasals and summarise our hypotheses based on the previous studies.

2.1 Aerodynamic patterns of voiceless nasals

Except for Ikema, no voiceless nasal geminates have been reported. Therefore, the following description pertains to voiceless nasals as singletons. Contrastive voiceless nasals of Tibeto-Burman languages and Tibetan have been instrumentally studied (Dantsuji 1984, 1986, Bhaskararao & Ladefoged 1991). Based on their investigations of Burmese, Mizo and Angami, Bhaskararao & Ladefoged (1991) classified voiceless nasals into two types: "Burmese" and "Angami" (Table 6).[5]

The best-known type, the Burmese type, consists of two acoustic/articulatory events: (a) voiceless frication noise followed by (b) a voiced nasal before a release. While the presence of the voiceless frication is necessary to establish a contrast with regular voiced nasal stops, a period of voicing is also needed for the identification of the place of articulation in voiceless nasals. Without a voiced release,

[5]Their study included recording corpora of Burmese (four minimal pairs with four distinct places of articulations differing in voicing by six speakers), Mizo (three minimal pairs with three places of articulations with three speakers) and Angami (three minimal pairs with three places of articulations with nine speakers) all uttered within frame sentences.

Table 6: A summary of the two different types of voiceless nasals, after Bhaskararao & Ladefoged (1991)

Types	Acoustic pattern	Airflow pattern	Languages
Burmese	Voiceless frication noise followed by a voiced nasal	Nasal airflow without oral airflow	Burmese (Myanmar) Mizo (Northeast India)
Angami	Post-aspirated; mostly voiceless during their release interval	Simultaneous oral and nasal flows at the release phase	Angami (Northeast India) Xumi (Southwest China) Tibetan (Southern China)

place cues may be too ambiguous in nasals (as pointed out by Ohala 1975; see also Kurowski & Blumstein 1993 for place cues in nasal consonants). Based on perception experiments, Dantsuji (1986) claimed that the bilabial, alveolar and velar places of voiceless nasals in Burmese are identified in the portion of voiced murmur following the voiceless part of the voiceless nasal segments.

The voiceless nasals of another type, represented by Angami, are entirely voiceless throughout their release interval. Blankenship et al. (1993) reported that there is a nasalised aspiration period between the release of oral closure and the onset of vocal fold vibration for the following vowel, where both oral and nasal airflows are observed. These facts have led to the coining of the term "aspirated voiceless nasals" for this type of voiceless nasal (Ladefoged & Maddieson 1996). Chirkova et al. (2019) identified two other languages of this type (see below). Bell et al. (2021) reported that Northern Welsh also has a voiceless nasal of this type. We examine below some additional details of previous findings that are relevant to our study.

Chirkova et al. (2019) conducted a study on voiceless nasals in three Tibeto-Burman languages (Xumi, (Kham-)Tibetan and Burmese), using audio, electroglottography (EGG), oral and nasal airflows and video recording of the lips. This study showed two distinct nasal and oral airflow timing patterns. Xumi (Tibeto-Burman language of Southwest China) has /m̥/ and /n̥/ as distinct voiceless nasal consonants. They are characterised by simultaneous oral and nasal flows. This indicates that the latter part of the oral constriction is loosened, resulting in a nasalised voiceless glottal fricative. Tibetan showed similar airflow patterns as Xumi and so it also belongs to the Angami type. In contrast, Burmese has a different pattern in which the voiced part following the voiceless part has no oral flow, which results in a regular nasal stop. While place cues may not be found within nasals, visual cues and formant transitions during the following vowel may play a role in cueing place in Xumi voiceless nasals, as suggested by Chirkova et al. (2019), and also by Gogoi & Wayland (2018) for the Angami case.

Based on the phonological descriptions and previous acoustic studies of voiceless nasals in Ikema (Hirayama 1983, Uchima 1984, Hayashi 2007, 2010, Igarashi et al. 2011, Takubo 2021, Nakama et al. 2022, Shinohara & Fujimoto 2018), it is expected that Ikema belongs to the Burmese type, with its release phase preceded by a voiced interval. The study of the airflow patterns of voiceless nasals in Ikema provides another test for this assumption.

2.2 Durational correlates of Ikema voiceless nasal geminates

Here we examine the durational patterns of voiceless nasal geminates, both as a whole and in terms of the proportions of their voiceless and voiced parts. Previous acoustic study of Ikema, described in more detail below, has shown a smaller voiceless proportion in durational patterns as compared to other languages (Shinohara & Fujimoto 2018). Ladefoged & Maddieson (1996: 111) noted that voiceless nasals are generally longer than voiced ones. Regarding the proportion of voiceless and voiced parts, Chirkova et al. (2019) measured the duration of voiceless nasal segments both in frame sentences and in isolation. Based on the electroglottography data on bilabial and alveolar nasals, they found that the voiced portion of voiceless nasal segments in Burmese is 33%. Dantsuji (1986: 2), whose test words appear to have been uttered in isolation, reported that the voiced portion formed the last 25–29% of voiceless nasals and is much shorter than that of the ordinary voiced nasals in Burmese.

In Ikema, Shinohara & Fujimoto (2018) examined acoustic recordings from five speakers in the Nishihara area of Miyako Island. They found that in words with voiceless nasals uttered in isolation, the voiced proportion is 83.5%.

In many languages, the contrast in phonological length between singleton and geminate consonants is primarily manifested by their phonetic duration (Lahiri & Hankamer 1988, among others). Acoustic confirmation of this for Ikema fricative and nasal consonants with phonological length contrast was obtained by Shinohara & Fujimoto (2018). The duration of [nn] in /nna/ ‘spiral shell’ was 183 ms, which is significantly different from that of [n] in /nada/ ‘tears’ of 79 ms.

The same study also examined the timing units of Ikema words. For words with varying numbers of moras and syllables, duration has been found to correlate better with the number of moras than with the number of syllables. This result is similar to what has been found in Tokyo Japanese, where word duration is controlled by mora count (Sagisaka & Tohkura 1984). Therefore, one would expect that a nasal geminate consonant would have a duration approximately equivalent to that of a light syllable, all other conditions being equal. However, the duration of words with a geminate, as measured in the acoustic signal (e.g., the entire duration of /nna/ 'spiral shell' or /n̥na/ 'rope'), was significantly shorter than that of other bimoraic words (e.g., /nada/ 'tears'). Additionally, contrary to the hypothesis put forward by Ladefoged & Maddieson (1996), voiceless nasal geminates have not been found to be longer than the voiced ones (see Figure 2).

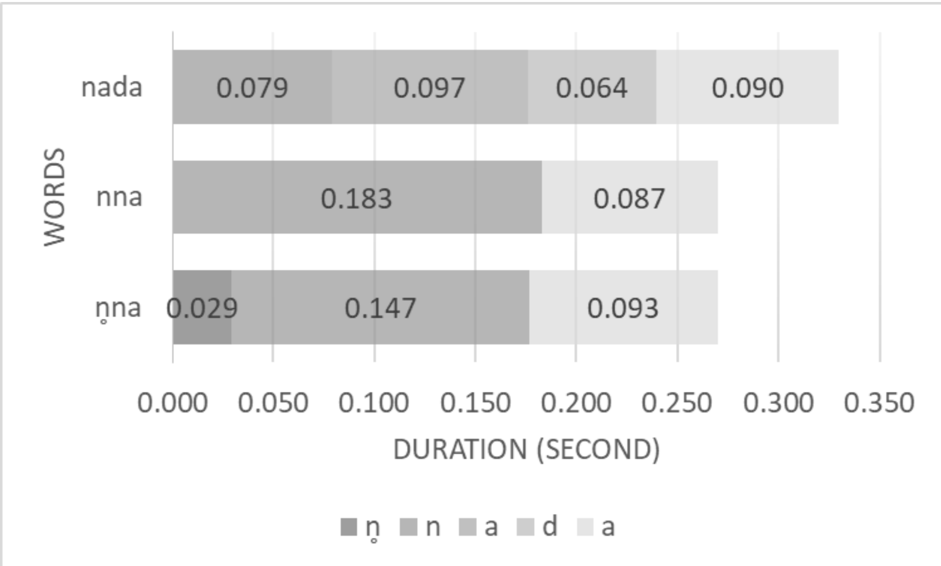


Figure 2: Segmental durations in /nada/ 'tears', /nna/ 'spiral shell', and /n̥na/ 'rope' measured in acoustic signals (in seconds) for five speakers, eleven tokens per item, by Shinohara & Fujimoto (2018: 264), Figure 15.12)

We hypothesise that the findings of the current study would replicate the previously observed longer duration of voiceless geminate consonants compared to singleton onset consonants in Ikema. Additionally, we expect that the rate of voicing for voiceless nasals in Ikema may differ from the cross-linguistically observed pattern in that its proportion is greater.

2.3 Non-temporal acoustic correlates of voiceless nasals

Ford (2016) and Ford et al. (2022) conducted acoustic investigations of voiceless nasals in six speakers from the Ikema Island. They have identified a significant distinction in the periodicity of nasal sounds between voiceless and phonologically voiced nasals. Specifically, they found that voiceless nasals exhibit lower Cepstral Peak Prominence (CPP) values, which indicates the non-periodic nature of these sounds (see Hillenbrand et al. 1994 for CPP). Likewise, the study by Shinohara & Fujimoto (2018), mentioned in Section 2.2, reported the presence of a short voiceless frication noise with a formant structure similar to the subsequent voiced nasal segments in words such as /m̥mu/ 'cloud' and /n̥na/ 'rope'. However, the words containing voiced nasal consonants, such as /maffa/ 'pillow' and /nna/ 'spiral shell', did not exhibit a discernible formant structure preceding the voiced nasal on the spectrogram. The observed formant structures during the frication period suggest that the voiceless portions are articulated with an oral constriction similar to the subsequent nasal segments. These findings confirm the acoustic distinction in terms of periodicity between voiceless and voiced nasals in Ikema.

The non-temporal aspect of our present acoustic study focuses on the acoustic properties of the onset of the following vowel. Acoustic cues that efficiently signal voiceless nasals in other languages include fundamental frequency (f0) and several breathiness measures. F0 has been extensively investigated as a significant acoustic correlate for distinguishing voicing and/or aspiration in different languages (see Hombert 1978; Hussain 2021, and references therein). Studies have demonstrated that voiceless nasals incur higher f0 onsets, as compared to voiced nasals (Maddieson 1984; Kirby 2021). Maddieson (1984) has discovered that f0 increases following voiceless nasals in Burmese. Similarly, based on the examination of a non-tonal Eastern Khmu language spoken in Laos, Kirby (2021) noted that voiceless sonorants (referred to as "continuants" in his terminology) incur even more pronounced f0 perturbation at the onset of the following vowel compared to voiceless obstruents. Therefore, we expect that voiceless nasals might have a higher f0 at the onset of the following vowel in comparison to voiced ones.

Gogoi et al. (2018) investigated voiceless nasals in Mizo, a Tibeto-Burman language spoken in Northeast India. Bhaskararao & Ladefoged (1991) had previously observed that Mizo has an airflow pattern similar to Burmese. Gogoi et al.'s study focused on measuring breathiness at the onset of the following vowel caused by voiceless nasal articulation in Mizo. They used H1-H2, the difference between the first and the second harmonics, which is a widely used measure of breathiness of the voice quality (Johnson 1997). The findings of Gogoi et al. (2018) have shown that H1-H2 is more similar to breathy voice at the onset of a vowel following a voiceless nasal than when following a voiced nasal stop. This acoustic difference may serve as a cue also for the voicing contrast in nasals.

Based on the previous studies, the acoustic measures mentioned above may indicate voicing differences in nasals. However, in the case of Ikema, a nasal has a long voiced interval after the voiceless period. Therefore, there may be no differences in f0 and H1-H2 at the onsets of the vowels following voiceless and voiced nasals. Considering the typology of voiceless nasals, a completely voiceless nasal without any voicing gesture is not plausible from aerodynamic and articulatory perspectives. Therefore, depending on the proportion of voiced part after the voiceless one, the impact from voiceless nasals on f0 and other acoustic values at the following vowel onset may be variable. We aim to determine what the case of Ikema is.

However, we also need to consider certain artefacts in our experiments. The number of Ikema words involving voiceless nasals is limited, which makes it impossible to establish a perfect paradigm. In addition to the difference in voicing, three other factors potentially contribute to the elevation of f0 in our data. First, it is well-known that close vowels have higher f0 as compared to open vowels (Whalen & Levitt 1995). Second, recent studies have reported higher f0 at the onset of the vowel after geminate consonants of certain segments, as opposed to singletons. Hamzah et al. (2020) have demonstrated that voiceless plosive geminates effectively raise f0 in Kelantan Malay along with nasals and laterals. Burroni et al. (2021) have also reported that initial geminate consonants are associated with higher f0 values during the following vowel in Pattani Malay, Salentino and Dunan. Finally, a high tone assigned from the lexical pitch-accent may also impact f0 at the vowel onset (this was not entirely controlled in our study). Therefore, follow-up evaluations were conducted to determine whether vowel quality, geminacy or pitch-accent might affect f0 values instead of voicing.

Our hypotheses on the aerodynamic and acoustic measurements are summarised as follows.

1. The aerodynamic patterns of Ikema's voiceless nasal will either follow one or the other of the two cross-linguistically recognised types – the Burmese or the Angami type – or represent a new type.

2. Since phonological descriptions and previous acoustic studies have indicated that the voiceless nasals of Ikema are composed of a voiceless interval followed by a relatively long voiced interval, the voicing rate in these sounds is likely to be greater than reported for other languages.

3. The voicing state of the nasal consonant influences f0 and H1-H2 values at the onset of the subsequent vowel. Nevertheless, the voiceless nasals in Ikema may not exhibit the expected effects due to the extended duration of their voiced part. In our (follow-up) analyses, the following factors are expected to exhibit elevated f0 values: the vowel /u/ (in comparison to /a/), a vowel following a geminate consonant (as compared to a singleton consonant), and a vowel assigned a high tone through lexical pitch-accent (in contrast to the one with an expected low tone).

3 Methods

To investigate the voiceless nasal geminates of Ikema in comparison with voiced singletons and voiced geminate nasals, we have employed both aerodynamic and acoustic data. We have examined the patterns of oral and nasal airflows. The acoustic analysis encompasses consonant duration and selected non-temporal measurements, namely f0 and H1*-H2*, at the onset of the following vowel. H1*-H2* is a corrected measure of H1-H2, with asterisks indicating that the corrections were made for the boosting effects of formant frequencies and bandwidths (Iseli et al. 2007, see Stevens & Hanson 1995 for the corrected measures). If higher f0 or higher H1*-H2* values are observed, it may indicate the voicelessness of the nasals. We have compared these values between voiceless and voiced nasals in our test words. Furthermore, we have calculated the durational proportions of the voiceless and voiced parts within voiceless nasal geminates.

3.1 Speakers

Ten Ikema speakers participated in the study, all of whom were born and raised on Ikema Island. Three male participants were born between 1952 and 1959 (with a mean age of 61.7 years at the time of recording in 2018), while seven female participants were born between 1932 and 1952 (with a mean age of 75.6 years). One male and two female participants had left Ikema Island during adulthood to study and work in Naha, Okinawa, or Kagoshima, before returning to live on Ikema Island or in Hirara on Miyako Island in their twenties. Those who reside on Miyako Island commute to Ikema Island for work and maintain regular contact with other Ikema speakers. The remaining participants have lived their entire lives on Ikema Island. In addition to speaking Ikema Miyako, all participants are bilingual in Japanese, as is typical of all current Ryukyuan speakers.

3.2 Test words

A collection of 13 test words was initially obtained from two sources, namely, Kibe (2012) and the word list developed for an Ikema dictionary (Hiroyuki Nakama, p.c., August 2018). The selected words were either minimal pairs or quasi-minimal pairs (as listed in Table 7). The list included four words with initial voiceless nasal geminates (two of which were segmentally homophonous), three words with initial voiced nasal geminates, two words with initial voiced singleton nasals, two words with medial singleton nasals and two words with medial geminate nasals. Three tokens of each test word were recorded from each speaker (however, see below for variation). The aerodynamic analyses included the following subset of comparable test words: *maffa, mma, hmmu, naa, nna, hnna* (the voiceless part in /m̥m/ and /n̥n/ is represented as *hm* or *hn*, respectively, in word forms in figures, tables and elsewhere). The main acoustic analysis included the same six words. Two more words, /n̥nu/ 'yesterday'; 'horn' were used in the additional (follow-up) analyses of f0. The durational analyses were based on 12 words.

Some segmental variation was noted across speakers. This may be attributed to regional differences, since the test words were mainly collected from the glossary of the Nishihara area on the main Miyako Island. Among the 13 words, one with an initial voiced nasal geminate /nnu/ 'straw rain cape' was not recognised by the speakers. This has made it impossible to compare /nnu/ with its voiceless counterpart /n̥nu/. As a result, the two voiceless items /n̥nu/ 'yesterday; rope' were excluded from the voicing comparisons. Two speakers produced the voiceless word /n̥na/ 'rope' as [naa], and one speaker did so twice out of the three tokens. This case was treated as having no voiceless interval. The same word was often produced with a long vowel ([n̥naa]) by six speakers. These tokens were excluded from the durational analyses but included in the other analyses. One speaker did not produce /m̥mu/ 'cloud'. F0 and spectra were not measurable in two tokens of /maffa/ pronounced by two speakers and were therefore excluded from the f0 and H1*-H2* analyses.

Ikema features a three-way pitch accent system (Section 1.2). Due to the limited number of words containing voiceless nasals and potential inter-speaker variation, the lexical pitch-accent was not controlled for in the selection of test words. However, its impact, if any, on our results is separately evaluated after the main test. In Table 7, we provide information on the accent type whenever possible (Thomas Pellard, p.c., 2020), mostly based on unpublished research in the Nishihara area on the main Miyako Island by Yosuke Igarashi). The accent types of the test words not documented by Pellard are not provided.

Table 7: Test words, their characteristics and token numbers of each experiment. *nnu is a word not recognised by our speakers and is excluded from the analysis

					Token number in analyses			
Word	Gloss	Accent	Label	Moras	Airflow	Main non-temporal	Additional non-temporal	Durational
maffa	pillow	B		3	30	28		30
na [na:]	name	B	*naa*	2	36	36	36	30
mma	mother	C		2	30	30	30	30
nna	spiral shell	B		2	32	32	32	30
n̥na	rope	B	*hnna/hnnaa*	2	23	23	23	4
*nnu	straw rain cape	B		2				
n̥nu	yesterday	C	*hnnu*	2			30	30
n̥nu	horn	B	*hnnu*	2			29	29
m̥mu	cloud	B	*hmmu*	2	27	27	27	27
kama	over there	?		2				28
ana	hole	?		2				27
hammai	food	?		4				30
kannai	thunder	?		4				29
Total token number					178	176	207	324

3.3 Recording procedure

Recording took place at a speaker's home or in a local community centre on Ikema Island in 2018. Before recording, the participants were informed of the procedure, provided written consent for data collection and usage and familiarised themselves with the word list through a discussion with the experimenter (one of the authors). The target words were produced three times when the experimenter asked the speakers to say the equivalent Ikema word of a standard Japanese word. Acoustic data were recorded simultaneously with the airflow data. We used a pneumotachograph machine linked to Scicon R& D's PcquirerX to record aerodynamic data. This aerodynamic system uses pressure transducers and two lightweight plastic masks to capture oral and nasal airflow during speech. The oral mask fits over the participant's mouth, and it is manually held in place by the participant. The nasal mask fits around the participant's nose and is held in place with a Velcro strap behind the head. In place of the nasal mask supplied by Scicon R& D, a CPAP mask (http://www.cpap-supply.com/Profile-Lite-Nasal-Mask-p/1004xxx.htm) was used, as it is similar but often more comfortable and easier to use due to its soft material. The microphone (integrated with the pneumotachograph machine) for audio recording was placed inside the oral mask. We checked that the masks were well placed on the speaker's face to avoid leaks. All the participants were compensated for their participation in the study.

3.4 Data analysis

The recordings were manually segmented in Praat (Boersma & Weenink 2022). Acoustic, oral and nasal airflow tracks were simultaneously explored. Segmentation was based on the acoustic tracks, except that the beginning of nasal airflow indicated the beginning of the voiceless nasal intervals. Nasal consonants were segmented using the visual inspection of spectrograms and acoustic and airflow waveforms (e.g., higher formants such as F2 and F3 are not visible during nasal closures, which makes it easier to identify the boundaries of nasals). Vowels surrounding the nasal consonants were identified by clear F2 energy in the spectrograms. Durational comparisons were conducted for all test words using the script developed by Kawahara (2010). Aerodynamic analyses were performed using the airflow reader Praat script by Styler (2011) where a low-pass filter is set at 40 Hz to recover the low-frequency component related to airflow from the mouth and nose. Fundamental frequency (f0) and H1*-H2* were measured from the onset of the following vowels using another Praat script, PraatSauce (Kirby 2018). All aerodynamic and acoustic measures (except data for duration analysis) were z-score normalised.

Linear mixed effects regression (LMER) models were performed using the *lme4* (Bates et al. 2015) and *lmer*Test (Kuznetsova et al. 2017) packages in R. The *emmeans* package (Lenth 2016) was used to perform post-hoc pairwise comparisons. Prior to the LMER analyses, we verified that there were no significant differences in the data between female and male groups based on a *t*-test. For all the LMER models, we performed pairwise comparisons, which included all the words (alpha value: $p = 0.05$). We only included the oral and nasal flow amplitudes of the voiced intervals in the models (i.e., onsets of the /n/ intervals in Figure 3). The reason is that if there are any differences in voiceless and voiced nasals, they should appear at the onset of /n/. Separate LMER models were performed on each acoustic variable. The LMER models included consonant type as a fixed factor, and the by-speaker and by-item intercept as a random factor (alpha value: $p = 0.05$). To examine the impact of word-initial nasals on the following vowels, F0 and H1*-H2* at the onsets of the subsequent vowels were included in the LMER models. The complete set of models and results is presented in the Supplementary materials. Several follow-up evaluations were conducted to determine whether vowel quality, geminacy or lexical pitch-accent influenced the f0 values. These evaluations were necessary due to the use of real words in the test, where ideal combinations were not always possible.

4 Results

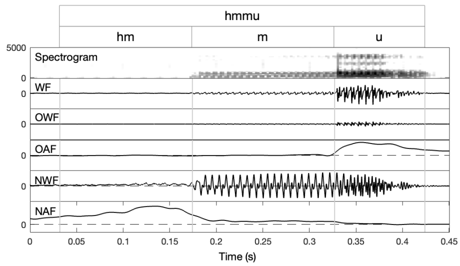
4.1 Aerodynamics of nasals

Each panel in Figure 3 represents a voiceless or voiced geminate consonant in two places of articulation: bilabial and alveolar. Spectrogram and waveform (WF) represent acoustic signals. The pressure transducers of PcquirerX have acquired sound pressure from the mouth (oral waveform, or OWF) and the nose (nasal waveform, or NWF). These data allowed us to label the beginning point of the articulation of the voiceless nasal consonant not seen in purely acoustic signals. To measure the amount of airflow, oral airflow (OAF) and nasal airflow (NAF), we applied a Bessel band-stop filter at 40 Hz (Section 3.4). The y-axis of OAF and NAF represents relative air volumes, litre per second (L/sec). The time intervals shown in all four figures are around 0.45 seconds.

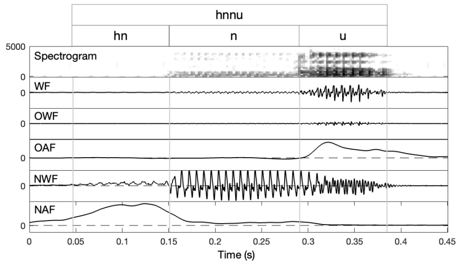
The patterns of oral airflow are similar between voiceless and voiced geminates and between the two places of articulation. This indicates that the air passage in the oral cavity was equally obstructed in all these cases. In contrast, nasal airflows are more distinct between voiceless and voiced geminates.

Voiceless nasals in the initial position exhibit a gradual rise in nasal airflow, and no frication noise is observed in oscillograms or spectrograms. No frication noise of voiceless nasals was captured in oscillograms or spectrograms (Figures 3(a) and 3(b)) because the microphone was placed inside the oral mask. The nasal airflow reaches its maximum volume in the middle of the voiceless interval and decreases during the voiced interval. The nasal airflow ends as the oral flow rises at the beginning of the following vowel.

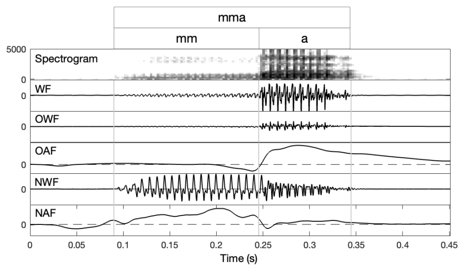
Voiced nasals start with a sharp acoustic boundary that coincides with nasal airflow (Figures 3(c) and 3(d)). The nasal flow reaches its maximum volume towards the end of the nasal interval. A trade-off relationship between nasal and oral airflows occurs at the vowel onset, while such a trade-off is absent in the case of voiceless nasal geminates. In both cases, nasal flow continues without oral flow during the oral occlusion, and the oral flow coincides with the release of oral constriction. The average duration of nasals in all the speakers is reported in Section 4.2.



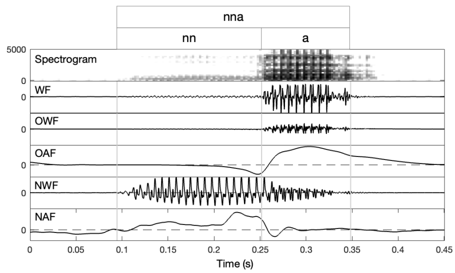
(a) *hmmu* 'cloud'



(b) *hnnu* 'horn'



(c) *mma* 'mother'



(d) *nna* 'spiral shell'

Figure 3: Spectrograms and waveforms of voiceless and voiced nasals. OWF = oral waveform, NWF = nasal waveform, OAF = oral airflow (L/sec), NAF = nasal airflow (L/sec)

We next present the oral and nasal airflow patterns that differentiate voiceless and voiced nasals of the near-minimal pair words. The patterns are represented in z-score from the mean of the quantity of the flow in graphs showing normalised duration (in %). In Figure 4, the "Voiceless interval" refers to the acoustically voiceless part preceding the voiced part in voiceless nasal geminates. In the same figure, the "Voiced interval" refers either to the voiced part of voiceless nasal geminates, the entire period of voiced geminate nasals or the entire period of singleton nasals.

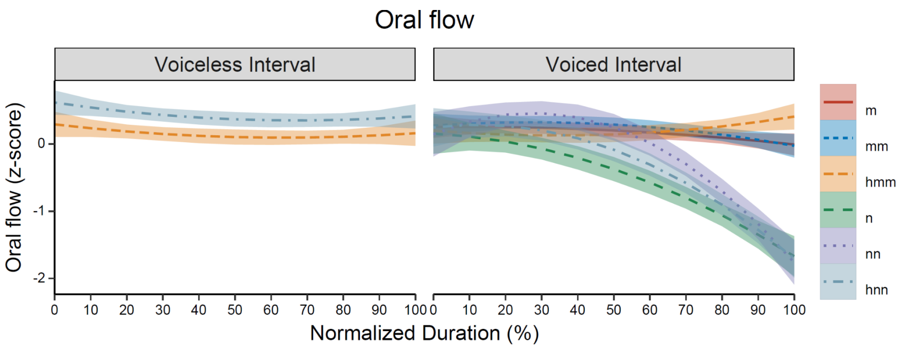
At the onset of the voiced interval, there is no clear difference in oral airflow between voiceless and voiced nasals. However, differences in oral airflow curves at the offset of the voiced interval can be observed between bilabial and alveolar nasals. Faster oral flow transitions are recognised in bilabials. Nevertheless, a clear difference in nasal flow patterns between voiceless and voiced intervals can be observed. Nasal flow gradually rises during the voiceless interval and then decreases while approaching the onset of the voiced interval, while voiced nasals and voiced parts of voiceless nasal geminates show stable nasal flow.

Table 8 (in the Supplementary materials) displays the pairwise comparisons of different types of nasals. The nasal airflow was able to differentiate several pairs, including voiceless and voiced nasals (e.g., *hmm* vs. *hnn*, *hmm* vs. *mm*), but no significant differences were found in nasal airflow for the voiced nasals (e.g., *m* vs. *mm*). The oral airflow distinguished *hmm* vs. *n* (estimate 0.9872, t =5.958, $p <$ 0.001) and *hnn* vs. *n* (estimate 0.8785, t = 5.523, $p < 0.001$) in addition to oral pairs with different places of articulation (e.g., *m* vs *n*). No other significant differences were observed in voiceless and voiced nasals in oral airflow.

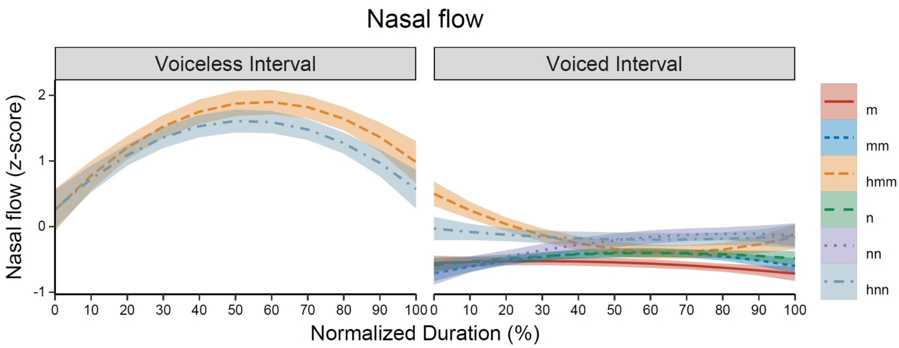
4.2 Durational characteristics of voiceless nasal geminates in Ikema

In this section, we compare the proportions of voiceless and voiced intervals in Ikema voiceless nasals and analyse the phonological length of voiceless nasal geminates. To achieve the latter, we have included words with different mora counts and measured the entire word durations. The duration of each item is averaged over three tokens from each of the ten speakers (see Section 3.2 for variable token numbers). The acoustic duration of each segment of all the test words is shown in Figure 5. Voiceless nasal geminates in Figure 5 are further divided into voiceless frication and voiced nasal parts.

The duration of the voiceless part of voiceless initial geminates is found to be shorter than the following voiced part. Specifically, the voiceless part had an average duration of 106 ms (SD: 6.8 ms). This was 37.5 % of the whole duration of the geminate, which had an average overall duration of 282 ms (SD: 17.3 ms). The



(a) oral



(b) nasal

Figure 4: Smoothed curves of oral (top) and nasal (bottom) airflows. Note that *z*-scores of the voiceless interval and those of the voiced interval are independent with respect to each other

duration of the voiced initial geminates was on average 198 ms, which accounted for 70 % of the whole voiceless geminate duration.

Next, we assess the phonological length of the test words containing voiceless nasals by comparing them to other words with varying mora counts (see Table 7 for mora count of each test word). Each bar in Figure 5 represents the average total duration of the test words. According to the hypothesis of moraic isochrony at the word level in Ikema, words with the same mora count are expected to have similar duration (Shinohara & Fujimoto 2018). Conversely, words with different mora counts are predicted to have different durations. As such, we have expected that four-mora words (*kannai* 'thunder' and *hammai* 'food') would be the longest, followed by the three-mora word (*maffa* 'pillow'). Also, according to the hypothesis, there should be no big difference in duration among the two-mora words, which constitute a group of the most numerous words, and the two-mora words would be shorter than the three-mora word.

Pairwise comparisons of the overall durations of all words revealed that among the pairs of two-mora words, the significant differences always included a word with a voiceless nasal (Table 9), with the latter being longer. For example, *ana* and *hnna* exhibited differences even though they are both two-mora words, while *ana* and *mma* did not show a difference. Four-mora test words (*hammai* and *kannai*) did not exhibit a statistically significant difference from the three-mora test word (*maffa*).[6] The word *hnna* [n̥na] 'rope,' which had fewer tokens than others, did not exhibit any statistically significant difference from longer words such as *maffa* or *kannai*. The other words with a voiceless nasal and all the other two-mora words were shorter than the three-mora word *maffa*.

4.3 Non-temporal acoustic measurements at vowel onsets after voiceless and voiced nasal geminates and voiced singletons

We have analysed the average values of f0 and H1*-H2* of the same subset of test words as used in the aerodynamic analysis. The values were *z*-scored to normalise for individual pitch differences. In addition to these results, we present follow-up analyses to evaluate the effects of vowel quality, geminacy and lexical pitch-accent, because high vowels, geminate consonants and high tone might raise f0 independently of the voicing difference of the consonants.

The voiceless nasal *hmm* showed the highest f0, followed by *mm*, and then by other geminate nasals (*hnn* and *nn*) in the third place. Singletons (*m* and *n*) had the lowest f0. There were no clear differences in H1*-H2*. Table 10 presents pairwise comparisons of f0, which show that several pairs with voiceless and voiced nasals were significantly different (e.g., *hmm* vs. *mm*). However, all the pairs distinguished by f0 either involved *hmm* or were between singletons and geminates. The sound *hnn* was only distinguished from the voiced singletons but not from the voiced geminates. It should be recalled that our selection of test words had some limitations. For instance, *hmm* was followed by [u], while all the other words were followed by [a]. The ambiguity regarding whether the higher f0 in *hmmu* is attributed to the voiceless onset nasal or the difference in vowel quality needs to be addressed.

We hypothesised that a closed vowel /u/ has a higher f0 than /a/, and that a vowel following a geminate consonant may also exhibit a higher f0 as compared

[6] In this particular case, however, note that both of our four-mora test words have two (heavy) syllables which might have influenced the results (i.e., some degree of syllabic isochrony might also be implied).

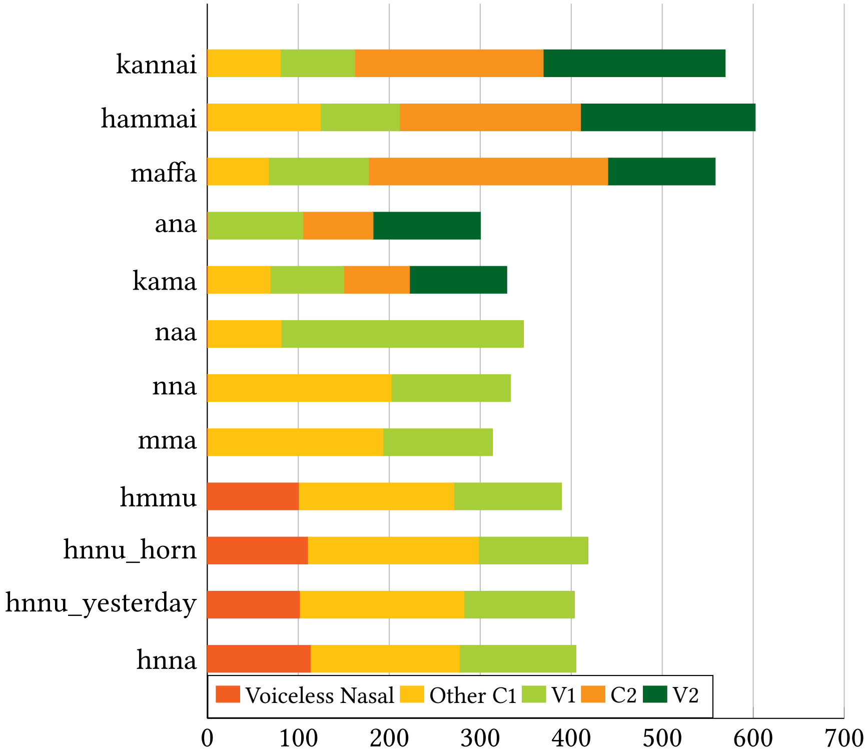


Figure 5: Average duration of segments in ms in the test words (typically three repetitions by ten speakers, but see Section 3.2 for the token number variability in some of the words). "Other C1" means an onset consonant of the initial syllable other than the voiceless nasal

to a vowel following a singleton onset (cf. Section 2.3). In order to assess the impact of vowel quality and geminacy on the f0 results, we have performed LMER statistical analyses where the two segmentally homonymic words *hnnu* ('horn'; 'yesterday') were additionally included. These words had been excluded from the voicing comparison because the voiced counterpart *nnu* was not recognised by our speakers. However, these words could be used for a vowel quality test with *hnna*.

The analysis for vowel quality was conducted in two steps. First, we examined the impact of the vowel on the f0 results for the voiced singletons (*maffa* and *naa*). The results showed no significant difference between *a* and *aa* (t(54.6) = -1.355, p = 0.1811). Second, we analysed the f0 results of the remaining geminates (*hmmu, hnnu, hnna/hnnaa, mma, nna*). Our results indicated that the f0 values of the vowels [a] and [u] gave different results, as demonstrated by the following statistical tests: *a* – *aa* (t (169) = 3.188, $p = 0.0048$), *a* – *u* (t (168) = -6.334, $p < 0.0001$), and *aa* – *u* (t (169) = -6.749, $p < 0.0001$). Thus, we conclude that the higher f0 in *hmmu* is likely due to its differing vowel quality, not due to the presence of a voiceless nasal.

We next compare the f0 values (z-score normalised) of the singleton and geminate nasals. Our results indicate a significant difference between the f0 following a singleton and the f0 following a geminate nasal (t (228) = 9.409, $p < 0.0001$). We can therefore deduce that *hnn* has higher f0 than *m* and *n* in our results rather because *hnn* is a geminate not because it is voiceless.

Concerning the pitch-accent type, there is one word (*mma* 'mother') that had been reported as having a different pitch-accent type (the C-type, the other test words having the B-type; see Table 7). According to the description (Igarashi et al. 2011 et seq.), the B-type accent on two-mora words is supposed to surface as the HL tone pattern and the C-type as the LH or HH pattern. Therefore, *mma* is expected to show a higher tone than the B-type words on the second mora. However, only two speakers have produced a higher average f0 in the vowel part of *mma* than in *nna*. Therefore, there might be inter-speaker variation concerning lexical pitch-accent. The pitch-accents did not seem to exert much influence on the current f0 results.

After examining the potential factors influencing f0, it is concluded that geminacy and vowel height are the main factors which have an impact on the results. Therefore, the results did not support the hypothesis that the voiceless nasal is acoustically differentiated by f0 at the vowel onset. Furthermore, no significant differences have been found across the voiceless and the voiced nasals in the measured voice quality (H1*-H2*) (Table 11).

5 Summary and discussion

This study has examined the aerodynamic and acoustic characteristics of word-initial voiceless and voiced nasal consonants in ten speakers of the endangered Ikema Miyako Ryukyuan dialect. To the best of our knowledge, voiceless nasals used as part of geminates have not been previously identified. The aerodynamic analysis has revealed that Ikema's voiceless nasal geminates consist of a voiceless frication portion at the beginning, followed by a voiced nasal portion before the release. However, the voiceless portion is relatively shorter compared to that of the voiceless nasals in other languages. The acoustic investigation has shown that the voicing contrast is only evident during the voiceless interval of the voiceless geminates, as there have been no significant differences in the f0 or breathiness measures (H1*-H2*) at the onset of the following vowel between the voiceless and voiced nasal geminates. The voiceless nasal frication noise corresponds to oral fricative or affricate consonants, such as [f] or [ts], in cognate words in other Miyako Ryukyuan dialects (Section 1.3). However, the perceptual cue of voiceless frication in Ikema's voiceless nasal is short and non-robust.

5.1 Aerodynamic patterns

Nasal airflow distinguishes between voiceless and voiced nasals. During the voiceless interval, a significant rise in airflow has been observed. Dynamic airflow patterns also differ between the voiceless and voiced parts within a voiceless nasal sound. For voiceless nasals, airflow peaks around the middle of the interval and decreases towards the voiced part, whereas voiced nasals exhibit a consistent airflow. In a recent real-time magnetic resonance imaging analysis of voiceless nasals in Ikema by two speakers from the Nishihara area (Fujimoto et al. 2023), a higher degree of velum lowering during the production of voiceless nasals was observed as compared to voiced geminate or singleton nasals. This pattern was consistent in both speakers. This distinct articulation may serve as a characteristic feature of voiceless nasals. Our present study reveals a substantial amount of airflow during the voiceless interval, which aligns with the aforementioned articulatory observation.

From a cross-linguistic perspective, our findings suggest that Ikema voiceless nasals conform to the Burmese type, rather than to the Angami type described in Bhaskararao & Ladefoged (1991) (cf. Section 2.1). Specifically, the nasal airflow continues through the closure release into the following vowel, and acoustic signals do not indicate the presence of a glottal fricative before the onset of the vowel as in Angami. However, there are differences from the Burmese airflow patterns found in Chirkova et al. (2019). The latter study characterised Burmese patterns (grouped with Mizo) as "pre-aspirated nasals," which means that the voiceless nasals were accompanied by both oral and nasal flows and ended in voiced nasals. We do not observe any oral flow or aspiration noise from the oral cavity during the voiceless phase. Thus, the term "pre-aspirated nasals" is not adequate to describe Ikema voiceless nasals.

The Burmese data from Bhaskararao & Ladefoged (1991) and Chirkova et al. (2019) suggest that among Burmese speakers, some individuals may exhibit a loosened oral constriction during the articulation of voiceless nasals, while the majority of speakers maintain their oral constriction throughout this phase. In Bhaskararao & Ladefoged's (1991) study, all speakers except one showed only nasal airflow during voiceless nasal production. The data from Chirkova et al.

(2019) do not necessarily contradict this pattern, as their airflow data are based on only three female speakers, and not all figures in their study indicate oral airflow during the voiceless nasal intervals. Hence, we propose that the presence or absence of oral airflow during or before the voiceless nasal period does not warrant a sub-classification of voiceless nasals into "pre-aspirated" and "not pre-aspirated," because this may just reflect idiosyncratic variation.

Our data show another difference from the Burmese results reported by Chirkova et al. (2019). The amount of nasal airflow in their data was similar between voiceless and voiced nasals, whereas our data indicate weaker nasal flow during the voiced periods. However, in Chirkova et al.'s comparison, "voiceless nasals" included the voiced period, whereas we separate the phonetically voiceless period from the phonetically voiced one within the voiceless nasal geminate.

5.2 Durational correlates and timing patterns

The voicing distinction between voiceless and voiced nasal geminates lies in a small portion of the nasal consonant. The average duration of the voiceless portion is 37.5 % of the entire (geminate) duration in our study. This duration is significantly longer than the result obtained in a previous study of Ikema spoken in the Nishihara area, where the voiceless portion was only 16.5 % of the duration (Shinohara & Fujimoto 2018, see below for the account of this discrepancy between the earlier and the current results).

The voicing rate in Ikema is almost reversed as compared to the Burmese voiceless nasals, where the *voiced* portion was reported around 30 % in previous studies (25 %-29 % in Dantsuji 1984, 1986, 24 % for male speakers across four places of articulation and 21 % for female speakers across three places in Bhaskararao & Ladefoged 1991, 33 % in Chirkova et al. 2019 based on EGG).

In the case of Ikema, the voiced portion following the voiceless interval may be phonologically specified as voiced, as it has developed from a voiced nasal onset (Section 1.3). Consequently, a long voicing period during the voiceless nasal geminates might be explained as an articulatory target, which could be distinct from the articulation of voiceless nasals in other languages. Furthermore, from a perceptual standpoint, as noted by Ohala & Ohala (1993), it would not be efficient to extend the voiceless interval to fill the geminate duration since it does not provide place cues or intense frication noise for indicating voicelessness. These weak acoustic cues of the voiceless nasal may have hindered the increase in the proportion of voicelessness in Ikema voiceless nasals.

Let us consider the timing patterns of voiceless nasals as geminate consonants. Word-initial voiceless nasal geminates have longer duration than singletons in our results, which confirms the finding in Shinohara & Fujimoto (2018: 264). The current study also confirms that all two-mora words, including those starting with a voiceless nasal, are shorter than three-mora words. On the other hand, voiceless nasal geminates are longer than their voiced counterparts in our data, and the overall duration of words with an initial voiceless nasal is longer than that of other two-mora words.

In Shinohara & Fujimoto's (2018) study, they found that the test words starting with (voiceless and voiced) nasal geminates were shorter compared to the other two-mora words (see Figure 2). However, in our current study, we observed a considerable difference in the duration of the voiceless interval, and this variation can be explained by several methodological differences. First, our voiceless intervals were segmented based on the waveform obtained through the airflow mask (see Sections 3.4 and 4.1 for details), which may have anticipated the acoustic frication noise which would have been captured by an external microphone. Second, it may be a dialectal difference between the varieties of Ikema. There is a possibility that the Nishihara variety, explored in the earlier study, is neutralising the voicing contrast in the initial nasal geminates. The third and presumably strongest effect might be potential hyper-articulation of the difference between voiced and voiceless nasals, which is related to the fact that the list of all test words was presented to speakers in a single block. In the current study, it was necessary to limit the time of wearing the airflow mask in hot and humid climates. The nasal geminate words in Shinohara & Fujimoto's (2018) acoustic study were instead mixed with other types of test words (a hundred words in total), which may have helped to avoid attracting the special attention of speakers to the voiceless nasals.

It should be noted that studies by Ladefoged & Maddieson (1996) and Chirkova et al. (2019) found longer durations for voiceless nasals as compared to voiced nasals in Burmese. There may be physiological explanations for this phenomenon, which may be explored in future studies to determine whether it is specific to the Burmese language or is a general characteristic of voiceless nasals.

5.3 Non-temporal acoustic characteristics

Previous studies have provided evidence that voiceless nasals can affect the fundamental frequency (f0) or spectral tilt of the following vowel. For instance, Maddieson (1984) observed higher f0 values after voiceless nasals in Burmese, and Kirby (2021) reported a similar effect in Eastern Khmu. Additionally, Gogoi et al. (2018) identified breathy voice at the onset of the vowel following voiceless nasals in Miso. In our study, we have investigated the non-temporal properties, f0 and

H1*-H2*, at the onset of the following vowel to examine voicing cues that could potentially signal the voicing contrast of nasals. A striking difference between Ikema and the previously studied languages is the absence of post-consonantal voicing cues. Our findings do not reveal any distinction between the vowel onsets following voiceless nasals and those following voiced nasals. This outcome was expected, given that Ikema is the only known language where the voiceless portion is consistently followed by an extended period of voicing. The long voiced interval may prevent the manifestation of voicing cues on the subsequent vowel.

We needed to conduct some additional tests since the real words did not always form perfect minimal pairs. For instance, the test words *hmmu* 'cloud' and *mma* 'mother' were contrasted not only in voicing but also in vowel quality. This made it impossible to directly observe the difference in f0 solely due to voicing. Among the additional tests, comparing the effect of geminate and singleton consonants on the f0 of the following vowel has revealed that all word-initial geminates, including voiceless nasals, induce higher f0 in the following vowel. Similar findings have been reported for other types of segments (Section 4.3). In Hamzah et al.'s (2020) study, a higher f0 at the onset of the following vowel was found most evident for voiceless plosives in Kelantan Malay. And f0 also distinguished sonorant length differences (nasals and laterals). Burroni et al. (2021) reported similar effects in a few other languages. However, since their results were averaged over various segmental types, whether this is common across different types of obstruents and sonorants remained unclear. Our study has added empirical evidence for voiced and voiceless nasal consonants.

5.4 Phonological predictions for voiceless nasal geminates

Our study confirms that Ikema has developed the voiceless nasal geminates, which retain the voiceless, fricative, nasal and moraic characteristics of cognate forms found in other Miyako Ryukyuan dialects (e.g., [fumu] > [m̥mu], Section 1.3). However, the voicelessness cue of these nasals may not be robust, as no enhancing cue has been identified in the following vowel. Based on these findings, there are potential scenarios for the future evolution of Ikema voiceless nasals. The weak acoustic cues may pose challenges in maintaining the voicing contrast in nasal geminates. The development of voiceless nasals from similar sequences (such as a voiceless segment followed by frication noise and a high vowel before a nasal, e.g., /tsImu/ 'liver') might be constrained, as is the case in other Miyako Ryukyuan dialects as well. It appears unlikely that Ikema will develop additional enhancing cues in the future, such as pitch or voice quality. The reason is that the presence of a long voiced interval may prevent the subsequent vowel from acquiring these features from the voiceless phonation, as long as the geminate is specified.

Despite the intriguing sound features found in Ryukyuan languages, there have been only a few instrumental studies conducted on them thus far. The phonological and phonetic aspects of other dialects may exhibit ongoing changes, giving rise to forms that fall somewhere between, for instance, [fumu] and [m̥mu]. Undertaking such studies would offer further insight into the direction of these changes. Cross-dialectal comparisons are crucial for understanding their evolution. Cross-linguistic phonetic investigations are also important for comprehending the current status of these uncommon sounds.

By investigating a unique case of word-initial voiceless nasal geminates in a Ryukyuan language, we contribute to the broader understanding of the diversity and complexity of sound systems in human languages. Further research on the phonological and phonetic aspects of uncommon speech sounds can shed light on the mechanisms behind their development and maintenance.

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Abbreviations

TOP	topicalisation
NAF	nasal airflow
NWF	nasal waveform
OAF	oral airflow
OWF	oral waveform
WF	waveform
SD	standard deviation

Appendix A Supplementary materials: Aerodynamic and acoustic correlates of word-initial voiceless nasal geminates in Ikema Miyako Ryukyuan

Original measurements used for the Supplementary materials reported below are available for download at https://sdrive.cnrs.fr/s/sJy8rcW7FmAG2wP

All the following analyses were performed using the *lme4* package in R. Pairwise comparisons were conducted with *emmeans* package. Consonant in the *lmer* models refers to nasal consonants.

(i) Models used in Table 8:

- Oral airflow: priming.lmer = lmer(OralFlowz ~ Consonant + (1|Item) + (1|Sp), data = 178)
- Nasal airflow: priming.lmer = lmer(NasalFlowz ~ Consonant + (1|Item) + (1|Sp), data = 178)
- *emmeans*(priming.lmer, pairwise ~ Target_consonant, lmer.df = ”satterthwaite”)

Table 8: Pairwise comparisons of oral and nasal flow amplitudes of word-initial voiceless and voiced nasals (*maffa*, *mma*, *hmmu*, *naa*, *nna*, *hnna*) (the values were z-score normalised; significant results in bold

	Oral flow			Nasal flow		
Comparisons	Est.	t	p	Est.	t	p
hmm vs. hnn	0.10	0.66	0.985	0.70	4.77	**<0.001**
hmm vs. m	−0.23	−1.39	0.731	2.00	13.40	**<0.001**
hmm vs. mm	0.06	0.39	0.998	1.87	12.57	**<0.001**
hmm vs. n	0.98	5.95	**<0.001**	1.84	12.31	**<0.001**
hmm vs. nn	0.55	3.34	**0.013**	1.67	11.19	**<0.001**
hnn vs. m	−0.33	−2.13	0.275	1.29	9.03	**<0.001**
hnn vs. mm	−0.04	−0.27	0.999	1.17	8.17	**<0.001**
hnn vs. n	0.87	5.52	**<0.001**	1.13	7.90	**<0.001**
hnn vs. nn	0.44	2.79	0.062	0.96	6.73	**<0.001**
m vs. mm	0.29	1.84	0.440	−0.12	−0.86	0.955
m vs. n	1.21	7.59	**<0.001**	−0.16	−1.12	0.869
m vs. nn	0.78	4.89	**<0.001**	−0.33	−2.28	0.205
mm vs. n	0.92	5.75	**<0.001**	−0.03	−0.26	0.999
mm vs. nn	0.48	3.04	**0.031**	−0.20	−1.42	0.710
n vs. nn	−0.43	−2.70	0.079	−0.16	−1.15	0.855

(ii) Models used in Table 9:

- Whole word duration: priming.lmer = lmer(Duration_total ~ Word + (1|Item) + (1|Sp), data = 324)
- *emmeans* (priming.lmer, pairwise ~ Words, lmer.df = ”satterthwaite”)

Table 9: Pairwise comparisons of word durations of all the words (significant results in bold)

Comparisons		Est.	t	p
ana	vs. hammai	−294.83	−16.045	**<0.001**
ana	vs. hmmu	−113.35	−5.99	**<0.001**
ana	vs. hnna	−200.38	−5.26	**<0.001**
ana	vs. hnnu_horn	−134.81	−7.27	**<0.001**

Comparisons		Est.	*t*	*p*
ana	vs. hnnu_yesterday	−115.86	−6.30	**<0.001**
ana	vs. kama	−37.96	−2.03	0.671
ana	vs. kannai	−264.36	−14.38	**<0.001**
ana	vs. maffa	−278.43	−15.15	**<0.001**
ana	vs. mma	−24.76	−1.34	0.972
ana	vs. naa	−42.23	−2.29	0.480
ana	vs. nna	−42.76	−2.32	0.459
hammai	vs. hmmu	181.47	9.87	**<0.001**
hammai	vs. hnna	94.44	2.49	0.344
hammai	vs. hnnu_horn	160.01	8.90	**<0.001**
hammai	vs. hnnu_yesterday	178.96	10.04	**<0.001**
hammai	vs. kama	256.86	14.15	**<0.001**
hammai	vs. kannai	30.46	1.71	0.862
hammai	vs. maffa	16.40	0.92	0.998
hammai	vs. mma	270.06	15.15	**<0.001**
hammai	vs. naa	252.60	14.17	**<0.001**
hammai	vs. nna	252.06	14.14	**<0.001**
hmmu	vs. hnna	−87.02	−2.28	0.491
hmmu	vs. hnnu_horn	−21.45	−1.16	0.991
hmmu	vs. hnnu_yesterday	−2.50	−0.13	1.000
hmmu	vs. kama	75.39	4.03	**0.003**
hmmu	vs. kannai	−151.00	−8.21	**<0.001**
hmmu	vs. maffa	−165.07	−8.98	**<0.001**
hmmu	vs. mma	88.59	4.82	**0.001**
hmmu	vs. naa	71.12	3.87	**0.007**
hmmu	vs. nna	70.59	3.84	**0.008**
hnna	vs. hnnu_horn	65.56	1.73	0.852
hnna	vs. hnnu_yesterday	84.51	2.23	0.524
hnna	vs. kama	162.41	4.27	**0.001**
hnna	vs. kannai	−63.98	−1.69	0.870
hnna	vs. maffa	−78.04	−2.06	0.648
hnna	vs. mma	175.61	4.64	**<0.001**
hnna	vs. naa	158.15	4.18	**0.002**
hnna	vs. nna	157.61	4.17	**0.002**
hnnu_horn	vs. hnnu_yesterday	18.95	1.05	0.996
hnnu_horn	vs. kama	96.85	5.29	**<0.001**
hnnu_horn	vs. kannai	−129.54	−7.20	**<0.001**

Comparisons		Est.	*t*	*p*
hnnu_horn	vs. maffa	−143.61	−7.98	**<0.001**
hnnu_horn	vs. mma	110.05	6.12	**<0.001**
hnnu_horn	vs. naa	92.58	5.15	**<0.001**
hnnu_horn	vs. nna	92.05	5.10	**<0.001**
hnnu_yesterday	vs. kama	77.90	4.29	**0.001**
hnnu_yesterday	vs. kannai	−148.50	−8.33	**<0.001**
hnnu_yesterday	vs. maffa	−162.56	−9.12	**<0.001**
hnnu_yesterday	vs. mma	91.10	5.11	**<0.001**
hnnu_yesterday	vs. naa	73.63	4.13	**0.002**
hnnu_yesterday	vs. nna	73.10	4.10	**0.003**
kama	vs. kannai	−226.40	−12.47	**<0.001**
kama	vs. maffa	−240.46	−13.25	**<0.001**
kama	vs. mma	13.20	0.72	0.999
kama	vs. naa	−4.26	−0.23	1.000
kama	vs. nna	−4.80	−0.26	1.000
kannai	vs. maffa	−14.06	−0.78	0.999
kannai	vs. mma	239.60	13.44	**<0.001**
kannai	vs. naa	222.13	12.46	**<0.001**
kannai	vs. nna	221.60	12.43	**<0.001**
maffa	vs. mma	253.66	14.23	**<0.001**
maffa	vs. naa	236.20	13.25	**<0.001**
maffa	vs. nna	235.66	13.22	**<0.001**
mma	vs. naa	−17.46	−0.98	0.998
mma	vs. nna	−18.00	−1.01	0.997
naa	vs. nna	−0.533	−0.03	**1.000**

(iii) Models used in Table 10:

- F0: priming.lmer = lmer(f0_z ~ Consonant + (1|Item) + (1|Sp), data = 176)
- *emmeans* (priming.lmer, pairwise~ Consonant, lmer.df = "satterthwaite")

Table 10: Pairwise comparisons of f0 of word-initial voiceless and voiced nasals (the values were *z*-score normalised; significant results in bold)

Comparisons	Est.	*t*	*p*
hmm vs. hnn	0.56	5.11	**<0.001**
hmm vs. m	0.95	9.30	**<0.001**
hmm vs. mm	0.52	5.24	**<0.001**
hmm vs. n	0.92	9.50	**<0.001**
hmm vs. nn	0.62	6.33	**<0.001**
hnn vs. m	0.38	3.52	**0.007**
hnn vs. mm	−0.03	−0.39	0.999
hnn vs. n	0.35	3.34	**0.012**
hnn vs. nn	0.05	0.536	0.994
m vs. mm	−0.42	−4.28	**<0.001**
m vs. n	−0.03	−0.32	0.999
m vs. nn	−0.32	−3.36	**0.012**
mm vs. n	0.39	4.20	**<0.001**
mm vs. nn	0.09	1.01	0.912
n vs. nn	−0.29	−3.23	**0.018**

(iv) Models used in Table 11:

- H1*-H2*: priming.lmer = lmer(H1H2c_z ~ Consonant + (1|Item) + (1|Sp), data = 176)
- *emmeans* (priming.lmer, pairwise~ Consonant, lmer.df = ”satterthwaite”)

Table 11: Pairwise comparisons of H1*-H2* of word-initial voiceless and voiced nasals (the values were z-score normalised; significant results in bold)

Comparisons	Est.	t	p
hmm vs. hnn	−0.05	−0.26	0.999
hmm vs. m	0.01	0.09	1.000
hmm vs. mm	0.14	0.72	0.978
hmm vs. n	−0.05	−0.27	0.999
hmm vs. nn	0.22	1.08	0.885
hnn vs. m	0.07	0.35	0.999
hnn vs. mm	0.20	0.94	0.932
hnn vs. n	0.01	0.02	1.000
hnn vs. nn	0.28	1.28	0.794
m vs. mm	0.13	0.64	0.987
m vs. n	−0.07	−0.37	0.999
m vs. nn	0.20	1.01	0.915
mm vs. n	−0.20	−1.05	0.897
mm vs. nn	0.07	0.36	0.999
n vs. nn	0.27	1.45	0.692

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Chapter 14

Preservation and loss of a rare contrast: Palatalization of rhotics in Slavic

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This chapter discusses the rise and development of the cross-linguistically rare contrast between plain and palatalized rhotics in Slavic. We observe that the contrast, which developed as a result of *yod*-palatalization (jotation) in Common Slavic, has been preserved only in languages which introduced additional palatalized rhotics as a result of palatalization before front vowels. We argue that this correlation is not coincidental, but that the functional load of the contrast as well as its integration into a correlation of plain and palatalized consonants were instrumental for the preservation of the rare contrast. However, only a few of the languages which had originally preserved the contrast still have palatalized rhotics today. In others we find either loss or stabilization of the contrast by altering the palatalized rhotic. The proposed analysis sheds light on the factors potentially involved in the development of rare contrasts.

1 Introduction

In the spirit of the volume, this chapter addresses a rare contrast between plain and palatalized rhotics attested in several Slavic languages, such as Russian (russ1263), Ukrainian (ukra1253), Eastern Bulgarian (Bulgarian: bulg1262), Upper Sorbian (uppe1395), and Lower Sorbian (lowe1385), e.g. Ukr /rad/ ‘glad’ : /rʲad/ ‘row’.[1] In other Slavic languages, the contrast is either absent, as in Slovenian (slov1268) and Bosnian/Croatian/Serbian (sout1528), or a different type of contrast is present as a result of a shift in the place or manner of articulation of the

[1]The list of abbreviations can be found at the end of the chapter.

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originally palatalized member of the contrastive pair /r/ : /rʲ/. For instance, in Czech (czec1258), the contrast in rhotics is preserved as /r/ : /r̝/ (cf. **marjā* 'sea-GEN.SG' > *mo*[r̝]*a*), and in Polish (poli1260) the sound change went one step further, with the original palatalized rhotic losing both its rhoticity and its palatalization (cf. **marjā* > *mo*[ʒ]*a*).[2]

Provided that the contrast is phonetically unstable and typologically rare (see the discussion in Section 2), we explore the reasons for its preservation in Slavic. It has been proposed that the palatalization contrast is preserved due to various phonetic stabilization strategies found in Slavic languages (Iskarous & Kavitskaya 2018). However, we find that the historical development of the palatalization system in Slavic can shed light on how and why the contrastive palatalization of rhotics was preserved. Secondary palatalization of rhotics first arose through an early sound change of *yod*-palatalization (jotation), and more palatalization contexts were introduced later in individual Slavic languages. We show that the /r/ : /rʲ/ contrast has been preserved only in those Slavic languages that acquired additional palatalization contrasts in positions other than the jotation context. We suggest that this correlation is not coincidental and that, in addition to the phonetic pressures, there are also functional pressures, such as the functional load of the contrast and the structure of the consonant inventory, that are crucial for the contrast preservation (Martinet 1952, Hockett 1967, Wedel, Kaplan, et al. 2013, Wedel, Jackson, et al. 2013).

We address the question of the rarity of the contrast in Section 2. Section 3 discusses the sources of the Slavic palatalized rhotics, and Section 4 addresses the issues of preservation and loss of these segments in Slavic. Section 5 will turn to the functional explanation of the contrast preservation, followed by the discussion of the phonetic considerations in the preservation and loss of palatalized rhotics, as well as some aspects of their acquisition.

2 Rhotics and palatalization

The phonetic secondary palatalization of consonants is widely attested in the world's languages, but phonological, that is, contrastive secondary palatalization is less typologically common (Bhat 1978, Stadnik 2002, Bateman 2011, Krämer & Urek 2016). For example, in a balanced 100 language sample, only 7 languages show a secondary palatalization contrast (Easterday 2017). The contrastive palatalization of rhotics specifically is even more rare (Hall 2000, Żygis 2005; Jaworski 2018: 47-50; Nikolaev & Grossman 2020: 431). It is attested

[2]In our reconstruction of PSl forms we follow Holzer (1995, 2003).

only in a handful of languages, e.g., according to PHOIBLE (Moran & McCloy 2019), palatalized trills occur in 28 (1.3%) languages in their database of 2186 languages, and palatalized taps occur in 18 (0.8%) languages in the database. LAPSyD (Maddieson et al. 2016) supports these results: only 13 languages out of 806 (1.6%) have palatalized rhotics.[3] For instance, the contrastive secondary palatalization of rhotics is present in Irish, Japanese, Marshallese, Tundra Nenets, and, importantly for us here, in several Slavic languages.

Although phonemic trilled rhotics are by no means rare, phonetically, they commonly exhibit a number of non-trilled allophones, such as taps, approximants, or fricated approximants (see Colantoni 2006, Wiese 2001, Verstraeten & de Velde 2001, Solé 2002, Recasens & Espinosa 2007, Żygis 2005, Jaworski & Gillian 2011; among others). Specifically in Slavic, while the rhotics are usually classified as trills, they are rarely truly trilled phonetically. In a detailed study, Jaworski (2018: 113-120) reports the following allophones of /r/ in Slavic: [r], [r̥], [ɾ], [ɾᶾ], [ɹ], [ɹ̥]. In Russian, the non-palatalized /r/, traditionally described as a trill, is most commonly realized as a tap and quite often surfaces as an approximant (Kavitskaya et al. 2009, Iskarous & Kavitskaya 2010, Jaworski 2018).[4]

Many proposals have addressed the incompatibility of rhotics and palatalization. It has been argued that the rarity of the palatalization contrast in rhotics is due to the conflicting articulatory and/or aerodynamic demands on palatalization and rhotics in general and trilled rhotics in particular. While palatalization involves tongue dorsum raising, rhotics require tongue root backing (see Kochetov 2005, Hall 2000, Iskarous & Kavitskaya 2010, Jaworski 2018; among others). To illustrate this, Figure 1 shows that in Russian, the tongue dorsum is raised towards the palate in the [rʲ] in comparison with the plain [r]. The comparison of the plain [r] and [d] in Figures 1 and 2 shows that both of these require tongue root backing (note that [d] is velarized in Russian). Finally, there is no tongue backing in the palatalized [dʲ], as expected (Figure 2). However, tongue

[3]Note that non-palatalized rhotics are much more common: for instance, 247 languages out of 806 (31%) in LAPSyD have segments that are classified as alveolar trills.

[4]A reviewer raises a question of whether Slavic rhotics can be characterized phonologically as trills, given the number of different allophones of these segments. While the resolution of this question is far from straightforward, there are several arguments for treating the Slavic /r/ as an underlying trill. First, the speakers of Slavic languages pronounce this segment as a trill in isolation. Second, the phonological behavior of the rhotic argues for the trill analysis: taps are mostly attested intervocalically, voiceless allophones of the /r/ are attested word-finally and before voiceless consonants, approximants are common post-vocalically, while there is a greater likelihood of trills occurring word-initially (Iskarous & Kavitskaya 2010). In regard to the diachronic data, all attested reflexes of the PSl **r* can be traced back to a trill rather than to any other rhotic.

backing is still present in the palatalized [rʲ], even though not as strongly as for the plain [r] (Figure 1).

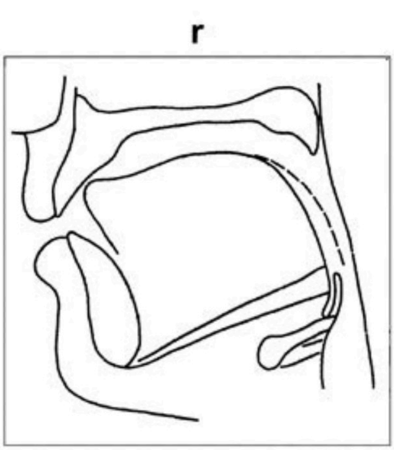


Figure 1: Tracings of the articulatory structures for [r] and [rʲ] in Russian (Iskarous & Kavitskaya 2018, adapted from Bolla 1981)

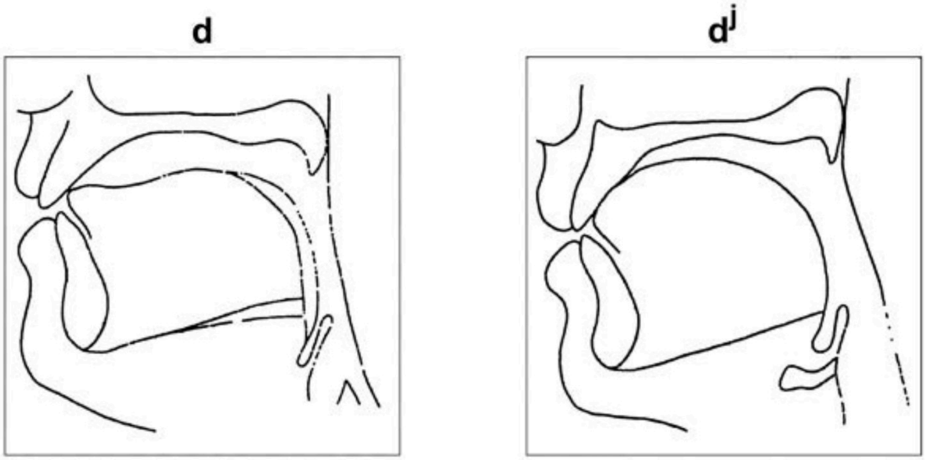


Figure 2: Tracings of the articulatory structures for [d] and [dʲ] in Russian (Iskarous & Kavitskaya 2018, adapted from Bolla 1981)

Trilling has an additional detrimental effect on palatalization. It has been suggested that this is due to the articulatory constraints on the production of palatalized trills, which result in conflicting aerodynamic demands on the tongue dorsum (Kavitskaya 1997, Ladefoged & Maddieson 1996: 221; Kavitskaya et al. 2009, Proctor 2011; among others). While palatalization requires fronting of the tongue into the palatal region of the mouth, trilling depends on tongue retraction in order to stabilize the tongue dorsum, which needs to be immobilized during the trilling in order not to inhibit the vibration of the tongue tip (McGowan 1992). Alternatively, Howson (2018) argues that the inconsistency between palatalization and trills is due to "the inability to create proper tongue stability and the constant movement towards a palatal target likely interferes with the aerodynamic conditions necessary to produce trilling" (Howson 2018: 148). Whatever the reason is, it is evident that palatalized trills are phonetically unstable segments.

It has been proposed that the conflicting articulatory demands on palatalized rhotics are responsible for the elimination of /rʲ/ and thus for the loss of contrast in rhotics in several Slavic languages (Kavitskaya et al. 2009, Jaworski 2018). However, given its instability and rarity, it is remarkable that the contrast /r/ : /rʲ/ is attested in Slavic languages belonging to different subgroups, such as Russian and Ukrainian (East Slavic), Eastern Bulgarian (South Slavic), Upper Sorbian and Lower Sorbian (West Slavic), as illustrated in (1).

(1) Contrastive /r/ : /rʲ/ pairs in Slavic

a. Russian
rad 'glad' : *rʲad* 'row'

b. Ukrainian
rad 'glad' : *rʲad* 'row'

c. Eastern Bulgarian
gora 'forest' : *gorʲa* 'burn'

d. Upper Sorbian
ʀad 'glad' : *ʀʲad* 'row'

In the remainder of the chapter we will first discuss the emergence and the development of palatalized rhotics in Slavic and then address the factors that influenced the preservation and loss of the /r/ : /rʲ/ contrast in the individual Slavic languages.

3 Sources of palatalized rhotics in Slavic

There are two main sources of palatalized rhotics in Slavic: jotation and palatalization before front vowels. Jotation is the term used in Slavic linguistics to refer to a Common Slavic change that comprises the palatalization of consonants before *j* (yod palatalization) and the subsequent loss of the glide that triggered palatalization. Jotation affected all coronal consonants, that is, /s, z, t, d, l, n, r/, including the laterals which have been introduced as a result of *l*-epenthesis between labials and **j*, cf. PSl **pj*, **bj*, **mj* > **plj*, **blj*, **mlj*.[5] Apart from rhotics, as a result of jotation all coronals underwent a change in the place of articulation, which in many cases was accompanied by a change in the manner of articulation. Thus, the Proto-Slavic sequences **sj* and **zj* are reflected as either [ʃ] and [ʒ], or [ʂ] and [ʐ] in attested Slavic, as shown in (2). The jotation reflexes of PSl **tj* and **dj* are shown in (3).

(2) Contemporary reflexes of PSl **sj* and **zj*
   a. PSl **nasjā* 'load, burden' > Ru *no*[ʂ]*a*, Cz *nů*[ʃ]*e*, Sln *nó*[ʃ]*a* 'attire'
   b. PSl **kazjā* 'skin, leather' > Ru *ko*[ʐ]*a*, Cz *ků*[ʒ]*e*, Sln *kó*[ʒ]*a*

(3) Contemporary reflexes of PSl **tj* and **dj* in the continuants of PSl. **swajtjā* 'candle' and **medjā* 'border'
   a. **tj* >
      [ts] Cz *svı́*[ts]*e*, Slk *svie*[ts]*a*, Po *świe*[ts]*a*
      [tʃ] Ru, BRu *sve*[tʃ]*á*, Ukr *svi*[tʃ]*á*, Sln *své*[tʃ]*a*
      [tɕ] BCS *svijè*[tɕ]*a*
      [ʃt] Bu *sve*[ʃt]
      [c] Mak *sve*[c]*a*
   b. **dj* >
      [z] Cz *me*[z]*e*
      [dz] Slk *me*[dz]*a*, Po *mie*[dz]*a*
      [dʒ] > [ʒ] Ru, Ukr, Bru *me*[ʒ]*á*
      [dʑ] BCS *mè*[dʑ]*a*
      [j] Sln *mé*[j]*a*
      [ʒd] Bu *me*[ʒd]*á*
      [ɟ] Mak *me*[ɟ]*a*

Laterals and nasals in the jotation context have either palatal or palatalized reflexes, e.g. PSl **valjā* > BCS *vo*[ʎ]*a* 'will' ~ Ru *vo*[lʲ]*a* 'will', PSl **vanjātī* > BCS *vo*[ɲ]*ati* 'smell' ~ Ru *vo*[nʲ]*at'* 'stink', or in the case of the lateral, may also have

[5]Sequences of velar obstruents and yod had most probably been eliminated by the pre-Proto-Slavic First (regressive) Palatalization at the time when jotation took place. For more details on the jotation change in Slavic see Shevelov (1964), Carlton (1991: 112-115), and Wandl & Kavitskaya (2023). A recent discussion of the Common Slavic velar palatalizations can be found in Wandl (2020).

undergone depalatalization, e.g. Po *wo*[l]*a*, Cz *vů*[l]*e* 'will'. Palatalized laterals and nasals occur in Russian, as can be seen from the examples above, and are also characteristic of the other East Slavic languages, Ukrainian and Belarusian (bela1254). However, the philological evidence from the East Slavic of the 11th and 12th centuries indicates that jotation originally induced a change in the place of articulation of laterals and nasals also in the East Slavic area. While laterals and nasals in the jotation context are marked orthographically in some manuscripts, secondarily palatalized laterals and nasals are not (see Kalnyn' 1961: 21–22, Živov 1996). Thus, Russian, Ukrainian, and Belarusian [l^j] and [n^j] in the jotation context developed from [ʎ] and [ɲ]. This suggests that a Common Slavic change in the place of articulation of consonants affected by jotation was not only typical for fricatives and plosives but also for laterals and nasals (Stadnik 2002: 143-145; Wandl & Kavitskaya 2023).

Rhotics take a special position with regard to jotation among coronal consonants. Unlike fricatives, plosives, laterals, and nasals, rhotics do not occur in the palatal region, which rules out a change in the primary place of articulation. Therefore, as we argued elsewhere (Wandl & Kavitskaya 2023), the /r/ : /r^j/ contrast is the only secondary palatalization contrast that can be reconstructed for Common Slavic (cf. also Stadnik 2002: 144). With respect to the primary place of articulation, the Common Slavic rhotics can be safely reconstructed as apical trills. Of the major Slavic languages, only Upper Sorbian shows a uvular reflex, which is likely to be the result of language contact with German (see Jaworski 2018: 80; Howson 2018: 132). However, considering the high frequency of instances in which rhotics were realized as taps in contemporary Slavic, described by Jaworski (2018) (see Section 2), it seems reasonable to assume a tap allophone for a Common Slavic pre-stage. The contemporary reflexes of the Common Slavic pair /r/ : /r^j/ resulting from jotation will be discussed in Section 4.

The second, chronologically later change that introduced palatalized rhotics in Slavic is palatalization before front vowels.[6] It occurred after the beginning of the disintegration of Common Slavic. Hence, it is absent from BCS, Slovenian, and Macedonian (mace1250).[7] Where palatalization before front vowels had occurred, it affected all consonants, although it should be noted that there may have been differences with regard to the vowels triggering palatalization in the individual

[6]See van Wijk (1937), Gerovský (1959), Koschmieder (1959), Shevelov (1964: 489–490), Carlton (1991: 160), Stadnik (2002: 167-176) on the late dating of the secondary palatalization change.

[7]The situation may be different in some South Slavic dialects. For example, the palatalization of consonants is found in Macedonian dialects spoken in Greece (see Ivić et al. 1981). We are grateful to Rafał Szeptyński for bringing these dialects to our attention. However, it should be noted that the dialects discussed by Ivić et al. (1981) do not contradict our assumptions below.

languages (cf. the survey in Carlton 1991: 157-164). Moreover, in some languages, secondary palatalization has been lost either as a result of depalatalization or due to changes in the place of articulation of the palatalized segments.[8]

What will be relevant for the discussion below is the phonologization of the secondarily palatalized consonants. Originally, secondary palatalization was an automatic process, which affected consonants before front vowels. Phonologization of the palatalized segments and thus the rise of the contrast /C/ : /C^j/ occurred only as a result of changes which rendered the palatalization triggers opaque, such as the backing or loss of the triggering vowel. As illustrated in (4) on the example of the Russian rhotics, denasalization and backing of the *e*-like nasal vowel **ę* (most likely pronounced as [ɛ] or [æ̃]) to non-front **a*, shown in (4a), and the loss of the front vowel **ь*,[9] shown in (4b), rendered the origin of palatalization opaque and thereby led to the phonologization of the contrast /r/ : /r^j/.

(4) a. pre-Ru **rędъ* > **r^{j}ędъ* > **r^{j}ad* > Ru *r^{j}ad* 'row-NOM.SG.M'
b. pre-Ru **korь* > **kor^{j}ь* > **kor^j* > Ru *kor^j* 'measles-NOM.SG.F'

Of these two changes, denasalization of **ę* to **a* is older. It is reflected in the earliest East Slavic texts and can therefore be dated approximately before 1000 AD. On the other hand, the loss of **ь* (and its back counterpart **ъ*) in East Slavic occurred between the 12th and the 13th centuries (the loss proceeded at a slower pace in Northern regions, cf., for example, Kiparsky 1963: 93 -99). However, according to some scholars, the vowel that arose from the denasalization of **ę* at first was still front (most likely pronounced as [æ]). Palatalization would thus have remained allophonic until the loss of **ь* led to the phonologization of palatalized consonants (see Jakobson 1929: 50; Lunt 1956, Kalnyn' 1961: 33–34, Živov 1996).[10]

Similar vowel backing processes occurred in other Slavic languages. For example, in Bulgarian and Polish there was a change of **ē* to **ā* in some contexts. The loss of **ь* (and its back counterpart **ъ*) in certain positions affected the entire Slavic speech area between the 10th and 13th centuries depending on the region (cf. Kalnyn' 1961 for a discussion of the phonologization of secondary palataliza-

[8]For more details on these developments, we refer the reader to specialized studies and the historical grammars of the individual Slavic languages (cf. Kalnyn' 1961, Carlton 1991, Stadnik 2002).

[9]Most likely pronounced as [ɪ] (cf. Matthews 1951: 109-110).

[10]For a different opinion, see van Wijk (1934, 1937).

tion in Slavic).[11] What is important for the argument below, is that the phonologization of secondary palatalization occurred only after jotation had introduced the contrast /r/ : /r^j/ and that palatalized rhotics resulting from jotation merged with those resulting from palatalization before front vowels.

4 Preservation and loss of palatalized rhotics in Slavic

The contrastive opposition between palatalized and non-palatalized rhotics was introduced at the Common Slavic stage, but this contrast is reflected only in some modern Slavic languages. As can be seen in Table 1, the contrast is directly preserved in Russian, Ukrainian, Upper Sorbian, and Lower Sorbian,[12] and Eastern Bulgarian. Moreover, orthographic evidence suggests that in Belarusian, rhotics depalatalized only in the 15th-16th centuries (see Kalnyn' 1961: 31–32, Wexler 1977: 152-154).[13] Later, the palatalization of rhotics was reintroduced with hypercorrection in some forms; the only two such cases provided by Wexler (1977) are [r^{j}at] 'glad' and [r^{j}ak] 'crawfish' (cf. Russian [rat] and [rak] respectively, with no palatalization, which supports the hypercorrection analysis). Only [r] is present in Standard Belarusian (Bird & Litvin 2020). In Slovak (slov1269), rhotics have been depalatalized in the course of the overall elimination of the correlation of palatalization in consonants between the 13th and 15th centuries (see Krajčovič 1975: 116-121). In most of the dialects the palatalized rhotic was simply depalatalized, but in East Slovak it was resolved into a sequence /r/ + /j/. The status of the palatalized rhotic in Upper Sorbian is disputed. While a phonemic status is assumed, for example, by Stone (1993), other researchers propose breaking of /ʀ^j/ into /ʀj/. According to Jaworski (2018: 300-304), this breaking may present a change in progress. In Polish and Czech, on the other hand, the plain vs. palatalized distinction developed into a different kind of opposition, and in Slovenian the palatalized rhotic became a sequence of /r/ + /j/.[14]

[11]The loss of *ь and *ъ is usually interpreted as the last sound change of the Common Slavic era (see Trubetzkoy 1922: 217).

[12]Apart from the apical trill, Lower Sorbian also shows uvular reflexes /ʀ/ and /ʀ^j/.

[13]Note that, according to Wexler (1977: 153–154), examples with depalatalized rhotics are attested from the 12th century onwards. However, the earliest examples he cites stem from the 15th century.

[14]Breaking of /r^j/ also occurred in Western Bulgarian where it is clearly a later development since it affected /r^j/ resulting not only from jotation but also from palatalization before front vowels. In Kashubian (kash1274), we find /r̝/ as in Czech in the speech of the older speakers while the middle and younger generations have /ʒ/ as the reflex of **r^j* (see Topolińska 1974: 122). A reviewer points out that the Czech /r̝/ is sometimes realized as [ʒ], taking the Polish route.

Table 1: Reflexes of the Common Slavic rhotics

Common Slavic (post-jotation)		r	r^j
East Slavic	Belarusian	r	r
	Russian	r	r^j
	Ukrainian	r	r^j
West Slavic	Polish	r	ʒ
	Czech	r	r̝
	Slovak	r	r
	Upper Sorbian	ʀ	$ʀ^j$
	Lower Sorbian	r	r^j
South Slavic	Slovenian	r	rj
	BCS	r	r
	Macedonian	r	r
	Eastern Bulgarian	r	r^j

Since only a few Slavic languages have fully preserved the Common Slavic contrast, the question of what determined its preservation or loss arises. We observe a correlation between the retention of the contrast in rhotics and the presence of secondary palatalization before front vowels. In other words, we find that the palatalized rhotic /r^j/ that resulted from jotation has been preserved only if a language acquired secondary palatalization before front vowels at a later stage. This correlation is illustrated in Table 2, which shows the reflexes of the words **marja* 'sea-NOM.SG.N' and **marjā* 'sea-GEN.SG.N' in modern Slavic languages.

Table 2 shows that the palatalized reflex of the jotated rhotic was originally preserved only in those cases where the palatalized consonants, which are the result of the later secondary palatalization before front vowels, are present in a given language. We propose that this correlation is not coincidental, and that the newly introduced palatalized rhotics from secondary palatalization before front vowels were instrumental in the retention of the /r/ : /r^j/ contrast. This implies that functional factors were involved in the preservation of the Common Slavic palatalization contrast.

The only language which did not acquire secondary palatalization before front vowels but has still preserved the contrast is Slovenian. As can be seen in Table 2, the original *r^j is reflected as the /rj/ sequence intervocalically. However, break-

Table 2: Palatalization of the rhotics before *j (jotation) and before front vowels

Language	PSl. **marja* 'sea-NOM.SG.N', **marjā* 'sea-GEN.SG.N'	Jotation reflex of *r (preserved/ lost)	Secondary palatalization before front vowels
Russian	*mo*[r^j]*e*, *mo*[r^j]*a*	preserved	+
Ukrainian	*mo*[r]*e*, *mo*[r^j]*a*	preserved	+
Belarusian	*mo*[r]*e*, *mo*[r]*a*	originally preserved, lost between the 15th-16th cc.	+
Polish	*mo*[ʒ]*e*, *mo*[ʒ]*a*	preserved	+
Upper Sorbian	*mo*[ʀ^j]*jo*, *mo*[ʀ^j]*ja*	preserved	+
Lower Sorbian	*mó*[r^j]*jo*, *mó*[r^j]*ja*	preserved	+
Czech	*mo*[r̝]*e*, *mo*[r̝]*e*	preserved	+
Slovak	*mo*[r]*e*, *mo*[r]*a*	originally preserved, lost between the 15th-16th cc.	+ (lost between the 15th-16th cc.)
Slovenian	*mo*[rj]*e*, *mo*[rj]*a*	lost	-
BCS	*mo*[r]*e*, *mo*[r]*a*	lost	-
Eastern Bulgarian	*mo*[r]*e*, *mo*[r^j]*a*	preserved	+
Macedonian	*mo*[r]*e*, *mo*[r]*a*	lost	-

ing of *r^j to *rj in Slovenian is dated between 9th and 10th centuries (Greenberg 2000: 95 f.). At this time, secondary palatalization resulting from palatalization before front vowels had not yet arisen or was at least not yet phonologized due to vowel backing and the loss of *ь in those Slavic languages which preserved the contrast. Therefore, breaking in Slovenian does not contradict our assumption that the /r/ : /r^j/ contrast was lost in the languages which did not acquire palatalization before front vowels. Rather we are dealing with an early case of the resolution of the articulatory conflict exhibited by palatalized rhotics (see Section 5.2).

The following section addresses the functional and phonetic factors involved in the development of rhotics in Slavic. The question of functional load is addressed in Section 5.1, phonetic considerations are discussed in Section 5.2, and Section 5.3 touches upon the potential relevance of acquisition for the contrast preservation and loss.

5 Contrast preservation factors

5.1 Functional pressures: the embedding of the sound change

We have seen that the palatalized rhotic /r^j/ is preserved in those Slavic languages that have acquired palatalized consonants from other sources in addition to jotation, i.e. through the palatalization before front vowels. This generalization holds without exceptions, which raises the question of why this should be the case. A possible answer to this question, the phonetic reality being equal in all cases, is connected to the embedding of sound change, that is, how change is embedded in its linguistic and social system (Weinreich et al. 1968). In particular, embedding includes functional pressures that can potentially affect the preservation of contrast. These are the functional load of the contrast and, relatedly, the integration of the contrast into the structure of the consonant inventory.

The functional load hypothesis (Jakobson 1931, Mathesius 1931, Trubetzkoy 1939, Martinet 1952; among others) holds that the amount of information transmitted by certain phonemes that participate in a contrast is inversely connected to the possibility of the loss of the said contrast. There are two possible interpretations of the amount of information transmission. First, it can be interpreted broadly, as the amount of work the contrast does in a language, which can be viewed as the number of contrastive positions a given phoneme occurs in. Second, it can be interpreted more narrowly, as the number of words that the contrast helps to distinguish (King 1967,b). While being entertained for almost a hundred years, the functional load hypothesis has remained inconclusive until recently. Wedel, Kaplan, et al. (2013) have tested the hypothesis on a large data set which consisted of many phonological mergers in 8 languages (English (Received Pronunciation and Standard American), Korean, French, German, Dutch, Slovak, Spanish, and Hong Kong Cantonese). The dataset included 56 mergers and 578 phoneme pairs that have not merged. The results have shown that the probability of phonemic merger is inversely related to functional load defined by the number of minimal pairs participating in the said contrast. These findings support a narrower interpretation of functional load (see also Bouchard-Côté et al. 2013 on Austronesian leading to the same conclusion).

We believe that the development of /rʲ/ in Slavic supports the assumption that functional load plays a role in sound change. As a result of jotation, palatalized rhotics could occur before any non-front vowel apart from **y*, **ъ* and **o*, i.e., before **a*, **u*, **ǫ* (an *o*-like nasal vowel). The loss of **ь* resulted in the additional pre-consonantal and word-final contrastive positions. Vowel backing did not introduce new types of contrastive positions (see discussion in Section 3). Thus, in Old East Slavic, the position before **a* was already contrastive in such cases as **morʲa* (< **morja*) 'sea-GEN.SG.N' when vowel backing introduced phonemic /rʲ/ in cases such as **rʲad* (< **rędъ*) 'row-NOM.SG.N'. The introduction of further contrastive positions preconsonantally and word-finally cannot be held responsible for the preservation of the contrast /r/ : /rʲ/ in only a part of the Slavic speech area since it affected all of Slavic. However, the phonologization of palatalized rhotics due to vowel backing and the loss of **ь* without doubt increased the absolute frequency of the phoneme /rʲ/. In turn, this potentially increased the number of minimal pairs, even though it should be noted that it is impossible to evaluate functional load for earlier stages due to the lack of exhaustive word lists and frequency counts (cf. Martinet 1952: 8-10 on problems in measuring functional load).

Yet another factor related to functional load could have played a role in the preservation of /rʲ/ in languages with palatalization before front vowels. Since palatalization before front vowels affected all consonants except the postalveolars, i.e. **p*, **b*, **m*, **t*, **d*, **s*, **z*, **n*, **l*, **r*, **w*, its phonologization resulted in a correlation of secondary palatalization. The contrastive pair /r/ : /rʲ/, which arose from jotation, have been the only pair with contrastive secondary palatalization in the system after the change in the place of articulation of the other jotation reflexes (see Section 3). However, this pair then became integrated into the larger system of palatalization oppositions. As has been argued by Martinet (1952: 17-20), the integration of a contrastive pair into a larger opposition has a stabilizing function due to the high functional yield of the correlated oppositions.

To sum up, we argue that the coincidence in the distribution of Slavic languages which have preserved the contrast /r/ : /r^j/ resulting from Common Slavic jotation and those which have acquired palatalization before front vowels is not accidental. The introduction of further palatalized rhotics and their integration into the overall correlation of palatalization increased the functional yield of the contrast, which was instrumental to its preservation. However, the palatalized rhotics were affected by several changes in those languages which had originally preserved the contrast. The factors that affected these developments are the topic of Section 5.2.

5.2 Phonetic considerations in the development of rhotics

As discussed in Section 2, several phonetic properties of rhotics render the /r/ : /r^j/ contrast unusual. First, trilled rhotics are articulatorily complex. Although they are robustly attested in many languages of the world, rhotics show a relatively high level of variability and regularly undergo de-trilling and other changes (Jaworski 2018: 39-42). Second, palatalized rhotics are articulatorily and aerodynamically more complex than other palatalized segments and as a result are less cross-linguistically common (Hall 2000, Nikolaev & Grossman 2020: 431). Given these properties, the contrast between plain and palatalized rhotics is unstable and frequently lost. In section 5.1, we have argued that functional factors had a stabilizing effect on the contrast /r/ : /r^j/ in Common Slavic. In what follows, we look into the development of the secondary palatalization contrast in rhotics in the individual Slavic languages and address the phonetic factors that contributed to the survival of this rare and unstable contrast.

We have seen that the conflicting articulatory/aerodynamic demands on rhotics (and trilling, in particular) and palatalization are resolved in Slavic languages in different ways (Kalnyn' 1961, Stadnik 2002, Kavitskaya et al. 2009, Iskarous & Kavitskaya 2010, Jaworski 2018; among others). While the plain rhotic is retained in all Slavic languages, the reconstructed palatalized rhotic is attested only in some languages and has either merged with the plain rhotic or undergone various changes in others. As shown in Table 1, the contrast is fully lost in BCS and Macedonian, as well as at a later stage in Belarusian and Slovak, where the palatalized trill merged with the non-palatalized one, and in Slovenian, where it is realized as a rhotic-glide sequence. The palatalized rhotic is preserved in Russian, Ukrainian, Upper Sorbian, Lower Sorbian, and Eastern Bulgarian. In Polish and Czech, the palatalized rhotics undergo further changes, and the conflicting aerodynamic and articulatory demands on trilling and palatalization are resolved through depalatalization and spirantization. In Czech, as well as in some dialects of Kashubian, the reflex of the palatalized rhotic has been described as a trilled fricative [r̝],[15] as in Czech [r̝at] 'row' (cf. Russian [rʲat]), [r̝eka] 'river' (cf. Russian [rʲɪka] 'river'), [par̝it] 'steam-3SG.PRS' (cf. Russian [parʲɪt] 'steam-3SG.PRS'). The trilled fricatives undergo further detrillization in Polish, resulting in a voiced postalveolar fricative [ʒ], as in [ʒɔnt] 'row', [ʒɛka] 'river' (Stieber 1973: 68 f., 109 f.).[16]

Slovenian and the neighboring Kajkavian dialects of Croatian exhibit yet another resolution of the rhotic contrast (cf. Kalnyn' 1961: 107–108). The original palatalized rhotic segment becomes a sequence of a non-palatalized rhotic followed by the glide [j], that is, the simultaneous rhoticity and palatalization receive the sequential realization of the gestures in Slovenian. The same outcome has been claimed for Western Bulgarian (Scatton 1993: 64; Stadnik 1998: 389). But while breaking in Slovenian goes back to the 9th-10th centuries (see Greenberg 2000: 95 f.), the same process in Western Bulgarian presents a more recent development affecting all palatalized consonants.[17]

Yet another potential contrast stabilization strategy with respect to the inventory structure is the velarization of the non-palatalized rhotic member of the contrastive pair. Litvin's (2014) articulatory study shows that all Russian non-palatalized consonants are uvularized or velarized, as was claimed by many scholars, including Trubetzkoy (1939), Reformatskii (1956, 1967), Halle (1959), Padgett (2001), Kochetov (2002), among others. Pompino-Marschall et al. (2016) describe Ukrainian non-palatalized consonants as velarized, and Bird & Litvin (2020) provide a similar description for Belarusian non-palatalized consonants. Finally, Radkova (2009: 42) refers to all non-palatalized consonants in Bulgarian as velarized.[18]

Both Upper Sorbian and Lower Sorbian have the palatalization contrast in rhotics (Stone 1993, 1998, Schaarschmidt 1997). The rhotics attested in most dialects of Sorbian are uvular, except for the Bautzen and Kamenz dialects of Lower Sorbian which retained the alveolar trills (Schaarschmidt 1997: 156). However,

[15] See Howson et al. (2014) for a proposal that the Czech *ř* is phonetically a breathy alveolar trill [r̤]. However, Howson et al. (2015) state that *ř* has fricative-like articulatory characteristics. Different articulatory variants of *ř* are discussed by Jaworski (2018: 218-220).

[16] Note that /rʲ/ can be found in a Polish dialect spoken in Romania (cf. Deboveanu 1971: 36-39) and Slovakia (cf. Ramšaková 2020). We are grateful to Rafał Szeptyński for pointing this out to us. In accordance with our hypothesis about the preservation of palatalized rhotics in Slavic, this dialect shows a palatalized vs. non-palatalized opposition in other consonants too.

[17] In Slovenian, breaking affected the jotation reflexes of **nj* and **lj* too (see Greenberg 2000: 140-143).

[18] See, however, Proctor's (2009, 2011) finding that only [l] exhibits velarization in Russian, contrary to the consensus in the previous literature.

the uvular pronunciation is most likely due to a prolonged contact with German rather than resulting from the phonetic variability or instability of the trilled rhotics (Howson 2018, Jaworski 2018: 46; and others).[19]

We have seen that Slavic languages employ different strategies to resolve the conflict between trilling and palatalization. Czech shows depalatalization, yielding the trilled fricative [r̝], Polish shows detrilling and spirantization, as in the fricative [ʒ], and Slovenian and Western Bulgarian resolve the conflict through gestural sequencing ([rj]). In the languages with the /r/ : /rʲ/ contrast, the rhotics belong to a dense consonant inventory with many other coronal segments that can be either non-palatalized or palatalized. As suggested by Iskarous & Kavitskaya (2010) for Russian, given the articulatory and aerodynamic complexity of trills and the density of the contrastive system, the rhotics would be resistant to coarticulation and remain phonetically stable regardless of the prosodic environment. However, contrary to the expectations, there is a systematic phonetic variability present in those Slavic languages which retain the palatalization contrast in rhotics. This variability corresponds to the phonological sound change strategies just outlined. Consider Russian, which has contrastive palatalization of rhotics in most environments, even word-finally (cf. /bor/ 'pine forest' vs. /borʲ/ 'Borya-voc (name)', where it is the least phonetically salient since the palatalization cues are largely present in the transition to the following vowel. First, Russian exhibits phonetic detrilling of the trilled rhotic: the tap [ɾʲ] is the most frequent allophone of the /rʲ/, and the approximant [ɹʲ] is commonly attested as well. Second, while the palatalization gesture is present throughout the palatalized rhotic in Russian, the intensity of palatalization rises throughout the onset of [rʲ]. This phonetic behavior is reminiscent of the sequential outcome of the palatalized rhotics in Slovenian and Western Bulgarian. Finally, spirantization is also one of the strategies used in Russian (Iskarous & Kavitskaya 2010, see Jaworski 2018 on the phonetic realization of palatalized trills in Slavic languages).

Iskarous & Kavitskaya (2010) propose that, unlike in many cases where phonetic variability is the source of sound change (Ohala 1993), the phonetic variability of Russian rhotics is the source of contrast stabilization. They hypothesize that the introduction of further phonetic differentiation with respect to the number of vibrations in a rhotic facilitates contrast maintenance, distinguishing the palatalized rhotics that are taps and approximants from the non-palatalized rhotics that are trills. This hypothesis implies a correlation between the phonetic nature of rhotic segments in Slavic languages and the retention of secondary

[19] Howson (2018) shows that the increase of F2 is significantly delayed for both alveolar and uvular rhotics in Sorbian, which is a "seed" of a potential sequential resolution.

palatalization. While most Slavic languages show at least some trilling realizations of the rhotics, Jaworski (2018: 305) argues that Slavic can be divided into two groups: trilling and non-trilling languages. The former group mostly consists of languages that appear to have two contrastive rhotics in their inventory. These languages include Russian and Ukrainian (but notably not Belarusian, which has only one rhotic that is trilled, as noted by Bird & Litvin 2020), and, to a much lesser extent, West Slavic languages. The latter group includes languages that have only one rhotic phoneme, such as BCS and Slovenian. Bulgarian is an exception to the generalization since it has contrastive rhotics but no trilled realizations of the /r/, according to Jaworski's (2018) study. Jaworski (2018: 317) suggests that lenitions, that is, the loss of trilling, occur more commonly in the languages that have only one rhotic,

> …because any rhotic allophone will serve its phonological function. In the latter group [trilling languages], on the other hand, the presence of two rhotic phonemes in the system requires speakers distinguish the two sounds in order to avoid potential homophony. It probably explains why the subjects representing the South Slavic languages did not produce any trills. By contrast, trilled allophones turned out to be relatively frequent in the speech of the Belorussian, Czech, Russian and Ukrainian informants.

To summarize, the Slavic languages, which lost the palatalized rhotic, exhibit several phonological strategies of contrast preservation. In the Slavic languages, which preserved the palatalized rhotic, the same strategies are manifested phonetically and contribute to contrast stabilization. It appears, however, that purely phonetic factors are not enough to distinguish between these two types of languages, those which phonologized the available phonetic strategies and those which did not.

5.3 Inter-speaker variability and acquisition of contrast

Since the embedding of sound change concerns linguistic systems and the speech communities involved, in this section we touch upon the potential connection of the variability of rhotics and the acquisition of contrast.

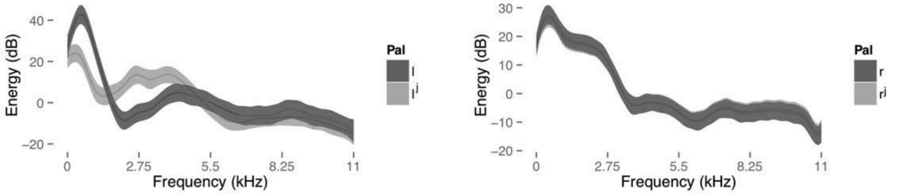
It is well documented that rhotics in general are acquired later than most other sounds (McLeod 2007, McLeod & Crowe 2018) whether they are approximants (Dodd et al. 2013 on English; Kehoe 2017 on German), taps (Kehoe 2017 on Spanish), or trills (Ball et al. 2001 on Welsh; Kehoe 2017 on Spanish). It has been further demonstrated through comparison of the acquisition of Welsh and English rhotics by Welsh-English bilingual children (Ball et al. 2001) that the Welsh trilled /r/ involves a larger range of substitutions than the English approximant /ɹ/, likely due to the particular articulatory difficulty of the former.

While there is plenty of literature on first language acquisition in Slavic, not much research is done specifically on phonological acquisition (Ionin & Radeva-Bork 2017). Russian is the only language with the /r/ : /r^j/ contrast for which sufficient data is reported. It matches the cross-linguistic order of segmental acquisition, as rhotics are acquired late (Timm 1977, Zharkova 2005).[20] According to Zharkova (2005), neither plain nor palatalized rhotics are among the ten most frequent consonants in the speech of the four subjects aged 1;9 to 3;0. This is not the case for other contrastive pairs with secondary palatalization. For example, all members of /t/ : /t^j/ and /n/ : /n^j/ oppositions are among the most frequent phonemes in early acquisition. In general, palatalization in Russian is acquired early, and some palatalized sounds serve as the most common substitutions for unpaired consonants, e.g., [t^j] is a frequent substitute for [ʃ], and [s^j] for [ʃ^{j}ː], where the latter consonants are unpaired with respect to palatalization. However, palatalized rhotics are acquired even later than the plain rhotics, also later than most other palatalized consonants, and certainly later than other palatalized coronals, presumably due to their greater complexity.

We can further hypothesize why the acquisition of rhotics presents such a great difficulty. In an experiment run on the basis of Contemporary Standard Russian, Iskarous & Kavitskaya (2018) demonstrate that, while the palatalization contrast is pervasive in Russian, some palatalized/non-palatalized pairs of consonants, such as /r/ : /r^j/, /p/ : /p^j/, /b/ : /b^j/, /m/ : /m^j/, /s/ : /s^j/, /z/ : /z^j/, appear to exhibit fewer spectral differences when averaged across speakers than others, such as /n/ : /n^j/, /l/ : /l^j/, /t/ : /t^j/, /d/ : /d^j/.[21] Even among the pairs of the first group, the palatalized vs. non-palatalized rhotics exhibit the least amount of spectral difference across speakers. Figure 3 shows the spectral contrast for palatalized and non-palatalized liquids pooled together for twelve speakers. Note that laterals (left panel) and rhotics (right panel) are strikingly different in that the palatalized vs. non-palatalized laterals are quite distinct in the lower part of the spectrum, while there are no differences between palatalized and non-palatalized rhotics.

[20] In Russian, /r/ often surfaces as a uvular rhotic in the speech of young children and would probably appear more in adult speech were it not stigmatized and corrected in childhood. Avanesov (1972: 89) mentions the uvular realization of the rhotic in Russian as a common speech impediment.

[21] Iskarous & Kavitskaya (2018) base their account on the reconstruction of a number of plain-palatalized pairs in Common Slavic. If the palatalization opposition can be reconstructed solely for the rhotics, as we argue elsewhere (see Wandl & Kavitskaya 2023), Iskarous & Kavitskaya's account requires revision, which is outside of the scope of this chapter.



a. /l/-/l^j/.

b. /r/-/r^j/.

Figure 3: Spectral contrast for liquids in Russian; 12 speakers (Iskarous & Kavitskaya 2018: 60)

The absence of spectral differences between non-palatalized and palatalized rhotics is truly unexpected since the contrast between these two segments is quite robust in Russian. Iskarous & Kavitskaya (2018) propose that the explanation for why the spectral differences are leveled out when a considerable number of speakers are pooled together lies in the great variability of Russian rhotics. On the contrary, the laterals [l] and [l^j] do not vary considerably across individuals, and thus continue to be distinguishable across speakers. While the formant transitions provide ample evidence for phonological contrast in both cases, the spectra in Figure 3 show that the learner is presented with a much more difficult task in discerning the palatalization contrast for the rhotics than for the laterals if the learning is exemplar-based and the available tokens are pooled together. When a learner is presented with highly variable tokens of sounds, which are phonologically contrastive but not distinct enough across speakers, the acquisition of these sounds may be impeded.

Interestingly, Iskarous & Kavitskaya (2018) show that a similar overlap in the inter-speaker spectra occurs only in the coronal fricatives /s/ : /s^j/, /z/ : /z^j/ and in the labials /p/ : /p^j/, /b/ : /b^j/, and /m/ : /m^j/. Palatalized labials are generally considered unstable and usually occur only if a language has other palatalized consonants (Hock 2006, Bateman 2011). For instance, in Slavic we find palatalized labials in a conservative variant of Polish, which otherwise exhibits secondary palatalization contrast only in velars. The same is true for a conservative variant of Lower Sorbian, which does not have a full-fledged correlation of secondary palatalization. This can be explained by the fact that these systems present an intermediate stage in the general loss of contrastive palatalization (Stadnik 2002: 33 ff.). The innovative consonant inventories of both varieties do not contain palatalized consonants anymore. In Polish, palatalized labials were retained because, unlike the palatalized coronals and velars, labials do not have an option to undergo a change of the primary place of articulation. In this regard, they are similar to the palatalized rhotic [r^j] (see Wandl & Kavitskaya 2023). The prediction that /s/ and /s^j/ contrast is less stable due to the minimal spectral difference also holds. While the /s/ : /s^j/ contrast arose in East and South Slavic as a result of the Common Slavic velar palatalizations (the so-called Second and Third palatalizations), it is also preserved only in the languages which developed secondary palatalization of **s* before front vowels. This suggests a possibility of a correlation between the differences in the spectral contrast of plain and palatalized consonants and the contrast's resistance to loss, along the lines of the explanation proposed by Iskarous & Kavitskaya (2018).

Future work on the acquisition of rhotics might shed further light on the fate of the /r/ : /r^j/ contrast in Slavic with respect to the functional and phonetic pressures that affect the contrast. There are several predictors of the relative timing of a child's acquisition of a sound. The articulatory complexity of a sound plays a role, and the other important predictors are frequency of occurrence (de Boysson-Bardies & Vihman 1991, Ellis 2002, Edwards & Beckman 2008, Edwards et al. 2015) and functional load (Hockett 1955, 1967, Wedel, Jackson, et al. 2013, Cychosz 2017, among others). We have also hypothesized that intra-speaker variability may be yet another predictor. These topics remain to be investigated for the Slavic languages.

6 Conclusion

To conclude, we discussed the rare /r/ : /r^j/ contrast which is present in several Slavic languages. We showed that, while the contrast can be reconstructed to Common Slavic, it has been preserved only in those Slavic languages which acquired the additional palatalization contrasts in positions other than the original jotation context. We argued that this correlation is not coincidental and proposed that functional pressures are crucial for the contrast preservation. The palatalized rhotic /r^j/ introduced into Slavic due to yod palatalization was preserved as a reflex other than /r/ only in the languages which developed further palatalized rhotics due to the overall palatalization of consonants before front vowels. We then looked into the development of the secondary palatalization contrast in rhotics in the individual Slavic languages and addressed the phonetic factors that contributed to the survival of this rare and unstable contrast, as well as provided some discussion of the acquisition of contrast. This study has demonstrated the relevance and importance of diachronic, phonetic, functional, and acquisitional factors in the explanation of contrast preservation and loss.

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Abbreviations

BCS	Bosnian/Croatian/Serbian	Po	Polish
BRu	Belarusian	PRS	present
Bu	Bulgarian	PSl	Proto-Slavic
Cz	Czech	Ru	Russian
GEN	genitive	SG	singular
Mak	Macedonian	Slk	Slovak
NOM	nominative	Sln	Slovenian
N	neuter	Ukr	Ukrainian

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Chapter 15

Ejective fricatives in Upper Necaxa Totonac: complex segments or consonant clusters?

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Ejective fricatives appear in only a small number of known languages and are presumed to arise in contrastive inventories well after the use of the glottalic airstream has been recruited to indicate a contrast between stop consonants. In Upper Necaxa Totonac ejective fricatives are supposed to have emerged from fricative + stop clusters through a series of mundane sound change processes that did not apply to stops. The result is an unusual system of contrasts in which two series of fricatives differ based on airstream, but plosive consonants do not. However, the peculiarity of this system depends on the phonological interpretation of ejective fricatives. This chapter summarizes established phonological patterns relating to ejective fricatives and provides some evidence and discussion relating to the phonetic nature and phonological identities of these sounds. The conclusion proposes an alternative phonological analysis: the ejective fricatives are still clusters.

1 Introduction

Ejective fricatives are fricative sounds produced with the glottalic airstream mechanism. They are cross-linguistically uncommon and generally do not appear in phonological systems that lack other more common airstream contrasts, such as those between pulmonic and ejective stops. Upper Necaxa Totonac (ISO 639-3: tku, Glottolog: uppe1275), a language spoken in the Northern Sierra of Puebla State, Mexico, appears to be an exception to this rule, with ejective fricatives at three places of articulation and zero airstream contrasts in either stops

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or affricates. This unusual state of affairs has been explained as the result of the coalescence of fricative + glottal stop clusters, a process that did not affect stops or affricates because they did not appear in similar phonological environments. Under this analysis, the system of contrasts in Upper Necaxa Totonac is peculiar in that includes ejective fricatives in the absence of ejective stops. However, the peculiarity of the system depends on the phonological interpretation of ejective fricatives as complex monophonemic units rather than segmental clusters. This chapter provides some evidence and discussion relating to the phonological identities and phonetic nature of the so-called ejective fricatives in Upper Necaxa Totonac.

1.1 Ejective fricatives: rare and various

Ejective fricatives are simple to describe in articulatory terms, but their complex production would seem to make them unlikely to appear in spoken language systems (Maddieson et al. 2001, Shosted & Rose 2011). Nevertheless, they are reported to occur, appearing in a few dozen languages across various phonological segment inventory database resources (Maddieson & Precoda 1990, Shosted & Rose 2011, Moran & McCloy 2019). Table 1 demonstrates the overall prevalence of pulmonic stops and fricatives in PHOIBLE 2.0 (Moran & McCloy 2019), as well as the extreme infrequency of ejective fricatives (both absolute values and percentages of the total number of languages reported in the database are provided).

Table 1: Frequencies of ejective and pulmonic stops and fricatives in PHOIBLE (Moran & McCloy 2019)

Stops	bilabial	alveolar	velar	uvular
pulmonic	2594 (86%)	2064 (68%)	2730 (90%)	256 (8%)
ejective	178 (6%)	156 (5%)	242 (8%)	84 (3%)
Fricatives	dental/alveolar	post-alveolar	lateral	
pulmonic	2020 (67%)	1104 (37%)	149 (5%)	
ejective	18 (<1%)	6 (<1%)	6 (<1%)	

Treatments of ejective fricatives often focus on the mechanism of their production and the resulting phonetic realizations (Beck 2006, Demolin 2015, Maddieson 1998, Maddieson et al. 2001, Puderbaugh 2015, Ridouane et al. 2015, Ridouane & Gendrot 2017, Seid et al. 2009, Shosted & Rose 2011), the configuration of phonological features necessary to account for them in phonological theory (Blevins

1993, Ridouane & Gendrot 2017), or both. In terms of their phonetics, ejective fricatives are as diverse as the languages they are a part of, but there are some common patterns that tend to occur. Ejective fricatives tend to have shorter frication durations than pulmonic fricatives (Maddieson et al. 2001, Gordon & Applebaum 2006, Ridouane et al. 2015, Ridouane & Gendrot 2017, Demolin 2002, Seid et al. 2009), and are frequently preceded or followed by short silent intervals (Gordon & Applebaum 2006, Ridouane et al. 2015, Demolin 2002, Seid et al. 2009, Maddieson et al. 2001), while pulmonic fricatives are not. Speakers may make use of many strategies to differentiate ejective fricatives from pulmonic fricatives, such as decreasing temporal overlap (Maddieson 1998), slowing the movement of articulators to prolong frication (Demolin 2015), decreasing the necessary volume of air by narrowing the oral constriction (Maddieson 1998) or moving the place of frication constriction further back in the mouth (Demolin 2002), or allowing for pressure to build up in the oral cavity via affrication (Shosted & Rose 2011, Moeng & Carter 2019). Contextual variation of surrounding vowels may also serve as a cue to the contrast (Ridouane & Gendrot 2017). These various production strategies result in many phonetic forms that represent particular contrasts in particular systems. However, just as speakers may employ many strategies to convey a given phonological unit, the same strategies may also be used to convey phonological structures that span more than one segmental contrast. For example, phonetically ejective fricatives may reflect phonological clusters, as has been reported to be the case in Klamath (Barker 1964, Blevins 1993) where the ejective fricatives appear in phonological environments that suggest speakers interpret them as clusters rather than individual units (Blevins 2001).

In all of the languages referred to above, the appearance of ejective fricatives implies a system with at least one ejective stop. This is presumably due to the relative ease with which glottalic airflow can be utilized during stop production, and the comparative complexity of its use in the production of fricatives (Maddieson et al. 2001, Shosted & Rose 2011). Upper Necaxa Totonac seems to be the only exception to this pattern, with a series of ejective fricatives at three places of articulation and no ejective stops at all (Beck 2006). Identification of ejective fricatives in Upper Necaxa Totonac has relied primarily on impressions of their auditory characteristics with some reference to historical reconstruction, syllable structure, and phonotactics. Evidence for the status of ejective fricatives as monophonemic units (rather than clusters) relies on their phonetic characteristics, as well as some distributional patterns. In the present chapter phonotactic and phonetic duration data are presented as a means of investigating their phonological status as either single phonemes or clusters.

1.2 Ejective fricatives in Upper Necaxa Totonac

This section summarizes the current understanding of ejectives as part of Upper Necaxa Totonac phonology. Particular focus is given to syllable structure and consonant cluster phonotactics as relevant factors in categorizing ejective fricatives either as phonemic units or clusters.

1.2.1 Sound inventory

The currently accepted consonant inventory of Upper Necaxa Totonac (Beck 2011) is presented in Table 2. With the exception of the ejective fricatives the inventory consists of sounds that are typologically quite common. However, the glottal stop, which is reported here as a consonant, plays a dual role as a potential component of laryngealization in vowels (Puderbaugh 2019a,b). Laryngealization of vowels is a widespread phenomenon across Totonacan languages, and may be used to indicate prosodic boundaries as well as lexical contrasts (Beck 2004, Levy 1987, 2015, Watters 1980). The phonology of Upper Necaxa Totonac involves few allophonic alternations and little apparent variation in spoken forms.

Table 2: Upper Necaxa Totonac consonant inventory in IPA format. Ejective fricatives appear in rows immediately below the pulmonic fricatives. Symbols in parentheses indicate marginal or borrowed contrasts

	Bilabial	Alveolar	Post-alveolar	Palatal	Velar	Glottal
Plosive	p	t			k	ʔ
Trill/Tap		(r,ɾ)				
Nasal	m	n			ŋ	
Affricate		ts	tʃ			
Fricative		s	ʃ		x	(h)
		s’	ʃ’			
Lateral fricative		ɬ				
		ɬ’				
Approximant	w			j		
Lateral approximant		l				

Glottal stops and ejective fricatives are entwined in Upper Necaxa Totonac due to their shared historical origins in the uvular *q of Proto-Totonacan. While some

Totonacan languages retain /q/, Upper Necaxa Totonac has shifted *q entirely to /ʔ/ in all contexts. As a result, /ʔ/ is considered to be part of the stop series in line with its historic origins. The synchronic distribution of ʔ therefore resembles that of other stop consonants, except that fricative + glottal stop clusters are supposed to have coalesced into ejective fricatives through mundane processes of language change that allowed for the temporal overlap of glottal closure and oral frication in all tautosyllabic environments (Beck 2006).[1] However, it is not clear from the evidence that the ejective classification is warranted. Descriptions of the ejective fricatives in Upper Necaxa Totonac have relied largely on auditory impressions such has having a "sharper" sound than pulmonic fricatives and being accompanied by visible glottal raising, with the addition of some inconclusive phonetic data also applied to the question (Beck 2006).

The vowel inventory of Upper Necaxa Totonac is a symmetrical 5-vowel system including the vowel qualities /a, e, i, o, u/ (Beck 2004), Table 3. Each of the five vowel qualities may be contrastively short or long, and laryngealized or non-laryngealized. Each vowel can also be stressed or unstressed. No combinations of vowel quality, length, laryngealization and stress are prohibited. However, Garcia-Vega & Tucker (2021) report no tokens of long laryngealized /ṵː, a̰ː, ḛː, o̰ː/ in their data set, perhaps indicating that these particular combinations of qualities and lengths with laryngealization are uncommon in the language overall. Stress is often used to distinguish nouns from verbs (Beck 2004, 2008). In nouns, stress falls on the penultimate syllable, unless the word ends in a long vowel or a closed syllable, in which case the heavy weight draws stress to the final syllable. Verbs are always stress final, except suffixed verbs, which follow the same stress rules as nouns.

Table 3: Upper Necaxa Totonac vowel inventory

	Front	Central	Back
High	i, iː, ḭ, ḭː		u, uː ṵ, ṵː
Mid	e, eː, ḛ, ḛː		o, oː, o̰, o̰ː
Low		a, aː, a̰, a̰ː	

[1]The distribution of glottal stops in Upper Necaxa Totonac is further complicated by its role as a potential indicator of prosodic boundaries and vowel laryngealization. These aspects of glottal stops in Upper Necaxa Totonac are left for future research.

1.2.2 Syllable structure and phonotactics

Like other Totonacan languages, syllables in Upper Necaxa Totonac have obligatory onsets (Kung 2007, McFarland 2009, Watters 1980, MacKay 1994), optional codas, and appear to follow the sonority sequencing principle such that fricative + stop clusters may appear in syllable onsets and stop + fricative clusters may appear in syllable codas, but not vice versa (Kirchner & Varelas 2002, Beck 2004).[2] An example of fricative + stop cluster in syllable onset is ***sk**auj* /skaux/ 'rabbit', while *pu**ks*** /pu**ks**/ 'overcast, gloomy' exemplifies a stop + fricative cluster in syllable coda. The sequence /ks/ is not allowed in syllable onset, nor is /sk/ allowed in syllable coda.

Syllable onsets in Upper Necaxa Totonac may consist of any single consonant, including affricates and ejective fricatives, or clusters of up to two elements, limited to a pulmonic fricative followed by a stop, nasal, or approximant, or a stop followed by an approximant (Kirchner & Varelas 2002).[3] Affricates are allowed in syllable onsets, as seen in ***ch**i'ntá:xna'* /t͡ʃḭn.ˈta:ʃ.na̰/ 'footprint'; they do not appear in syllable codas. Likewise, ejective fricatives appear in onsets, but not codas, e.g. ***x'**onunhó:* /ʃʼo.nuŋ.ˈʔo:/ 'white louse'. When vowel-initial roots or prefixes appear at the start of a word, glottal stops may be inserted to satisfy the need for a syllable onset where the underlying form does not include one. For example, *a:chulá:* /a:.t͡ʃu.ˈla:/ 'more', would be realized as [ʔa:.t͡ʃu.ˈla:] in isolation. It is not clear whether forms that include a glottal onset in their underlying form differ phonetically from those with syllable-initial glottal epenthesis.[4]

Syllable codas are optional in Upper Necaxa Totonac and may be filled with any singleton stop, pulmonic fricative, or nasal, or a cluster be made up of a stop or a nasal followed by a pulmonic fricative, including ʔ + fricative sequences. Examples of singleton codas are *slu**lh*** /sluɬ/ 'crocodile', *xtu**m*** /ʃtum/ 'different', and *xke'jé**t*** /ʃkḛ.xet/ 'an herb'. All combinations of stop + fricative appear in coda position except for clusters of /t/ followed either by /s/ or /ʃ/. For example, *akaku:lú:**klh*** /a.ka.ku:.ˈlukɬ/ 'scorpion'. Ejective fricatives do not appear in syllable codas. The lack of alveolar stop + fricative clusters in coda position may be

[2] This description of syllable structure in Upper Necaxa Totonac is preliminary and has not been the subject of substantial or rigorous study. Recent research has called into question the universality of the principle of sonority sequencing (Yin et al. 2023). With respect to Upper Necaxa Totonac, the topic is taken as given for the purposes of this chapter and left for future researchers to examine further.

[3] Kirchner & Varelas (2002) does not differentiate between oral and glottal stops, but the ejective analysis assumes that fricative + glottal stop clusters do not occur within a single syllable, unlike oral stops.

[4] This chapter leaves an investigation of epenthetic glottal onsets for future research.

due to their similarity to affricate segments /t͡s/ and /t͡ʃ/, which do not appear in coda position (except in ideophonic productions). Ejective fricatives do not appear in coda position, but glottal stop + fricative clusters do, e.g. *po'hlh* /po̰ʔɬ/ 'dark, in shadow'.

In comparison to pulmonic fricatives and stops, ejective fricatives and affricates appear in more restricted environments in that they do not occur word-finally or in clusters. They also resemble one another in their phonotactic restrictions: both ejective fricatives and affricates occur only in syllable onsets, and neither may appear as part of a cluster. In fact, the distributions of ejective fricatives, affricates, and onset fricative + stop clusters are exactly identical (Kirchner & Varelas 2002, Beck 2006).

1.3 Ejective fricatives in Upper Necaxa Totonac

Ejective fricatives in Upper Necaxa Totonac are reported to be the result of the debuccalization of *q to /ʔ/, followed by increasing temporal overlap of the glottal stop closure with frication, eventually resulting in phonetically ejective fricatives. This process presumes historical clusters of fricative + *q, and implies that fricative + /ʔ/ clusters were part of the phonology at least for a time. For example, the Proto-Totonacan form *squli 'whistle' would have passed through an intermediate stage, /sʔoli/, before arriving at its current state as *s'olí* /s'oˈli/ in contemporary Upper Necaxa Totonac. It stands to reason to consider, then, whether these sequences have in fact coalesced into individual complex segments or if they might still be clusters. This question can be addressed from both distributional and phonetic perspectives.

The historical origin of ejective fricatives as clusters would predict a parallel distribution between ejective fricatives and clusters that limits the likelihood of phonological differentiation between clusters and ejectives (Beck 2006). In the synchronic phonology of Upper Necaxa Totonac, the distinguishing characteristic between clusters and ejective fricatives is reported to be that clusters may resyllabify into sequences that cross syllable boundaries, while ejective fricatives occur only as complex units in syllable onsets (Beck 2006). The whole evidence for resyllabification (or lack of it) seems to be based only on impressions of the linguists who completed the documentation rather than any rigorous investigations with speakers. When preceded by an open syllable, pulmonic fricative + stop clusters may resyllabify such that the fricative appears in the coda of the preceding syllable. An example of this is ***pálhka*** 'griddle', which syllabifies as /ˈpaɬ.ka/. In contrast, ejective fricatives preceded by an open syllable remain instead as a single unit in the onset of the following syllable, such as is seen in *pa:**lh**'á:* 'cut open sth's belly', which syllabifies as /paː.ɬ'aː/. Table 4 presents some further examples of this syllabification scheme in both mono-morphemic and morphologically complex polysyllabic stems with fricative + consonant clusters and ejective fricatives at word internal syllable boundaries.

Table 4: Syllabification of fricative + stop clusters and ejective fricatives. *Notes:* Examples are presented in practical Upper Necaxa Totonac orthography (in italics) and phonemic notation using IPA symbols. Morpheme boundaries are indicated by '-', syllable boundaries by '.'. Grammatical morphemes are represented in small capital letters. INCH: inchoative/inceptive/decausative, indicating 'coming into' a state; AGT: agentive nominalizer, indicating the person or thing performing an action; CS: causative; DTRNS: detransitivizer. Further information on these morphemes is available in Beck (2011).

Clusters		Ejectives	
Morphology	Syllabification	Morphology	Syllabification
*mí**st**u'* /ˈmistṵ/ 'cat'	/ˈmis.tṵ/	*hó'**x'**a'* /ˈʔo̰ʃ'a̰/ 'skin'	/ˈʔo̰.ʃ'a̰/
*pá**lhk**a* /ˈpaɬka/ 'griddle'	/ˈpaɬ.ka/	*pa:lh'á:* /paː-ɬ'aː/ 'cut open smth's belly'	/paː.ˈɬ'aː/
*ta**xt**ú* /ta-ʃtuː/ INCH-out 'leave'	/taʃ.ˈtuː/	*a'**hs'**awiní'* /a̰ʔ-s'awi-ˈnḭ/ head-defeat-AGT 'trickster, deceiver'	/a̰ʔ.s'a.wi.ˈnḭ/
*ki**lhh**ó'x'a'* /kiɬ-ʔo̰ʃ'a̰/ mouth-skin 'one's lips'	/kiɬ.ˈʔo̰.ʃ'a̰/	*ma:**x'**a'he:nín* /maː-ʃ'a̰ʔa-eː-nin/ CS-shine-CS-DTRN 'be illuminated'	/maː.ʃ'a̰.ʔeː.ˈnin/

Some rare instances of fricative-final prefixes affixing to glottal-initial roots appear in the *Upper Necaxa Totonac Dictionary*, all of which are produced by the combination of one of three highly productive fricative-final prefixes: *ix-* /iʃ-/ 'his/her', *helh-* /ʔeɬ-/ 'mouth (interior)', and *kilh-* /kiɬ-/ 'mouth (exterior)'. These prefixes in combination with roots beginning with /ʔ/ result in heterosyllabic sequences of fricative + glottal stop. For example, *kilhhó'x'a'* /kiɬ.ʔó'.ʃ'a̰/ 'one's lips' is made up of the prefix *kilh-* /kiɬ-/ attached to the stem *hó'x'a'* /ʔó'.ʃ'a̰/ 'skin'.[5] It is not clear from existing descriptions whether there is a phonetic difference between such clusters occurring across morpheme boundaries and morpheme-initial ejective fricatives.

In a previous investigation into ejective fricatives in Upper Necaxa Totonac, ejective fricatives were found to be produced with longer frication intervals and very short flanking silence (Beck 2006), a finding that is unlike the patterns seen in other languages that have been described as making use of ejective fricatives in their phonologies. Further details of the phonetics of ejective fricatives are summarized and reported in Section 3.3.

1.4 Structure of this chapter

In the sections that follow, both phonological and phonetic evidence is applied to the question of whether the ejective fricatives in Upper Necaxa Totonac have in fact coalesced into complex segments, or remain as clusters of fricative + /ʔ/. Section 2 considers the segmental distributions present in the *Upper Necaxa Totonac Dictionary* using simple collocational analysis and a computational learner. Section 3 investigates durational differences between pulmonic and ejective fricatives, as well as pulmonic fricative + stop clusters.

2 Distribution of ejectives and other sound classes

The historical origins of ejective fricatives in Upper Necaxa Totonac reported in Section 1.3 preclude the possibility of obvious phonological evidence to distinguish them from clusters (Beck 2006). However, by comparing their distributional properties to pulmonic fricatives, fricative + stop clusters, and affricates, we may glean some information about their likely status in the synchronic phonology. The analysis here begins with a simple collocational analysis of the *Dictionary* text, including frequencies and distributions of pulmonic and ejective

[5] This is the only case of reported fricative + glottal stop clusters across both syllable and morpheme boundaries (Beck 2006).

clusters, and fricative + stop clusters. The analysis then makes use of a computational learner developed to investigate differences in distribution that may help to differentiate between complex segments and clusters.

2.1 Collocation

This section presents a collocational analysis of the lexical entries in the *Upper Necaxa Totonac Dictionary*. The distributions of individual segments and clusters are considered.

2.1.1 Methods

The materials for the present analysis were extracted from the digital version of the *Upper Necaxa Totonac Dictionary* (Beck 2011). The *Dictionary* consists of 9,062 lexical entries with transcriptions, definitions, and grammatical notes including morphological, syntactic and dialectal information. All forms were included in the analysis, including head words, inflected forms, and those affixes that received their own entries. The *Dictionary* is likely the most comprehensive resource on Upper Necaxa Totonac and as such makes a good resource to build the current corpus. It was compiled over many years of fieldwork in the communities of Patla and Chicontla, and it broadly represents the language as it has been encountered to date. While it is possible that certain types of sequences may be over-represented in a corpus built from dictionary forms, the subject matter and vocabulary in the *Dictionary* are broad and not limited by style or topics as a corpus of stories or conversations would be (Bauer 2015).

The dictionary materials were converted to IPA representation using grep and regex (regular expressions) find-and-replace methods in a plaintext file. The transliteration process was straightforward due to the transparent orthography currently in use for Upper Necaxa Totonac. The orthography used in the *Dictionary* follows conventions of the Secretariat of Public Education (SEP) and the National Indigenous Institute (INI) of Mexico, with some modifications to capture aspects of the phonology that these conventions do not take into account, such as the use of <h> to represent the glottal stop phoneme (Beck 2011). Some phonological contrasts are represented by digraphs or symbols modified by diacritics, and some symbols are used for more than one purpose. For example, the symbol <h> surrounded by vowels is interpreted as a glottal stop. However, <h> also appears in the digraphs <ch>, representing a post-alveolar affricate /tʃ/, <lh>, representing a lateral fricative /ɬ/, and <nh>, representing a velar nasal N, or /ŋ.ʔ/ when preceding a vowel. All linguistic forms presented here are also transcribed in an IPA format, so further particulars of the orthography are omitted from the present chapter.

Following a method similar to Bauer (2015), phonological transcriptions were accepted as given in the published dictionary. Because some segments were encoded by complex character sequences (i.e affricate digraphs, ejective fricatives, vowels with length, stress and laryngealization diacritics), phonemic symbols were separated by spaces on either side. Segment sequences such as clusters were therefore split into component segments by these spaces, while complex segments such as /t͡ʃ/ were retained as a unit without a space between the two characters of the digraph. The resulting list of prepared lexical data was then converted into a single text string from which immediately preceding and following segments were identified for all segments using the shift function from the `data.table` package (Dowle & Srinivasan 2017) in R (R Core Team 2017).

2.1.2 Results

The corpus built from the *Upper Necaxa Totonac Dictionary* consists of 69,080 phonemic segments. Of these segments, 28,966 (42%) were vowels, 15,705 (23%) were stops, 6,292 (10%) were fricatives, and 1,941 (2.8%) were affricates. The remainder of tokens was made up of other consonant types including nasals, liquids, and glides. About 93% of the fricative tokens were pulmonic, with three places of articulation being roughly equally represented (/s/ 30.21%, /ʃ/ 31.04%, /ɬ/ 31.8%). Ejective fricatives make up most of the remaining 7% of fricative tokens in the dictionary, with /s'/ accounting for nearly half of these (2.97%). The post-alveolar /ʃ'/ made up 1.95% of fricative tokens, and /ɬ'/ accounted for the remaining 2%. The remainder of fricative tokens were velar fricatives, which have not been described as participating in the ejective/pulmonic fricative series of contrasts and were not included in the analyses that follow. Table 5 demonstrates the apparently distinct distributions of ejective fricatives compared to pulmonic fricatives at the same places of articulation, and highlights the similarity of ejective fricatives to affricates in their distribution. Both ejectives and affricates are limited to pre-vocalic positions in syllable onsets. By contrast, the pulmonic fricatives have a wider distribution, appearing in onsets, codas, and various cluster configurations. The table also shows that ejective fricatives are relatively rare compared to both pulmonic fricatives and affricates.

2.1.2.1 Onset clusters

A fairly high proportion of pulmonic fricatives occur before stops (/s/ 40.77%, /ʃ/ 41.07%, /ɬ/ 29.92%), while ejective fricatives appear only before vowels. This

Table 5: Distributions of fricative and affricate segments across phonological contexts

	s	ʃ	ɬ	s’	ʃ’	ɬ’	ts	tʃ
_ vowels	518	346	539	187	123	126	974	967
_ stops	775	802	599	-	-	-	-	-
_ other C	442	415	499	-	-	-	-	-
_#	166	190	365	-	-	-	-	-

would appear to serve as evidence for a distinction between the fricatives in terms of their possible phonotactic configurations. However, a comparison between ejectives, clusters and affricates reveals a different pattern. Table 6 presents the count data for fricative + stop clusters, ejective fricatives, and affricates according to the environment they appear in: in all pre-vocalic contexts, or in a subset of such contexts in word-initially position. Here, when we compare the ejective fricatives to fricative + stop clusters, we see that ejective fricatives appear in numbers very similar to most other fricative + stop clusters. By contrast,

Table 6: Distributions of fricatives in clusters with stops at three places of articulation compared to ejective fricatives and affricates. “C1” refers to the first consonant in the onset, while “C2” refers to the second consonant in the onset. Where C2 is not specified, the onset consists of only one segment. Word initial tokens (#_V) make up a subset of all pre-vocalic tokens (_V)

C1	s			ʃ			ɬ			
C2	p	t	k	p	t	k	p	t	k	ʔ
_V	135	461	178	52	564	188	142	302	145	10
#_V	32	105	70	15	60	50	35	65	40	-
C1	s’			ʃ’			ɬ’			
_V	187			123			126			
#_V	57			42			46			
C1	ts			tʃ						
_V	974			967						
#_V	205			252						

the affricates /t͡s/ and /t͡ʃ/ occur far more frequently than any of the fricatives whether in singletons or clusters.

The data also show differences in the overall frequency of occurrence among stop + fricative pairings. The most common stop for fricatives to form a cluster with is the alveolar /t/. There also appears to be a particularly low number of clusters involving the post-alveolar fricative and the bilabial stop. Perhaps most striking is the near complete lack of clusters formed from fricatives and glottal stops.

2.1.2.2 Coda clusters

Coda clusters have structures exactly opposite of onset clusters (stop + fricative). Ejective fricatives do not occur in syllable codas, but clusters of glottal stops followed by fricatives do. If we interpret the ejective fricatives as clusters of fricatives followed by glottal stops, the opposite sequence (i.e. glottal stop followed by a fricative) would be expected to occur in coda position. This pattern is parallel to that of the oral stops which also appear in clusters with fricatives, and distinct from affricates which do not appear in coda position. Table 7 reports total numbers of stop + fricative clusters in the data, as well as tokens appearing word finally. The overall prevalence of glottal stop + fricative clusters is very similar to that of clusters with the velar stop, barring specific variation of particular combinations.

Table 7: Distributions of fricatives in coda clusters preceded by stops at four places of articulation. “C1” refers to the first consonant in the coda cluster, while “C2” refers to the second consonant in the cluster

C1	p			t			k			ʔ		
C2	s	ʃ	ɬ	s	ʃ	ɬ	s	ʃ	ɬ	s	ʃ	ɬ
_#	10	11	3	-	1	2	54	27	11	11	47	39
total	23	20	8	-	-	21	226	172	148	235	244	207

By looking at the distributions of clusters as well as individual segments, we can see that fricative + stop clusters pattern with both ejective fricatives and affricates in that they appear only in syllable onset position. Distribution of the so-called ejective fricatives indeed differs from that of pulmonic fricatives, but mirrors that of fricative + stop clusters. This supports the claim that there may not be a phonological basis for distinguishing between clusters and ejective fricatives. While the present data is certainly suggestive of a pattern that does not differentiate between ejective fricatives and clusters, Section 2.2 below considers whether these patterns reflect a learnable contrast.

2.2 Computational learning of complex segments

The analysis above has shown that ejective fricatives occur in environments and numbers similar those of stop + fricative clusters. On the other hand, affricates, which are also limited to syllable onset position, are far more frequent than either ejective fricatives or fricative + stop clusters in the *Dictionary*. The data above has shown that /ʔ/ + fricative sequences in consonant codas also occurs in the data, at a frequency that is similar to coda clusters involving /p/ and /k/. As a further investigation of these patterns, the segmental data from the *Dictionary* was fed into a computational learner created by Gouskova & Stanton (2021) and designed to distinguish clusters from complex segments in various languages based on statistical distributions of sequences, explicated below. The learner has previously been able to identify various complex segments including affricates, prenasalized segments, labiovelars, and labialized consonants from a variety of languages.

The learner is made up of three components: an inseparability measure, a unification procedure, and iteration. The inseparability measure is a statistic indicating how likely a consonant is to be in a specific CC sequence as opposed to other environments. This is basically a mutual information score. The unification procedure determines whether a sequence of symbols should be concatenating into a complex string based on the value of the inseparability measure and the overall cluster frequency. The default inseparability value at which to unify two consonants is 1, and the cluster frequency must be significantly different from zero in order to ensure that small numbers of cluster tokens are ignored. In other words, two consonants are unified when they occur more often immediately adjacent to each other in sequence than in other environments (Gouskova & Stanton 2021). The iteration component repeats the entire process of calculating inseparability scores and unifying consonant sequences based on the statistical distributions in the modified inventory. The learner continues to iterate through these components until there are no more sequences that qualify for unification at a given threshold.

The data that is provided to the learner must be formatted such that any potentially complex segments are separated into their component parts. For example, the affricate /t͡ʃ/ would be split into two components, <t> and <ʃ>. Likewise, the

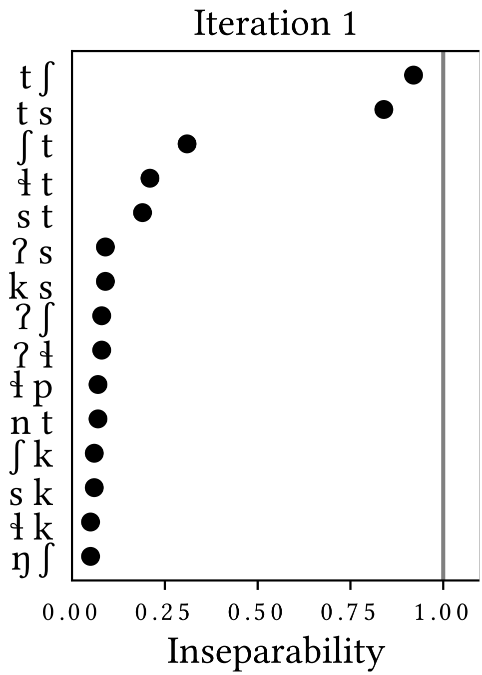

Figure 1: Inseparability plot from the initial simulation with all dictionary forms included as originally transcribed. The sequences /t s/ and /t ʃ/ approach but do not cross the inseparability threshold needed to unify the sequences into complex affricate sequences and initiate further iterations of the learner

ejective fricatives are provided to the learner as sequences of fricative followed by glottal stop, e.g. /ɬ'/ is provided to the learner as <ɬ ʔ>. Two sets of initial learning data were supplied to the computational learner. The first set consisted of the materials as described in 2.1.1, with all segments encoded as they are represented in the dictionary. In this form, the learner completed a single iteration and did not find any monophonemic complex segments, though the sequences <t s> and <t ʃ> did have the highest inseparability values, which were only minimally below the threshold needed for the learner to unify them and perform further iterations. Figure 1 shows a plot of the inseparability values with the learning data in this initial format.

In the second set of learning data, a modified data set was supplied to the learner with all glottal stops that had appeared after laryngealized vowels removed. This data set was created due to findings in Puderbaugh (2019b) showing a strong correlation between laryngealized vowels and following glottal stops.

The correlation suggests that the glottal stops appearing after laryngealized vowels are redundant. The presence of this redundancy could introduce noise into the data that might lead to difficulties for the compututional learner in establishing the the relevant collocational patterns. In order to alleviate some of this noise, the redundant glottal stops were removed. Figure 2 shows the output of the learner with this modified data set.

Subsequent to the removal of glottal stops that had followed laryngealized vowels, the learner completed four iterations. In the first iteration, the learner was able to unify the sequence <t ʃ> into <tʃ>. The alveolar affricate /ts/ was very near the threshold in the first iteration, but was not unified until the second iteration of the learner. In the third iteration, the learner unified the sequence <ʃ t> and then stopped on the following iteration as no further sequences met the inseparability criterion for unification.

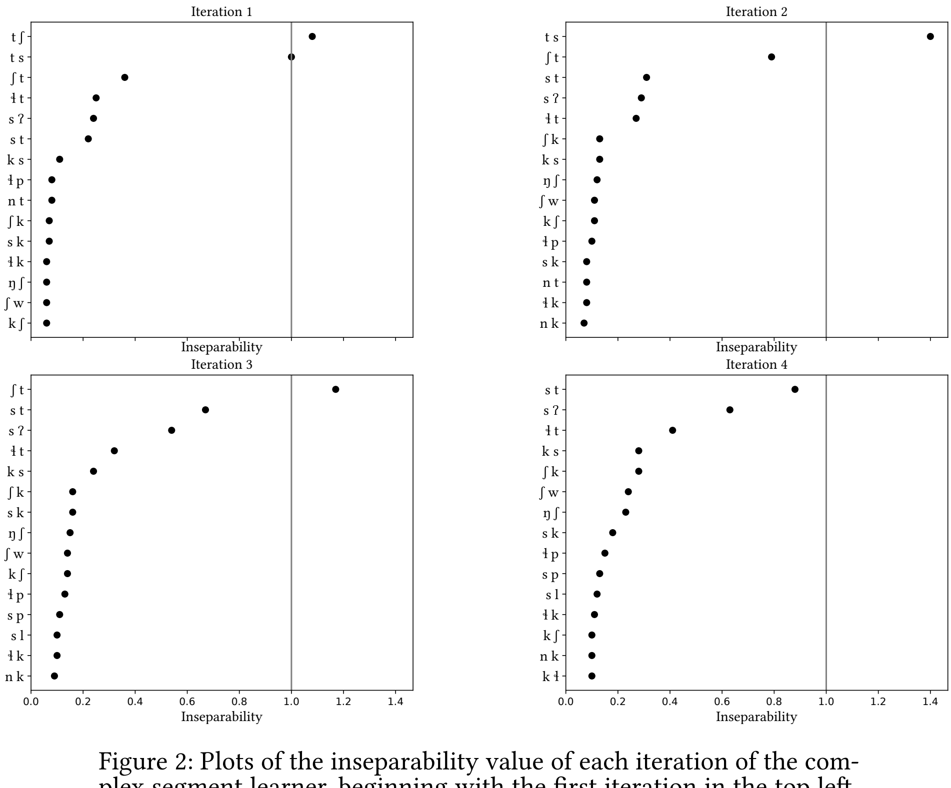

Figure 2: Plots of the inseparability value of each iteration of the complex segment learner, beginning with the first iteration in the top left, and proceeding from left to right through the remaining iterations. The vertical line indicates the threshold at which a sequence is considered to be a complex segment by the learner

The output of the learner shows that affricates were established as monophonemic units by this method based on the frequency of occurrence. However, the ejective fricatives were not unified by the learner, as they occur in frequencies similar to those of other fricative + stop clusters. In later iterations, the most frequent ejective /s'/ does approach the inseparability threshold, well ahead of any of the other ejective fricatives. This perhaps suggests that this sequence may be on its way to becoming sufficiently frequent that the learner could identify it as a complex monophonemic unit within Upper Necaxa Totonac phonology. This also illustrates the different rates at which various sequences occur in the data. Despite never crossing the threshold in the learner, the overall frequency of <s ʔ> suggests it has a different pattern from the other purported ejective fricatives. There is some potential that the shift from cluster to ejective is well underway, but only applies to the alveolar items. However, the learner also unified the sequence <ʃ t>, which has not been identified as a unit by linguists, in the third iteration. We can also see that the sequence <s t> was also approaching the inseparability threshold ahead of the most frequent ejective /s'/. This result may be due to the choice to use the *Dictionary* as the data source, or may highlight the limitations of relying on segmental frequency, which may not be sufficient to establish phonemicity in all cases. The present chapter will leave the question of the suitability of dictionary data to this application for future work on the phonotactics of Upper Necaxa Totonac.

3 Phonetics of ejective fricatives in Upper Necaxa Totonac

The above analyses have demonstrated that the ejective fricatives are distributed similarly to fricative + stop clusters in the lexicon. They have also shown that, at least in the *Upper Necaxa Totonac Dictionary*, the ejective fricatives do not occur at sufficiently high frequencies for a computational learner to identify them as complex monophonemic units. In this section, the phonetic nature of these sequences is considered, with a focus on the acoustic duration of ejective and pulmonic fricatives. The results show that the ejectives are unlikely to be produced by the glottalic airstream, and instead fit within observed patterns of duration compatible with an analysis of them as fricative + stop clusters.

3.1 Duration in fricative categories

Production of ejective fricatives frequently involves intervals of frication preceded or followed by intervals of silence (indicating oral or glottal closure, or a lack of airflow). Comparison of the duration of these intervals to analogous intervals in pulmonic fricatives has often revealed salient differences between the airstream categories.

3.1.1 Frication intervals

Ejective fricatives are often found to be produced with shorter frication intervals compared to their pulmonic counterparts. In Tlingit, ejective fricatives were produced with 148 ms of frication noise compared to 222 ms in pulmonic fricatives (Maddieson et al. 2001). Ejective fricatives in Turkish Kabardian were produced with frication intervals of about 130 ms, compared to 191 ms for pulmonic fricatives (Gordon & Applebaum 2006). Similar patterns were also found to be the case in Mehri (88 vs. 122 ms; Ridouane et al. 2015, Ridouane & Gendrot 2017) and Amharic (85 vs. 134 ms; Demolin 2002, Seid et al. 2009). As a follow up to the measurement of frication duration in normal speech, speakers of Amharic were asked to maintain frication for as long as they could in both ejective and pulmonic conditions. The result was about 10 seconds of noise in pulmonic fricatives, and 0.6 seconds of noise in ejective fricatives. This demonstrates the limited air supply during ejective production and strengthens the description of the sounds as ejective. A notable exception to the usual finding is the pattern seen in Yapese (Maddieson 1998). In this case, frication durations were roughly similar across pulmonic and ejective categories, differing by only about 20 ms at the two places of articulation studied: labiodental – 100 vs. 120 ms, interdental – 150 vs. 170 ms. Although they appear to be monophonemic units, the production of ejectives in Yapese involves a sequence of fricative constriction followed by glottal constriction, in other words a phonetic cluster. In Upper Necaxa Totonac, Beck (2006) found that ejective fricatives were produced with 143 ms of frication noise while pulmonic fricatives were produced with only 96 ms of frication before vowels and 101 ms in fricative + stop clusters. Despite the variability of frication across languages, this is the only reported case of ejective fricatives having longer frication intervals than pulmonic fricatives.

3.1.2 Flanking silent intervals

Ejective fricatives are often produced with silence preceding and/or following frication, though this varies by language and speaker. Gordon & Applebaum (2006) report that ejective fricatives were followed frequently by a silence in Turkish Kabardian, though the duration of this silent interval was unquantified. In Mehri, some speakers were found to almost always produce silent intervals while others almost never did (Ridouane et al. 2015). In this study, pulmonic fricatives were followed by silent intervals. In ejective fricatives, the average post-frication lag interval ranged from about 21 ms word-initially to 25 ms between vowels. Intervocalic ejectives were also preceded by a silent interval of approximately 24 ms on average. In Amharic, ejective fricatives were followed by post-frication lags of approximately 30 ms (Demolin 2002, Seid et al. 2009), while Maddieson et al. (2001) found post-frication silent intervals of 46 ms in ejective fricatives and 1 ms in pulmonic fricatives in Tlingit. Beck (2006) reports a post-frication silent interval of 9 ms in ejectives and 3 ms in pulmonic fricatives in Upper Necaxa Totonac.

3.1.3 Total duration

Comparisons of total duration tend to reveal no difference between ejective and pulmonic fricative categories (Ridouane et al. 2015, Ridouane & Gendrot 2017, Maddieson et al. 2001). However, ejective fricatives in Amharic were reported to have shorter duration than pulmonic fricatives in all conditions (initial and word-medial singleton fricatives, and word-medial geminate fricatives; Seid et al. 2009).

3.2 Methods

Digital audio recordings were provided by four speakers of Upper Necaxa Totonac. The audio files were annotated and segmented, and durations of various events during the production of the ejective fricatives were measured and compared. This section provides further information about the materials and methods used in the phonetic study.

3.2.1 Speakers and Recordings

Four speakers of Upper Necaxa Totonac (two women, two men) provided the audio data included in the acoustic analyses. Speakers ranged in age from about 30–60 years old. All speakers had grown up speaking Upper Necaxa Totonac in the area local to Patla and Chicontla, with younger speakers being exposed to more Spanish earlier in life. All of the speakers still speak Upper Necaxa Totonac in the community on a daily basis, though Spanish is also very frequently used. Interactions with the author were undertaken in Spanish.

Recordings were made in speakers' homes using a digital recorder and head-mounted microphone. The word list was presented in the same order to all speakers, though it was not intentionally arranged in any particular order. Speakers were asked to repeat each word three times within the frame sentence *ixla wanli'* … *chuwa* [ʃla wanli̯ … tʃuwa], meaning roughly 'he said … now'. During recording, speakers were able to see and read both the intended Upper Necaxa Totonac form and the written translations in Spanish on the author's laptop screen. In addition to these written prompts, speakers were also orally prompted with a Spanish translation.

3.2.2 Materials

The word list for this study was compiled from orthographic forms found in the *Upper Necaxa Totonac Dictionary* (Beck 2011). The list was designed to balance potential sources of variability in ejective fricatives, pulmonic fricatives, and affricates. Table 8 provides examples of words in each condition. Tokens were collected across word position, segmental context, and proximity to lexical stress. Word list items were not controlled for the number of segments that appear in the word. The list as designed consisted of 130 words. Forms that were not produced by all speakers, including speech errors and alternative forms, were excluded from the analyses, resulting in 121 common lexical items and 1,452 fricative tokens expected to be included in the analysis. Twelve words included two different fricative tokens, increasing the overall number of expected tokens to 1,500. In some cases, speakers did not recognize the word that was intended by the word list, or produced fewer than three usable repetitions of some words, reducing the final data set to 1,430 productions.[6]

3.2.3 Annotation

The recorded audio was annotated to allow for consistent comparison among tokens. All instances of fricatives and affricates appearing in the data were included in the annotations and subsequent analysis, which means that some word forms containing more than one fricative contributed multiple data points per repetition. The audio files were labeled in accordance with the phonemic forms of words as transcribed in the dictionary (Beck 2011), rather than the auditory impression of each segment. The segmentation and annotation was completed using Praat (Boersma & Weenink 2018).

Tokens were annotated according to three possible events: pre-frication closure, frication noise, and post-frication lag. Closure intervals were defined as beginning at the end of the second formant in the preceding vowel or sonorant,

[6]The complete wordlist is available in Puderbaugh (2019a).

Table 8: Examples of Upper Necaxa Totonac words presenting various frication conditions. Stress and laryngealization refer to the categorization of the following vowel. Target segments are shown in **bold** in orthographic representations

	Word Initial		Word Medial	
	stressed	unstressed	laryng	non-laryng
pulmonic	***s**á:sti’* /ˈsaːs.tḭ/ ‘new’	***s**alún* /sa.ˈlun/ ‘hoe’	*sé’h**s**i’* /ˈsḛʔ.sḭ/ ‘sweet’	*ta**s**a:tanú:n* /ta.saː.ta.ˈnuːn/ ‘stuck, fixed in place’
ejective	***s**’á’lhwa’* /ˈs’a̰ɬ.wa̰/ ‘slow of movement or thought’	***x**’etím* /ʃ’e.ˈtim/ ‘seeded and deveined chili’	*li:**lh**’á:’n* /liː.ˈɬ’a̰ːn/ ‘plough’	*ta**s**’awí* /ta.s’a.ˈwi/ ‘lose, be defeated’
cluster	***x**ka’j* /ˈʃka̰h/ ‘pineapple’	***lh**taká’la’* /ɬta.ˈka̰.la̰/ ‘board’	*li:**x**pa’tán* /liːʃ.pa̰.ˈtan/ ‘pestle of a molcajete (mortar)’	*tu:**s**púlh* /tuːs.ˈpuɬ/ ‘one’s toes’
affricate	***ch**í’px* /tʃḭpʃ/ ‘dense’	***tz**alá’j* /tsa.ˈla̰h/ ‘brittle, fragile, thin (stick)’	*chu’**ch**ó’hx* /tʃṵ.ˈtʃo̰ʔʃ/ ‘banana blossom’	*a:’tu:’**ch**i:yé:tlh* /a̰ː.tṵː.tʃiː.ˈjeːtɬ/ ‘mint’

or the abrupt end of frication noise where applicable, and ending with the onset of broad spectrum energy in the release (burst or frication), or the onset of vowel phonation in cases where the release burst was not apparent. Closure intervals were labeled with the name of the following segment and <c> for closure (e.g. <tc> indicates the closure of an alveolar stop). Although all fricatives were most commonly produced without any preceding closure, some instances of prefrication silence were observed in fricatives of both airstream types. Frication intervals began with a burst, if present, or the onset of frication noise, and ended with the end of noise, as indicated by visible amplitude in the waveform, or the onset of modal vowel phonation, where present. Frication intervals were labeled according to the segmental category (e.g. <tʃ> for a post-alveolar affricate, or <ʃ'> for a post-alveolar ejective fricative). In many tokens, frication was followed by an interval of silence or near silence before the beginning of modal phonation in the following vowels, regardless of supposed airstream mechanism. Figures 3-5 illustrate sample annotations of the data.

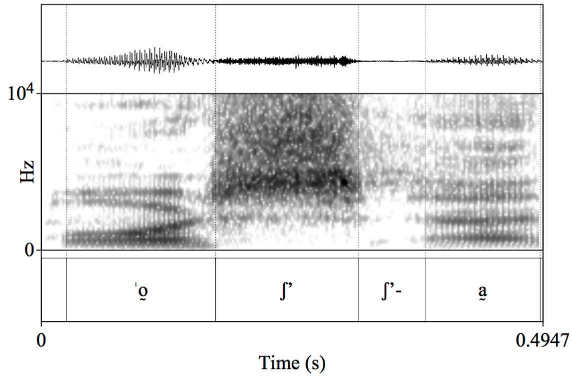

Figure 3: Post-frication silent interval in /ʃ'/. Detail from *cha:'hó'x'a'* /tʃa̰ːˈʔo̰ʃ'a̰/ 'tree bark'

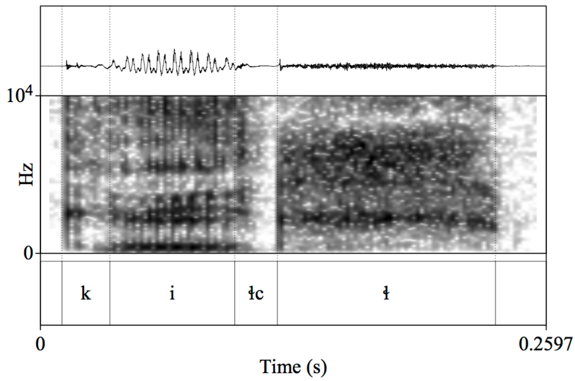

Figure 4: Pre-frication silence in /ɬ/. Detail from ***kilh**pa'nlhúlu'* /kiɬ-pa̰nɬulṵ/ 'jowly, with swollen cheeks'

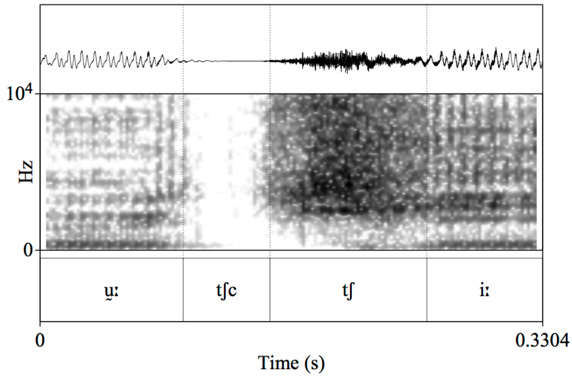

Figure 5: Pre-frication closure in a production of the affricate /tʃ/. Detail from *a:'tu:'chi:yé:klh* /a̰ːtuːtʃiːˈjeːkɬ/ 'mint'

3.3 Results

This section reports descriptive statistics on the duration of frication and of silent intervals, and total duration during the production of ejective and pulmonic fricatives in various contexts. Ejective fricatives have shorter frication duration than pulmonic fricatives before vowels, but similar frication duration compared to fricatives before pulmonic stops. Clusters have longer post-frication silent intervals than ejective fricatives, but this is found to vary by place of the stop closure. Overall duration varies according to condition, with ejective fricatives and cluster having the longest durations and affricates the shortest. Further details appear below.

3.3.1 Frication duration

Table 9 presents descriptive statistics for frication intervals only. Pulmonic fricatives were produced with the longest average frication duration, and affricates with the shortest. Average frication intervals of ejective fricatives and fricative + stop clusters were roughly equal. A pairwise comparison of least-squares means between all four conditions showed significant differences between all conditions ($p < 0.005$) except between ejectives and fricative + stop clusters (df = 148.17, $t = 1.457$, $p = 0.47$). Statistical analysis did not show any significant differences in frication duration based on place of articulation.[7]

[7] The statistical models on which these results are based are provided in the Appendix to this chapter. See Puderbaugh (2019a) for further information on the statistical models and detailed results.

Table 9: Frication duration in four phone types

	Mean	Median	SD	SE	*N*
affricate /t͡s, t͡ʃ/	87	79	55	4.44	151
pulmonic /s, ʃ, ɬ/	161	159	46	3.27	196
ejective /s’, ʃ’, ɬ’/	135	130	34	1.38	615
cluster (fricative + stop) /sp, st, sk, ʃp, ʃt, ʃk, ɬp, ɬt, ɬk/	137	131	37	1.73	468

3.3.2 Duration of post-frication silence

Table 10 reports the duration of post-frication silent intervals across the four frication conditions. These results show that pulmonic fricatives and affricates have similar average post-frication lag times of 16 ms and 25 ms, while ejective fricatives and clusters more closely resemble each other with average lag durations of 88 ms and 123 ms. The difference in average duration in ejective fricatives and clusters is considered in more detail below.

As a follow up, items appearing in clusters (represented by the bottom row of Table 10) were further subdivided into sets according to the place of articulation of the stop. Table 11 and Figure 6 report the duration of silent intervals grouped by the place of stop closure. In both the figure and the table, ejective fricatives are referred to as having a “glottal” place of closure. The average closure duration was longest in bilabial closures, and shortest in glottal closures. Pairwise comparisons between these places of stop closure showed that durations differed significantly between the bilabial and glottal places (df $= 13.30$, $t = -4.482$, $p < 0.005$), and between alveolar and glottal places (df $= 6.19$, $t = -3.45$, $p < 0.05$). No other pairs differed significantly from one another.

Table 10: Duration in milliseconds of silent intervals following frication

	Mean	Median	SD	SE	*N*
affricate /t͡s, t͡ʃ/	16	15	5	1.15	22
pulmonic /s, ʃ, ɬ/	26	17	27	4.08	43
ejective /s’, ʃ’, ɬ’/	88	84	39	1.61	582
cluster (fricative + stop) /sp, st, sk, ʃp, ʃt, ʃk, ɬp, ɬt, ɬk/	124	118	42	1.96	460

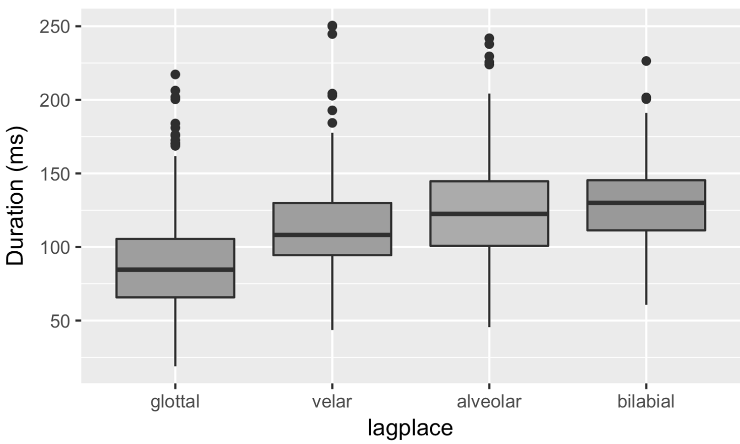

Figure 6: Duration in milliseconds of post-frication silence in clusters and ejective fricatives. The place represented here refers to the place of closure. For ejective fricatives, this is indicated as “glottal”

Table 11: Duration of post-frication silence at four places of closure in fricative + stop clusters, rounded to the nearest millisecond. Ejective fricatives are considered here as consisting of frication followed by a glottal stop closure

	Mean	Median	SD	SE	*N*
bilabial /p/	134	131	39	3.68	115
alveolar /t/	130	123	47	3.79	155
velar /k/	117	108	35	2.87	149
glottal /ʔ/	88	84	39	1.61	582

3.3.3 Total duration

Table 12 presents descriptive statistics of the total duration (from onset of frication to onset the following vowel) in four frication conditions (affricates, pulmonic fricatives, ejective fricatives, and fricative + stop clusters). Affricates were produced with the shortest average duration, and clusters with the longest. A pairwise comparison between least-squares means of all conditions revealed that all conditions differed significantly from each other ($p < 0.005$).

Table 12: Total duration in four segment types, including frication and flanking silences and rounded to the nearest millisecond

	Mean	Median	SD	SE	*N*
affricate /t͡s, t͡ʃ/	98	84	58	4.74	151
pulmonic /s, ʃ, ɬ/	179	164	73	5.24	196
ejective /s’, ʃ’, ɬ’/	218	210	60	2.41	615
cluster (fricative + stop) /sp, st, sk, ʃp, ʃt, ʃk, ɬp, ɬt, ɬk/	260	247	66	3.08	465

3.4 Summary

Table 13 provides a comparison of previously reported duration data and the results of the present study. In the present study, the results show that frication intervals in the ejective fricatives of Upper Necaxa Totonac fall within the range of observed durations in other languages: frication was shorter in ejective fricatives than in pre-vocalic pulmonic fricatives and longer than in affricates. Between clusters and ejective fricatives, frication duration was nearly identical. Post-frication silent intervals were substantially longer than reported in previous work and found to vary according to the place of stop closure. As a result of the long frication and long silent intervals, ejective fricatives were found to have greater total duration than pulmonic fricatives, a finding that is again out of line with previous findings in languages with confirmed ejective fricatives. In light of this variation, the post-frication silences in ejective fricatives could be interpreted as a continuation of a general trend of shorter duration at places of articulation further back in the vocal tract. Such an interpretation would support the analysis of these sequences as clusters of segments rather than monophonemic units.

Table 13: Summary of ejective fricative duration data, rounded to the nearest millisecond. Blanks indicate a lack of available data

	Frication	Silences	Total duration
Other languages	(Section 3.1)		
Pulmonic	106–222		106–223
Ejective	120–148	21–45	88–194
Upper Necaxa Totonac	(Beck 2006)		
Pulmonic	96	3	
Ejective	143	9	
Cluster	101		
Affricate			
Upper Necaxa Totonac	(Section 3.3)		
Pulmonic	159–161	17–26	164–179
Ejective	130–135	84–88	210–218
Cluster	131–137	118–124	247–260
Affricate	79–87	15–16	84–98

4 Ejective fricatives or glottal stop clusters?

The ejective fricatives of Upper Necaxa Totonac appear at first to be quite unusual, not only because of their supposed ejectivity but also because of the structure of the consonantal system they are a part of. In order to be *rare*, however, we must first determine that they are in fact what we claim them to be. The phonology of Upper Necaxa Totonac gives no immediate clues to the monophonemic status of ejective fricatives. The ejective fricatives in Upper Necaxa Totonac are far less common than the pulmonic fricatives across all places of articulation. They are limited only to onset position and are presumed not to resyllabify the way that fricative + stop clusters do. In their distributions, they seem at first to resemble affricates, which are similarly limited in where they may occur. However, unlike the affricates ejective fricatives appear to be quite rare even in their limited environments, posing challenges to their potential learnability. However, when we compare the ejective fricatives to fricative + glottal stop clusters, we see that they occur at frequencies similar to the other combinations, with the exception of alveolar clusters, which are all but nonexistent in the data. This finding of parallelism between the ejective fricatives and fricative + stop clusters is not surprising given the historical shift from *q in Proto-Totonacan to /ʔ/ in Upper Necaxa Totonac. The overall duration of the ejective fricatives also aligns well with an interpretation of them as clusters. Where previous studies of ejective fricatives in other languages have found that the overall duration of pulmonic and ejective fricatives are similar to one another, the ejective fricatives of Upper Necaxa Totonac are instead longer than their pulmonic counterparts in the present findings. The small differences in total duration that do appear seem to be related to the place of closure during stop production, rather than to a unique production mechanism during frication. These findings are substantively different from those reported by Beck (2006), who found instead that the pulmonic fricatives had frication periods shorter than any other reported language, as well as shorter than that of the ejective fricatives.

There are two options for analysis here: ejective fricatives are phonemically ejective, contrasting with pulmonic fricatives, or ejective fricatives are clusters among an established series of fricative + stop clusters. There are no clear-cut criteria for answering this question, despite proposals for possible ways of distinguishing these categories extending back into the early 20th century (Trubetzkoy 1939, Pike 1947, Stark 1947, Uchihara 2021). According to Trubetzkoy's criteria, in order to postulate a unit phoneme, (i) sequences may not break over a syllable boundary; (ii) complex articulations must be homorganic; (iii) the combined duration may not exceed that of other phonemes in the same language; (iv) sequences may appear in positions where clusters are not allowed; (v) the analysis of complex sounds must lead to symmetry in the phonemic inventory; (vi) the constituent parts of the sequence may not be interpreted as allophones of other phonemes.

The ejective fricatives of Upper Necaxa Totonac do not break over syllable boundaries, but their component articulations are not homorganic. The overall duration of the ejective fricatives is longer than that of any other unit phonemes, and similar to that of clusters. The ejectives appear in precisely the same locations as clusters, particularly if we consider the /ʔ/ + fricative coda clusters to be the mirror image of ejective fricatives. The inclusion of ejective fricatives in the Upper Necaxa Totonac sound inventory introduces an odd asymmetry by requiring a production mechanism that is not used for any more common purpose in the sound system. It is furthermore possible that only one (alveolar) of the three purported places of articulation is currently developing toward a coalescence of its component parts, which would lead to further asymmetry. Neither the fricatives nor the glottal constriction are unique to the ejective fricatives. Thus, on most of these criteria, the ejective fricatives do not seem to be instances of complex segments, but rather clusters.

Another potential set of criteria for determining whether sequences should be interpreted as units or clusters is provided by Pike (1947). In addition to tautosyllabicity, which has already been addressed above, Pike posits two criteria: (i) parallel patterns in straightforward sequences can be held as evidence for those that are in question; (ii) sequences that are paralleled by the reverse of the same segments ought to be interpreted as clusters. The data and analysis in Section 2.1 have shown that the ejective fricatives are paralleled by many straightforward sequences of fricatives in combination with various other stops. The data also show that the ejective fricatives are mirrored by sequences of /ʔ/ + fricatives sequences in coda position. Thus, besides appearing tautosyllabically, which is in fact an empirical question that has not been thoroughly addressed, the ejective fricatives of Upper Necaxa Totonac also fail to meet most of Pike's criteria for complex segments.

We can compare the above considerations to a similar scenario relating to the affricates /t͡s, t͡ʃ/. These segments do not break over a syllable boundary. In fact, clusters of /t/ and /s/ or /ʃ/ do not even occur in environments that might potentially lead to ambiguity on this point. Both /t͡s, t͡ʃ/ are homorganic articulations. The overall duration of these complex units is shorter than any fricatives or clusters. They do appear where other clusters are not allowed in that stop + fricative sequences are limited to coda position, while the affricates appear only in onset position. Their inclusion in the sound inventory does not introduce any asymmetry. Their constituent parts do appear as allophones of other phonemes. Furthermore, the affricate sequences are not paralleled by similar combinations of stops followed by frication. While they are not paralleled by their reverse sequence in coda position, /st/ and /ʃt/ do appear in syllable onsets. Thus, the affricate phonemes of Upper Necaxa Totonac satisfy five of Trubetzkoy's six criteria, and largely also conform for to Pike's two criteria. On balance, the affricates appear to be well analyzed as monophonemic rather than clusters, unlike the ejective fricatives.

5 Conclusion

The data and analyses above have shown that there are many reasons to believe that the ejective fricatives of Upper Necaxa Totonac are in fact fricative + glottal stop clusters. The data show that they more closely resemble clusters than other complex segments in the language, and they fail to meet most classical criteria for determining complex segmenthood. They furthermore fail tests of learnability with modern computational methods, and their acoustic durations also suggest that they are in fact clusters. Interestingly, although the data indicates that they are not ejective, fricative + glottal stop clusters are themselves rather rare and therefore of potential interest for phonological typology.

The current puzzle is an example of a common problem in phonological typology: the source and veracity of available documentation. The set of implicit criteria used for determining segmenthood in descriptive and documentary contexts is not at all well delimited. However, it is crucial to the identification of any phonological universals or rarities that we establish transparent and thorough methods for relating the two fields. Both phonetic and phonological evidence need to be taken into account when determining the identity of particular sounds used in language. The identification of ejective fricatives in Upper Necaxa Totonac was based primarily on the impressions of an individual linguist that were integrated into the *Upper Necaxa Totonac Dictionary* (Beck 2011). When considering the phonological typology, we must ensure that we are talking about well-established phonological entities with clear evidence behind them. If the ejective fricatives are monophonemic, the sound system of Upper Necaxa Totonac is a typological oddity. On the other hand, if they are clusters, the synchronic phonology of Upper Necaxa Totonac becomes much simpler, with clear and common historical changes leading to its present configuration. This second scenario aligns with the phonetic data presented here. It is furthermore in line with the general phonotactic patterns of the language, which allow for fricative + stop clusters in every environment where ejective fricatives also occur. Interpreting the ejective fricatives as clusters would therefore simplify the segmental inventory of Upper Necaxa Totonac and eliminate the need to explicate the rarity. Because databases that are used to investigate phonological typology and phonological universals tend to include information relating only to individual segmental contrasts, it is difficult to say whether clusters of fricatives and glottal stops constitute phonological rarities themselves. In the absence of either phonetic or phonological evidence for a unique segmental contrast, perhaps it is best to consider the alternative analytical solutions which will make it not so rare after all.

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Appendix

This section presents summaries of the models used in the statistical analysis of Section 3.1. The models were built separately for each dependent variable. In each model, the fitting procedure began with random intercepts specified for Word and Speaker to account for inherent differences between speakers and lexical items. The fixed effects structure included two-way interactions between all pairings of the independent variables (reference levels in italics): condition (*ejective*, cluster, pulmonic, or affricate), word position (*initial* or medial), place of articulation (*alveolar*, post-alveolar, or lateral), stress (of the following vowel; *unstressed* or stressed), and vowel laryngealization (of the following vowel; *no* or yes). After model fitting and model criticism were complete, multiple comparisons of conditional means were performed using the *lsmeans* package (Lenth 2016). Further details can be found in Puderbaugh (2019a).

Table 14: Summary of linear mixed effects regression model of frication duration (N = 1,430)

coef	Est.	SE	df	t	Pr(> |t|)
(Intercept)	4.9672	0.0740	4.9433	67.0861	0.0000 ***
conditioncluster	−0.0152	0.0437	136.3694	−0.3481	0.7283
conditionpulmonic	0.0562	0.0522	225.2882	1.0752	0.2835
conditionaffricate	−0.5560	0.0560	262.1392	−9.9350	0.0000 ***
v2laryngealyes	−0.0941	0.0410	24.1915	−2.2921	0.0309 *
v2stressstressed	0.1582	0.0367	146.3012	4.3149	0.0000 ***
wordposmedial	−0.1269	0.0552	7.2171	−2.3005	0.0539 *
placepostalveolar	−0.1026	0.0311	240.4922	−3.3037	0.0011 **
placelateral	−0.0749	0.0335	211.5120	−2.2353	0.0264 *
conditioncluster:v2laryngealyes	0.0428	0.0390	490.2559	1.0990	0.2723
conditionpulmonic:v2laryngealyes	0.1516	0.0534	438.6484	2.8383	0.0047 **
conditionaffricate:v2laryngealyes	−0.0458	0.0567	654.4760	−0.8077	0.4196
conditioncluster:v2stressstressed	−0.0631	0.0503	244.9984	−1.2543	0.2109
conditionpulmonic:v2stressstressed	−0.0009	0.0741	154.8787	−0.0117	0.9907
conditionaffricate:v2stressstressed	−0.2871	0.0677	452.4925	−4.2419	0.0000 ***
conditioncluster:wordposmedial	−0.0239	0.0502	166.8000	−0.4748	0.6356
conditionpulmonic:wordposmedial	0.0603	0.0616	177.9500	0.9792	0.3288
conditionaffricate:wordposmedial	0.4576	0.0713	311.3013	6.4141	0.0000 ***
v2laryngealyes:placepostalveolar	0.1852	0.0412	411.2193	4.4943	0.0000 ***
v2laryngealyes:placelateral	0.1139	0.0458	473.6831	2.4881	0.0132 *

Table 15: Summary of linear mixed effects regression model of lag duration including all four conditions (N = 1,107)

coef	Est.	SE	df	t	Pr(> |t|)
(Intercept)	4.5332	0.0878	10.9339	51.6322	0.0000 ***
conditioncluster	0.3402	0.0805	6.5995	4.2252	0.0045 **
conditionpulmonic	−1.2863	0.2167	3.8357	−5.9356	0.0046 **
conditionaffricate	−1.5736	0.1443	3.9165	−10.9087	0.0004 ***
fricationplacepostalveolar	−0.1036	0.0738	163.9262	−1.4037	0.1623
fricationplacelateral	0.0935	0.0827	106.3854	1.1303	0.2609
wordposmedial	−0.3994	0.0846	69.9077	−4.7204	0.0000 ***
v2stressstressed	−0.0400	0.0998	13.7680	−0.4012	0.6944
v2laryngealyes	−0.0843	0.0351	402.9234	−2.4028	0.0167 *
fricationplacepostalveolar:wordposmedial	0.3375	0.1100	138.0113	3.0697	0.0026 **
fricationplacelateral:wordposmedial	0.1877	0.1162	128.6923	1.6151	0.1087
fricationplacepostalveolar:v2stressstressed	−0.2256	0.1077	273.3722	−2.0947	0.0371 *
fricationplacelateral:v2stressstressed	−0.1326	0.1052	227.2147	−1.2605	0.2088
wordposmedial:v2stressstressed	0.3929	0.1014	209.4187	3.8760	0.0001 ***

Table 16: Summary of linear mixed effects regression model of total duration from onset of frication to onset of following vowel (N = 1,427)

coef	Est.	SE	df	t	Pr(> $\|t\|$)
(Intercept)	5.4677	0.0702	6.8185	77.8802	0.0000 ***
conditioncluster	0.1438	0.0517	120.4509	2.7797	0.0063 **
conditionpulmonic	−0.3024	0.0598	217.4712	−5.0608	0.0000 ***
conditionaffricate	−0.7603	0.0632	245.0148	−12.0260	0.0000 ***
v2laryngealyes	−0.1254	0.0381	527.3923	−3.2951	0.0010 **
v2stressstressed	0.1994	0.0430	136.0534	4.6328	0.0000 ***
wordposmedial	−0.1259	0.0627	8.4812	−2.0085	0.0774
placepostalveolar	−0.1460	0.0407	28.0098	−3.5879	0.0013 **
placelateral	−0.0847	0.0395	113.6976	−2.1435	0.0342 *
conditioncluster:v2laryngealyes	0.0882	0.0429	578.6095	2.0535	0.0405 *
conditionpulmonic:v2laryngealyes	0.2035	0.0591	492.7427	3.4456	0.0006 ***
conditionaffricate:v2laryngealyes	−0.1106	0.0612	742.6632	−1.8074	0.0711
conditioncluster:v2stressstressed	−0.1453	0.0575	230.5044	−2.5291	0.0121 *
conditionpulmonic:v2stressstressed	−0.1921	0.0870	143.5211	−2.2082	0.0288 *
conditionaffricate:v2stressstressed	−0.4729	0.0743	403.3724	−6.3671	0.0000 ***
conditioncluster:wordposmedial	0.0017	0.0592	148.7945	0.0287	0.9771
conditionpulmonic:wordposmedial	−0.0507	0.0718	164.9282	−0.7063	0.4810
conditionaffricate:wordposmedial	0.1060	0.0801	274.9668	1.3234	0.1868
v2laryngealyes:placepostalveolar	0.1854	0.0455	474.7367	4.0715	0.0001 ***
v2laryngealyes:placelateral	0.1066	0.0502	565.1744	2.1219	0.0343 *

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Part VI

Preaspiration

Chapter 16

On the rarity of pre-aspirated consonants

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This chapter presents a typological overview of pre-aspiration, a phenomenon frequently described as rare or very rare in the languages of the world. Three main questions are discussed: (i) How is pre-aspiration defined? (ii) Is pre-aspiration so rare? (iii) Why should(n't) pre-aspiration be rare? I conclude that pre-aspiration is indeed rare, even if broader definitions of the phenomenon are adopted. The chapter provides a discussion of the challenges that surround the task of quantifying pre-aspiration.

The most fundamental challenge resides in a considerable amount of variation which exists in how pre-aspiration is defined. In addition, the chapter raises issues with how the phonological status of pre-aspiration tends to be determined and argues that pre-aspiration seems to have the reputation of being rare due to specific approaches to contrastiveness.

It is further suggested that even cases where pre-aspiration may not be phonologically relevant are useful for our understanding of the typology of the phenomenon and for phonetic typology.

The chapter concludes with a list of specific research questions which need to be addressed so that we can better understand the typology of pre-aspiration.

1 What is pre-aspiration?

1.1 Defining pre-aspiration

In his seminal work, Silverman (2003) provides a cross-linguistic overview of the phenomenon referred to as pre-aspiration, which has been claimed to be rare,

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very rare, or extremely rare (e.g. Bladon 1986: 2, 7, Jones & Llamas 2003, Nance & Stuart-Smith 2013: 147, Roos 1998, Silverman 2003, Stevens & Hajek 2007). As Ní Chasaide states as well, "[i]t would appear to be comparatively rare and exotic, and is typically given only a cursory mention in phonetics textbooks" (1985a: 34). This chapter reviews the research done on pre-aspiration since Silverman's (2003) article. It addresses the following research questions:

- RQ1: How is pre-aspiration defined?
- RQ2: Is pre-aspiration rare?
- RQ3: Why should(n't) pre-aspiration be rare?

Pre-aspiration is a phenomenon that has been defined in a number of ways. As a starting point, it will be defined here as a period of glottal friction, transcribed as [h], which is found in sequences of vocalic and consonantal sonorants, and phonetically voiceless obstruents,[1] and which is often seen as preceding the obstruent. More specifically, pre-aspiration is found in the transition from the sonorant to the obstruent, as in Welsh English *bat* [ba^{h}t^{s}]. Articulatorily, pre-aspiration involves laryngeal abduction (Löfqvist & Yoshioka 1981, Ní Chasaide 1985a: 149–158), often discussed in terms of spread glottis (e.g. Kingston 1990). Crucially, this glottal abduction is timed so that it precedes the closure gesture of a plosive or an affricate and the oral release gesture of a fricative (as in Welsh English *mass* [ma^{h}s]). Acoustically, pre-aspiration has been (generally) defined as a period of glottal friction manifesting itself through low-amplitude acoustic energy spread relatively evenly across a range of frequencies. The criteria of identification of the phenomenon in the acoustic signal will vary depending on the obstruent consonant involved. An example involving a plosive is found in Figure 1. We can observe a gradual increase of noisiness in the signal, marked as "breathiness" and "pre-aspiration" in the annotation. Pre-aspiration follows a more modal (and less breathy) segment and precedes the closure of the plosive. The same would be found if the consonant was an affricate. In the case of fricatives, the spectral properties of pre-aspiration tend to be different from those of fricatives with oral constriction; namely, most fricatives differ from [h] in that they are less likely to show a relatively equal distribution of energy across a range of frequencies (see Hejná 2016c).

[1]One of the reviewers asks if voiced obstruents can ever be pre-aspirated, and if not, then why not. A pre-aspirated voiced obstruent would have to show an increase of breathiness, i.e. voiced pre-aspiration, but crucially this glottal abduction could never become voiceless. If it did, the

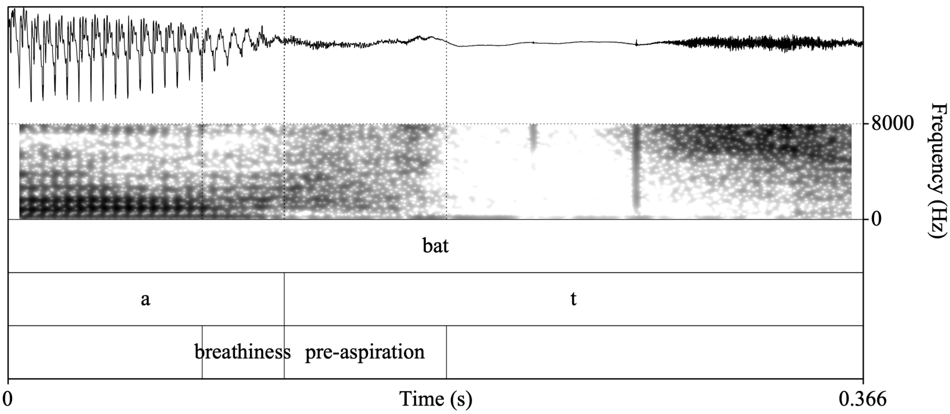

Figure 1: Example of pre-aspiration in the word *bat*, as produced by a speaker of Welsh English, using acoustic data

As is discussed in more detail in Section 2.7, pre-aspiration frequently manifests itself by a gradual increase of breathiness, which can ultimately lead to the loss of voicing and result in voiceless pre-aspiration. This onset of glottal friction has been measured through Voice Offset Time, or VOffT, by some researchers (e.g. Pind 1998), as a measure analogous to Voice Onset Time (VOT) used to analyse the duration of post-aspiration.

Importantly, the literature on pre-aspiration in the languages of the world quickly reveals differences across the definitions of the phenomenon, and formulating an inclusive definition may become a rather cumbersome task as a result. These differences are linked to four factors:

(i) the nature of the sequences in which pre-aspiration occurs: more specifically, the manner of articulation of both the preceding and the following segments;

(ii) the presence of voicing: whether only voiceless frication should be considered pre-aspiration;

(iii) the source of frication in pre-aspiration: whether it is purely glottal, or oral, or both;

obstruent would not be voiced anymore. I have in fact seen some plosives with phonetic voicing during their closure and a period of slack voice prior to the closure. However, see Steriade (1994: 230–234), Kehrein (2002: 211), and Section 2.6.

(iv) the status of pre-aspiration as a segment or a sub/suprasegment: whether it forms a part of a consonantal cluster hC rather than being part of a single consonantal phoneme.

In order to explore the three research questions formulated above, several contentious issues surrounding the phenomenon need to be (re)visited. Section 2 opens with a discussion of what has been seen as pre-aspiration phenomena (Silverman 2003), including "true" or "genuine" pre-aspiration (or pre-aspiration proper), sonorant devoicing, pre-affrication, vowel devoicing, sequences of [h] and consonants, /s/ debuccalisation, breathy sonorants, and other related phenomena. As will be shown, different approaches to the definition of pre-aspiration have various consequences for our understanding of the typological behaviour and the frequency of the phenomenon, as also mentioned by Clayton (2010: 32) and Iosad (2025 [this volume]). The second contentious issue, introduced in Section 3, is linked to the phonological status of pre-aspiration. Should typologists consider languages as having pre-aspiration only if pre-aspiration is contrastive? How is contrastiveness established? Is contrastiveness the only diagnostic of the phonological status of a phenomenon? And is it the case that pre-aspiration is rarely contrastive?

Next, the discussion moves to the proposals suggested to explain why pre-aspiration is very rare. The predominant proposal in earlier work is linked to the so-called Perceptual Inferiority Hypothesis (Silverman 2003, Clayton 2010), according to which pre-aspiration is rare because it is difficult to hear. A review of the extremely limited literature available in this area (Section 4.1) does not support this hypothesis. However, historical and structural reasons for whether we should expect pre-aspiration to be rare are discussed in Section 4.2. Finally, practical challenges related, for instance, to the quality of the acoustic signal in the data the researcher may work with are introduced in Section 4.3.

The conclusion reached in this chapter is that pre-aspiration is rare, but not as rare as suspected, and not necessarily for the reasons put forward in the literature. Most importantly, however, I conclude that very little is known about the phenomenon – possibly too little for us to be able to assess how common pre-aspiration is in the languages of the world. This being the case, the chapter ends with a list of research questions that need to be addressed in future research on pre-aspiration.

Before diving into these issues, however, Section 1.2 provides an overview of languages reported to have pre-aspiration of some type.

1.2 Which languages have pre-aspiration?

With the caveat that different researchers can adopt rather different definitions of the phenomenon, my conclusions are that pre-aspiration has been reported in (at least) 19 languages families and (at least) approximately 84 languages. The 19 language families can be found across the globe, including Afro-Asiatic, Algic, Arawakan, Austronesian, Indo-European, Mongolic-Khitan, Nakh-Dagestanian, Otomanguean, Sino-Tibetan, Siouan, Tarascan, Tucanoan, Tungusic, Turkic, Uralic, Uto-Aztecan, Bora(n)/Witotoan, and Yuchi; and the Urarina isolate. The appendix to this chapter provides a list of these pre-aspirating languages by language family (Tables 1–19). Needless to say, estimating the exact number of languages reported to have pre-aspiration is rendered challenging by the fact that distinguishing languages and dialects is not straightforward. Furthermore, the definition of pre-aspiration provided in the previous section generally covers pre-aspiration which might be considered prototypical. This prototypical pre-aspiration has been referred to with the following terms: genuine pre-aspiration (Silverman 2003), prototypical pre-aspiration (Clayton 2010: 86), pre-aspiration proper (e.g. Helgason 2002, 2003), and true pre-aspiration (e.g. Torres & Kasak 2019: 132, Helgason 2002: 24, Koreman et al. 2008: 25). However, the term "pre-aspiration" has also been used for other phonetic and phonological phenomena, as will be shown in the next section. This necessarily impacts the estimated number of pre-aspirating languages.

2 The pre-aspiration collective

A definition of a linguistic phenomenon necessarily affects our estimates regarding how frequently it is found in the languages of the world. As Silverman (2003: 576) states, "[w]hile primary sources sometimes acknowledge that "pre-aspiration" is indeed a cover term for a variety of phonetic configurations, the secondary literature is typically remiss in carefully documenting this variability". A range of phenomena have been referred to as pre-aspiration by different researchers:

- pre-aspiration (also "true" or "genuine" pre-aspiration, pre-aspiration "proper");
- pre-affrication (or pre-spirantisation);
- sonorant devoicing;

- /s/ debuccalisation;
- /hC/ clusters;
- vowel devoicing (or vowel aspiration);
- glottalisation/laryngealisation.

To what extent does this menagerie of pre-aspiration consist of phenomena that may perhaps not be cases of pre-aspiration? Each phenomenon is considered briefly in the remainder of this section, focusing on why these may and have been considered pre-aspiration by some but not by others. For reasons of space, the aim is to focus on the overall overview rather than go into language-specific (and often complex) debates.

2.1 Pre-affrication and pre-spirantisation

Silverman's (2003: 529) overview of pre-aspirating languages brings our attention to the fact that most pre-aspirating languages do not necessarily involve glottal friction in the phonetic implementation of pre-aspiration. Instead, they employ oral friction, or what Silverman refers to as pre-spirantisation. Thus, Chamicuro (Arawakan) is reported to have glottal friction while Goajiro (Arawakan) is reported to have oral friction as the phonetic realisation of pre-aspiration.

Indeed, Silverman points out that this oral realisation of the phenomenon seems to be so common that pre-aspiration realised as *glottal* friction is actually even rarer (2003: 575). To reason why pre-aspiration is cross-linguistically realised with oral and not (just) glottal friction has been linked to perception. Silverman (2003: 575) notes that glottally realised pre-aspiration can develop into orally realised "pre-aspiration" in order to become perceptually more salient (see also Blevins 2004: 111–112, Kehrein 2002: 1, 4, 57–58, 213). It is challenging to assess just how frequent oral variants of pre-aspiration are cross-linguistically; however, Clayton (2010: 117) proposes that this is "probably quite a widespread phenomenon". There is also an articulatory link between the two. Esling et al. (2019: 124) point out that the amount of airflow passing through the larynx in the production of pre-aspiration can be manipulated in order to increase the turbulence and the perceived noisiness of the phenomenon. Thus, there is variation in the noisiness levels of pre-aspiration not only when contrasting oral and glottal realisations, but also at the level of the larynx as a whole, and no doubt within oral realisations as well.

Variation is found not only across languages and speakers but within individual speakers as well. I would like to show an example from my own (Welsh English) data, in which friction with rather different spectral profiles can be found. Examples like those shown in Figures 2 and 3 are very common in my corpus.

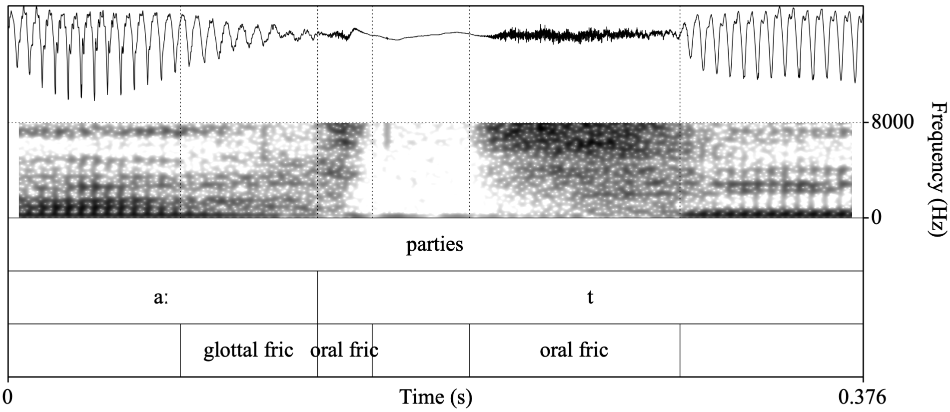

Figure 2: Example of pre-aspiration in the word *parties*, as produced by a speaker of Welsh English, using acoustic data. Abbreviations: “glottal fric” = glottal friction; “oral fric” = oral friction

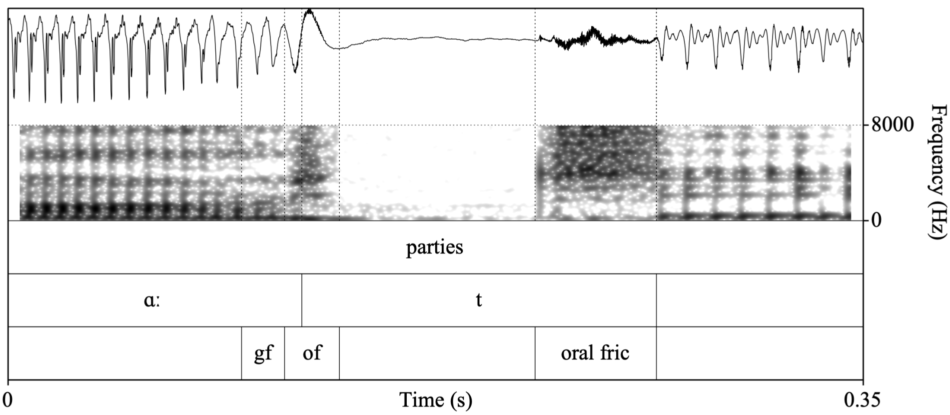

Figure 3: Example of pre-aspiration in the word *parties*, as produced by a speaker of Welsh English, using acoustic data. Abbreviations: “gf” = glottal friction; “of” and “oral fric” = oral friction

The annotations in Figures 2–3 show acoustic events that could be labelled “glottal friction” and “oral friction”, to employ the two categories highlighted by

Silverman (2003). While glottal friction usually displays a fairly even distribution of lower-intensity energies across a range of frequencies, oral friction tends to be concentrated at specific frequencies which depend on the quality of the sound in question (e.g. Fry 1982). In the absence of articulatory data, which most phoneticians working on pre-aspiration do not have at their disposal, instances such as those found in Figures 2–3 might be labelled as partially pre-spirantised or pre-affricated (for pre-affrication, see Laver 1994: 150–151). However, we need to bear in mind that higher-intensity energy in and of itself does not necessarily signal an oral source, and spectral properties should be carefully examined. One fact is nevertheless undoubtedly certain: pre-aspiration is realised with a range of phonetic variants, and a single token can display sequences of variably turbulent friction.

Pre-aspiration realised with primarily oral friction should be included in typological overviews of the phenomenon. Indeed, spectral properties of pre-aspiration (and those of post-aspiration) are a very important aspect to consider: Silverman (2003) argues that pre-aspiration is not a mirror image of post-aspiration because the latter lacks orally generated friction. However, work by Hejná (2015, 2016a) and Nance & Stuart-Smith (2013) suggests that post-aspiration is spectrally more varied as well. We should therefore adopt more varied approaches towards acoustic analyses of post-aspiration and pre-aspiration which would go beyond our use of Voice Onset Time[2] and Voice Offset Time, respectively, as the sole or predominant analytical tools.

2.2 Sonorant devoicing

Another phenomenon very closely linked to aspiration in general is sonorant devoicing, as in, for instance, pre-plosive sonorant devoicing in Welsh English *milky* [mɪl̥kʰɪ]; and post-plosive sonorant devoicing in *train* [tɹ̥eɪn]). The term "sonorant devoicing" refers to the devoicing of consonantal sonorants. Several pre-aspirating languages have been noted to show sonorant devoicing as well (e.g. Faroese, Icelandic, Lule Sámi, Swedish, cf. Ladefoged & Maddieson 1996: 70, Helgason 2002: 11). Various researchers have treated sonorant devoicing as a manifestation of pre-aspiration (e.g. Ladefoged & Maddieson 1996: 70, and other researchers mentioned in Helgason 2002: Section 2.2 in particular).

There is a good reason why pre-aspiration and sonorant devoicing should be considered together: they seem to be closely linked both from a synchronic and a diachronic point of view. Indeed, Ladefoged & Maddieson (1996: 70) discuss

[2] Maddieson (p.c. 2021) expressed similar sentiments to me with respect to (post-)aspiration in Thai and Navajo.

pre-aspiration in both VC (vowel-consonant) and NC (sonorant-consonant) sequences under the phenomenon of pre-aspiration. Hejná (2016b) proposes that pre-aspiration first innovates in the sequences of vowels and phonetically voiceless obstruents and then spreads to environments which include sonorant consonants as well. In this view, pre-aspiration and sonorant devoicing could be seen as phonotactically determined realisations of the same phenomenon.

Despite the fact that sonorant devoicing preceding voiceless obstruents has been considered part of a more general process of pre-aspiration, the terms "pre-aspiration" and "sonorant devoicing" or "sonorant voicelessness" have nevertheless been used for the two segmentally different contexts (pre-aspiration for vowels, sonorant devoicing for sonorant consonants). Researchers studying pre-aspiration thus need to be wary that the term "pre-aspiration" is primarily used in the literature for sequences including first of all vowels (but sometimes also sonorant consonants) and "sonorant devoicing" for sequences including sonorant consonants.

2.3 The question(s) of /hC/ clusters and debuccalisation of /s/

2.3.1 Pre-aspirated singletons vs /hC/ clusters

One of the thorniest aspects surrounding the typology of pre-aspiration pertains to the decisions whether a language does indeed have pre-aspirated consonants or clusters of /hC/ instead. More generally, Clayton (2010: 9, 33) treats instances of [h] before voiceless non-continuants (including plosives and affricates) as pre-aspiration, while cases with [h] which can occur in other consonantal contexts as forming a cluster. For Clayton (2010: 33), pre-aspiration is therefore a feature restricted to plosives and affricates. However, if a language shows [h] not only in the vicinity of voiceless plosives but also near other consonants, [h] in the vicinity of a voiceless plosive is not considered by him to be a case of a pre-aspirated plosive but rather a case of an /hC/ cluster. Clayton, therefore, does not include languages such as Chamicuro (Arawakan), Finnish (Uralic), Huatla Mazatec (Otomanguean), and Spanish (Indo-European) in the list of pre-aspirating languages, while some other researchers do (see Tables 1–19). Kehrein & Golston (2004) present a somewhat more radical approach to the issue at hand, namely, the Prosodic Account. In this framework, laryngeal specifications are delegated to the realm of prosody rather than (directly) that of segments. This has implications for the debates connected to languages where it is not clear whether pre-aspiration is part of a segment or indeed a consonantal segment in a cluster. More specifically, Kehrein & Golston (2004) and Kehrein (2002: 90, 98, 100, 117, 213) predict that these two options (/p^h/ vs /ph/) are never contrastive, which seems to be borne out by the data found in the languages of the world (also Steriade 1992: 79, 1994).

Such debates clearly have implications for which languages “make it” to the list of pre-aspirating languages. To provide some contested examples, Torres & Kasak (2019: 132) discuss Hidatsa (Siouan) and its “<hC> elements”, and conclude that these do not present pre-aspiration.[3] In addition, Helgason (2002: 25) mentions Comanche and Mono (Uto-Aztecan) as languages for which the pre-aspiration vs cluster debates are ongoing. The arguments put forward in individual studies are diverse and can require an in-depth understanding of the phonological system of the language in question, including its historical development. Van ’t Veer et al. (2025) present an apt example. The authors analyse pre-consonantal [h] in Ecuadorian Siona (Tukanoan) in order to shed light on whether the language has pre-aspiration or a /hC/ cluster. They conclude that the phenomenon is pre-aspiration, despite the synchronic co-occurrence of [h] not only with obstruents but also with /ɲ/. This is because the pre-nasal [h] is analysed as having a phonemic status and not as part of the pre-aspiration process operating in the language. This situation is accounted for through both diachronic and synchronic analyses.

2.3.2 Debuccalisation of /s/

Debuccalisation of /s/ plays an important role in typological discussions of pre-aspiration. As we will see, it is also very much linked to the debates on pre-aspirated singletons vs /hC/ clusters.

Debuccalisation includes a range of processes whereby an orally articulated segment becomes articulated primarily by the laryngeal articulator (Esling et al. 2019). Debuccalisation examples include such processes as [s] → [h] or, for instance, [t] → [ʔ]. Pulmonic sounds are not the only ones that can undergo debuccalisation (Fallon 1998). As Fallon (1998: 200) notes, debuccalisation is “a common process which recurs in many language families all over the world”. Debuccalisation of /s/ in the environment of voiceless plosives (e.g. [sk] → [hk] ~ [^{h}k]) is a contentious issue in the pre-aspiration literature. On the one hand, we find approaches such as those by Silverman (2003: 593), who very explicitly mentions “[s]-stop clusters” as a common historical source of pre-aspirated plosives. On the other hand, some approaches explicitly reject languages with debuccalisation as pre-aspirating. This is because such cases may be considered consonantal clusters rather than pre-aspirated singletons.

[3] I have not been able to identify clear reasons for this in their paper. This is because it seems to be assumed right from the beginning that “<h>” is a segment (and, therefore, not pre-aspiration).

The discussion of [s]-stop clusters giving rise to [h]C (i.e., pre-aspirated consonants, at least on the surface) nevertheless does frequently refer to the process of debuccalisation as a historical source of pre-aspiration. This includes much of the work on pre-aspiration in dialects of Spanish (e.g. see Chappell 2014, 2015, Cronenberg et al. 2020, Torreira 2007, and the references therein). Interestingly, pre-aspiration in Icelandic – one of the most well-known pre-aspirating languages – has also been interpreted by some as originating in the process of debuccalisation, albeit one which involves geminates (Fallon 1998: 36). Although these geminates nevertheless consist of geminated plosives, this example shows that debuccalisation cannot be avoided in typological discussions of pre-aspiration.

The take-home message of this section is that, for many languages, debates linked to the status of [h] as pre-aspiration are ongoing, and it is not clear what (synchronic and/or diachronic) criteria should be used to reach an answer that would leave everyone satisfied.

2.4 Vowel devoicing

> "The question now is how do consonantal aspiration and vowel devoicing relate to one another, if they do at all."
>
> (Windsor 2016: 67)

Vowel devoicing, or vowel aspiration, is another phenomenon which is sometimes referred to as pre-aspiration.[4] Some researchers have in fact defined pre-aspiration as involving vowel devoicing (e.g. Karlsson & Svantesson 2011: 121). In such cases, the two terms seem to be used either interchangeably or in a way such that pre-aspiration presents a specific type of vowel devoicing. Others nevertheless distinguish between the two (e.g. Stenzel 2004, Miller et al. 2005, Elias-Ulloa & Aramburú 2021, Liberman 1982: 90–117). The former approach is substantiated by the fact that most of the studies focusing on pre-aspiration report the phenomenon in the sequences of vowels and phonetically voiceless obstruents. A considerable amount of ink has been spilt over the questions surrounding the affiliation of pre-aspiration, i.e. whether pre-aspiration should be considered part of the consonant, of the vowel, of both, or of neither (e.g. Hejná 2015: 33–36, 65–66). Pre-aspiration does present us with a certain unavoidable indeterminacy, considering its traditional presence in the sequences of sonorants (vowels and sonorant consonants) and obstruents. The presence of pre-aspiration in exactly this segmental environment results in its phonetic realisation as typically reflecting a change from the voicing of a vowel or a sonorant consonant to the voiceless-

[4] See also Jensen (2000: 204) for a discussion of post-aspiration as a voiceless vowel.

ness of an obstruent. Looking back to Figure 1 above, we can see that the voiceless glottal friction labelled "pre-aspiration" (voiceless pre-aspiration) is preceded by local breathiness (voiced component of pre-aspiration). The role of local breathiness is discussed further below in Section 2.7. The local breathiness is important as it shows that in the sequences of vowels and phonetically voiceless obstruents, we typically see a transition from a more modal to a less modal vowel. The transition is caused by laryngeal abduction, which increases and ends up in voicelessness – voiceless aspiration, or indeed what most researchers would consider to be pre-aspiration.

However, "vowel devoicing" is a term familiar primarily from the literature focusing on languages such as Japanese and French (e.g. Tsuchida 2001, Smith 2003). There are two important similarities between what is normatively referred to as "pre-aspiration" and "vowel devoicing". Firstly, laryngeal abduction occurs in the context of a vowel. Secondly, the process of abduction, which can lead to partial and full devoicing (i.e. including voiceless friction), is conditioned primarily by voiceless segments.

There are nevertheless also some differences between "pre-aspiration" and "vowel devoicing". Firstly, pre-aspiration is more frequent and longer in duration with low vowels (cf. Hejná 2015: 107–108, Morris & Hejná 2020: 17, for overviews), while vowel devoicing is rather favoured by high vowels (Ohala 2011: 65). Secondly, pre-aspiration is not reported to emerge in the sequences of a pause plus a vowel (e.g. pause + *aloe*) and a vowel plus a pause (e.g. *Ha!* + pause, *uh* + pause), while vowel devoicing is (e.g. Smith 2003: 193, Tsuchida 2001). Indeed, the two main historical sources of vowel devoicing identified in the literature include, firstly, a typically short vowel surrounded by voiceless segments and, secondly, an occurrence of a vowel at a domain edge (e.g. Blevins 2004: 199, Kuznetsova 2015). Thirdly, although pre-aspiration has been reported to result in full devoicing of a vowel (Jatteau & Hejná 2016: 16), in my own experience with data from English dialects, Halh Mongolian, and Welsh, this seems to be extremely rare, occurring in two out of approximately 9,000 tokens. Those are the contexts where the vowel is surrounded by heavily aspirated obstruents. On the other hand, vowel devoicing is frequently reported to affect the entire vowel segment (Oberly & Kharlamov 2015: 1–2, Kuznetsova & Verkhodanova 2019). Fourthly, pre-aspiration is preferred in stressed environments (e.g. Hejná & Jespersen 2019: 241–242, see also van 't Veer et al. 2025 [this volume] and Craioveanu 2025 [this volume]), whereas vowel devoicing seems to be favoured in unstressed environments (see e.g. the discussion in Smith 2003).

These observations are not based on a comprehensive inspection of the literature. Instead, they are primarily meant to initiate a discussion for future research in order to tease apart instances of vowel devoicing and pre-aspiration (or indeed also different types of what could be considered vowel devoicing). However preliminary the observations above may be, they nevertheless indicate that pre-aspiration and vowel devoicing are rather two different phenomena. They may also be phonetically fairly similar but functionally different, and so the decision in each case would require an in-depth analysis of segmental and prosodic conditioning, and of whether a vowel is found to be fully devoiced or not (and how frequently). Unfortunately, not all sources that discuss pre-aspiration provide a sufficient amount of detail for this (see also Silverman 2003: 577).

This being the case, unless more research is conducted, we may not always be able to conclude whether we are dealing with vowel devoicing or pre-aspiration for the languages in the descriptions of which both terms have been used. A case in point is Udihe (Tungusic). According to Liberman (1982: 126, 300), Udihe – or what he refers to as Ude(ge) – is a language in which pre-aspiration can be found. However, this information is conveyed in form of a passing comment, and it is unclear where this information actually comes from. An in-depth analysis reveals that Udihe exhibits vowel devoicing (partial or full aspiration) rather than any kind of normatively defined consonantal pre-aspiration (Kuznetsova 2022). Oberly & Kharlamov (2015) provide another relevant case with their analysis of Southern Ute (Uto-Aztecan). Discussions surrounding pre-aspiration/vowel devoicing in Blackfoot (Algic) also present a very relevant example (Reis Silva 2008). Similarly, van 't Veer et al. (2025 [this volume]) touch upon pre-aspiration being discussed as vowel devoicing in Siona and Western Tukanoan languages. The need for more in-depth work in this area is also voiced by Stenzel (2004: 55).

2.5 Glottalisation/laryngealisation

Finally, to a limited extent, we find that some researchers use the terms "laryngealisation" and/or "glottalisation", and/or "pharyngealisation" to (potentially) discuss pre-aspiration. Hejná (2015: 149) provides an example of a relevant discussion which may be challenging to make sense of by the readers. In his discussion of "pseudo-støds and related phenomena" in Tuvan (Turkic), Ket (Yeniseian), and Ude(ge) (Tungusic), Liberman (1982: 126–127) equates the term "pre-aspiration" with "pharyngealisation" and what might also be glottalisation.[5]

[5] Kuznetsova (2022) mentions that the phenomenon in question in Tuvan and in a related language Tofa is usually referred to as "vowel pharygealisation", while her field data (Kuznetsova, p.c., 2022) rather shows vowel laryngealisation/glottalisation. Furthermore, I am informed that glottalisation shows no traces of breathiness there, and this is the case in Ket as well (see references in Kuznetsova 2022).

It may be challenging to discern from these descriptions whether the phenomenon in question is laryngeal friction produced by glottal abduction or not. For instance, Dwyer (2000: 427) refers to a "glottalised *h* stem" in some Turkic languages in a discussion of subsegmental pre-aspiration and pre-glottalisation. However, she provides transcriptions showing pre-aspiration, which may be somewhat confusing for the reader. In other work, we also find cases in which glottalisation or laryngealisation is mentioned – very explicitly and unambiguously – as a possible realisation of pre-aspiration. For example, Karlsson & Svantesson (2012: 4) report that "[p]re-aspiration often manifests itself as laryngealisation of the preceding vowel" in their data from selected Mongolic, Turkic, and Tungusic languages. Similarly, Stevens & Hajek (2007) mention pre-glottalisation as one of the possible realisations of pre-aspiration in their Sienese Italian data.

The reason why some confusion can be found in sources might be explained by the fact that pre-aspiration and pre-glottalisation can co-occur within the same token. Indeed, laryngeal abduction and laryngeal adduction are not necessarily mutually exclusive (Hejná 2023, Moisik et al. 2022), although they have been known to be contrastive in some languages, such as Udihe (Kuznetsova 2022), and are represented with the two different laryngeal features [spread glottis] and [constricted glottis] in various phonological frameworks. Hejná (2023) shows examples of simultaneous production of pre-aspiration and pre-glottalisation in Welsh English, which she interprets as local whispery and/or breathy creak. Karlsson & Svantesson (2011) further discuss intriguing examples of pre-aspiration inducing creakiness in present-day Mongolian dialects. Watson et al. (2025 [this volume]) in turn draw attention to the production of sonorants by a Mehri (Afro-Asiatic) speaker whose acoustic evidence shows the presence of glottalisation, while the electroglottographic evidence suggests the presence of glottal abduction. For a brief general discussion (with a focus on English data) of the relationship between pre-aspiration and (pre-)glottalisation in voiceless obstruent contexts from a diachronic and a synchronic perspective, see Hejná (2015: Ch. 5).

To provide an interim summary, all the phenomena discussed in this section (Sections 2.1-2.5) can be and have been treated as different from pre-aspiration and from one another. Nevertheless, they can very often be connected via a range of synchronic and diachronic links, depending on the language in question. As we have also seen, we do not always (as yet) have sufficiently in-depth data available in order to resolve questions of this type. In the remainder of this section (Sections 2.6-2.7), two final issues which are relevant to fundamental definitional aspects of pre-aspiration are discussed. Firstly, pre-aspiration is not found solely in the context of plosives (or stops), as discussed in Section 2.6. Secondly, different approaches to how pre-aspiration is quantified follow from how the phenomenon is defined, even in cases where the definition would fall within what has been labelled as “true pre-aspiration” above (Section 2.7).

2.6 It’s not just plosives

2.6.1 Pre-aspirated obstruents

Two of the major works on the typology of pre-aspiration target pre-aspirated plosives rather than pre-aspirated obstruents (Silverman 2003, Clayton 2010). At least three other PhD theses have been dedicated to pre-aspiration, and these too show a strong focus on pre-aspirated oral plosives. Ní Chasaide’s (1985a) work specifically analyses Icelandic, Irish, and Scottish Gaelic through a range of in-depth acoustic, articulatory, and perceptual analyses of plosives. Helgason (2002) discusses the history of pre-aspiration in Scandinavian languages. Helgason primarily relies on acoustic and perceptual analyses of pre-aspirated plosives, but includes a discussion of pre-aspirated fricatives as well. Hejná (2015) offers detailed acoustic analyses of Aberystwyth English (i.e., Welsh English) pre-aspiration. This work, too, is primarily concerned with plosives, with pre-aspirated fricatives discussed noticeably less so. Does the inclusion of fricatives (and affricates) change our understanding of how frequent pre-aspiration might be in the languages of the world?

To the best of my knowledge, pre-aspirated fricatives have been reported in English (Indo-European; Hejná et al. 2021), Swedish (Indo-European; Helgason 2002: 89), Western Yugur (Turkic; Roos 1998: 30), and – depending on the analysis – also in Blackfoot (Algonquian; Windsor 2016: 75), Chamicuro (Arawakan; Silverman 2003[6]), Forest Nenets (Uralic; Salminen 2007), Kickapoo and Menominee (Algic; Gathercole 1983), Salar and Kälpin Uyghur (Turkic; Dwyer 2000: 427), and Shetland Norn (Indo-European; Knooihuizen 2013). Helgason (2002: 89) actually concludes that “preaspiration is not a particular feature of stops, but a general characteristic in production of voiceless consonants”, which is also supported by Clayton (2010: 9).

Importantly, however, all of these languages have pre-aspirated plosives as well. It therefore seems that the presence of pre-aspirated fricatives implies the presence of pre-aspirated plosives, but the presence of pre-aspirated plosives does not imply the presence of pre-aspirated fricatives. This corresponds to what we observe for post-aspiration, which is more common with plosives than with

[6]Clayton (2010: 61) rejects the analysis of the phenomenon as pre-aspiration in Chamicuro, as also mentioned in Section 2.3 and Section 2.6.2.

fricatives (e.g. Jacques 2011, and the references therein). Scottish Gaelic (Indo-European) has been explicitly commented on as lacking pre-aspiration in fricatives (e.g. Clayton 2010: 17), as has Urarina (isolate; Elias-Ulloa & Aramburú 2021: 140). Halh Mongolian is another example of a language which has pre-aspirated plosives but not fricatives (Jatteau & Hejná 2018).

The absence of pre-aspiration in fricatives is, however, not necessarily commented on explicitly in work on pre-aspirating languages. This challenge has been more generally noted by Silverman (2003: 577), and also by Clayton (2010: 17): "Holmer [1949] provides no indication that voiceless fricatives are also pre-aspirated in Goajiro, which would be telling, but neither does he rule it out". Generally, it is challenging to know whether absence of an explicit comment on pre-aspiration in the fricative context means that pre-aspiration is not found in this context in the language in question, or if the authors did not look for it.

Scottish Standard English (Gordeeva & Scobbie 2013) might present an apparent contradiction to the general observation that a language with pre-aspirated fricatives also has pre-aspirated plosives. Gordeeva & Scobbie (2013: 262) report pre-aspirated fricatives but not pre-aspirated plosives in their data: the plosives are reported to be pre-glottalised.[7]. The same pattern (V$^{\text{h}}$F but V$^{\text{ʔ}}$P, as in *mass* [ma$^{\text{h}}$s] and *mat* [ma$^{\text{ʔ}}$t]) has been found also elsewhere (cf. Hejná & Scanlon 2015 on Manchester English). However, it seems to be limited to word-final obstruents (e.g. *mush*, *mutt*) rather than, for instance, word-medial obstruents (e.g. *mushy*, *mutter*). In the latter, pre-aspiration can be found. Word-medial tokens were not included in the Scottish Standard English analysis by Gordeeva & Scobbie (2013), and we therefore cannot conclude whether Scottish Standard English might be a counterexample to what seems to be a robust tendency.

Having analysed 18 Aberystwyth English speakers with varying degrees of pre-aspiration and pre-glottalisation in their fortis obstruent production, Hejná (2015: 183) suggests that pre-aspiration might develop in post-aspirated plosives first, and spread to fricatives only afterwards. If this proposal is on the right track, the presence of pre-aspiration in fricatives should not affect our current general picture (predominantly based on the distribution of pre-aspirated plosives) of how frequent pre-aspiration is in the languages of the world.

2.6.2 Pre-aspirated sonorants

Finally, we should mention the question of pre-aspirated sonorants. The discussion of whether sonorants can be pre-aspirated is one of the more contentious

[7]For a brief discussion of glottalisation blocking pre-aspiration, see Hejná & Kimper (2019: 204), Hejná (2021), and Hejná et al. (2021: 216–217)

areas of the pre-aspiration research, although the issue is not necessarily generally voiced by researchers (or indeed seen as such). To take just a few examples, on the one hand, Watson et al. (2025 [this volume]) report the presence of pre-aspirated sonorants in Śḥerɛt (Afro-Asiatic). Willis (2007) discusses pre-aspirated trills in Cibaeño Dominican Spanish (Indo-European). Suzuki (2011) shows word-initial pre-aspirated plosives (including voiced ones), affricates (including voiced ones), fricatives, nasals, and approximants in Amdo Tibetan, Khams Tibetan, and Shar Tibetan (Sino-Tibetan).[8] Elias-Ulloa & Aramburú (2021) present analyses of pre-aspirated plosives and /l/ ([^{ɦ}l]) in Urarina (isolate). On the other hand, some definitions of pre-aspiration preclude sonorant consonants from the possibility of being pre-aspirated, including those I have presented in my own work so far (e.g. Hejná 2021, Hejná et al. 2021). As mentioned above, there is certainly a degree of received wisdom according to which one should expect pre-aspiration only or primarily in the plosive context (e.g. Willis 2007: 34).[9] Some definitions explicitly limit the phenomenon to oral plosives (Ladefoged & Maddieson 1996: 70, Laver 1994: 150). Ladefoged & Maddieson (1996: 70) discuss other consonants involving laryngeal abduction, but not in terms of pre-aspiration. As mentioned in Section 2.3, Clayton (2010: 61) also rejects analyses of pre-aspiration in Chamicuro on the grounds that glottal friction occurs not only with obstruents but also with nasals, laterals, and glides in the language. This is given as an argument that the phenomenon in question presents a cluster of /h/ with another consonant in Chamicuro.

What these cases have in common is that phonetically a part of a sonorant shows breathiness or glottal abduction. Clayton (2010) proposes three major environments where pre-aspiration in plosives innovates:

1. voiceless or aspirated plosives;
2. geminated (voiceless) plosives;
3. clusters of nasals and voiceless plosives.

[8] Pre-aspirated nasals are mentioned for Khams Tibetan and Sakar Tibetan, while pre-aspirated /j/ is listed for Shar Tibetan. A pre-aspirated fricative is cited for Sakar Tibetan. Pre-aspirated fricatives are given for Khams Tibetan. Voiced and voiceless pre-aspirated affricates are shown for Khams Tibetan. Pre-aspirated voiced plosives are shown for Sakar and Shar Tibetan. Finally, voiceless pre-aspirated plosives are present in all three Tibetan languages.

[9] For the rather intriguing example of Huautla Mazateco, see Steriade (1994: 230–234), who concludes that only plosives are pre-aspirated in the language, and "segments which originate as plosives" (1994: 232).

He does not exclude other possibilities (2010: 74–75). The third precursor is particularly intriguing here, as it seems to be the case that a nasal can be reanalysed as breathy in a specific environment and ultimately become [h]. The acoustic and perceptual link between nasalisation and voiceless friction (or aspiration) has been acknowledged and has been referred to as rhinoglottophilia (cf. Matisoff 1975, Garellek et al. 2016, and the references therein). The point of contention might however be a phonotactic one: rhinoglottophilia is not limited to the nasals surrounded by voiceless plosives.

For the so-called pre-aspirated trills in Dominican Spanish, Willis (2007: 46) cites personal communication with Susan Guion. Guion proposes that trills require the build-up of pressure to initiate trilling, which may result in local breathiness of trills if the glottis is abducted. Willis (2007: 45) concludes that the term "pre-aspiration" is "a misnomer" in case of Dominican Spanish on the grounds of the presence of voicing. Instead of "pre-aspirated", then, Willis (2007: 46) labels these trills "pre-breathy voiced vibrant[s]". Even if one ignores the fact that "true" pre-aspiration may be realised solely as local breathiness (see Figure 4 in Section 2.6), one might however also suggest that, similarly to what might be analysed as pre-aspirated laterals, the presence of voicing may be much more likely due to the voicing nature of the segments involved. If voiceless plosives, traditionally associated with pre-aspiration, are indeed voiceless, it is not surprising that pre-aspiration can be realised as voiceless in this environment. The same should not be assumed for consonantal sonorants. Regarding the explanations for pre-aspirated laterals or glides, however, it is not entirely clear at this point how exactly these types of segments might develop putative (voiced) pre-aspiration.

Pre-aspirated sonorant consonants, if indeed pre-aspirated, would necessarily show significant phonetic differences in comparison with pre-aspirated plosives.[10] Unlike plosives, they are not associated with a closure, which manifests itself acoustically by a period of silence (as in Figures 1–3). Unlike voiceless fricatives, sonorant consonants are typically voiced, and so it seems natural that – if these segments develop aspiration – this aspiration will likely be voiced (i.e., realised as local breathiness, see Section 1) rather than voiceless. Similarly to pre-aspirated plosives, pre-aspirated sonorant consonants involve a gesture of glottal abduction prior to an oral articulatory event, such as tongue tip raising (/l/, /n/, /ɾ/), lip closure (/m/), or trilling (/r/). Such oral articulatory events are comparable to that of a release of an oral plosive – indeed, both oral and nasal stops stop the airflow in the oral cavity. The timing of sonorant consonants which develop ini-

[10] For a discussion of primarily phonological but also phonetic differences between aspirated and glottalised plosives and nasals, see Kehrein & Golston (2004) and Golston & Kehrein (2013).

tial breathiness, or aspiration, is therefore also in line with what we find in pre-aspirated voiceless obstruents. Using this line of argumentation, Suzuki (2011) analyses a range of consonants, including sonorants, in different Tibetan languages as pre-aspiration. Suzuki (2011: 2) operates with the definition according to which pre-aspiration "is an aspiration preceding the main initial consonant, which can be counted in Tibetan as a time to prepare the tongue to a certain articulatory position. […] Voiceless preaspiration is indicated as [$^{\text{h}}$], and the voiced counterpart as [$^{\text{ɦ}}$]". More inclusive approaches to what counts as pre-aspiration in turn necessarily have implications for whether breathy, voiced plosives can be considered pre-aspirated (see Footnote 1 above).

A final example is Schreier's (2005) discussion of the loss of pre-aspiration in Middle English. What is meant by pre-aspiration by Schreier is the Modern and Old (and Middle) English /w/ and /ʍ ~ hw/ contrast, as in *Wales* and *whales* /ʍeɪlz/, which is absent in most Present Day English varieties. In the word *whales*, the initial phoneme contains a type of aspiration which can be realised and analysed in different ways (see e.g. Kolísková 2017, Lawson & Stuart-Smith 1999). Traditionally, however, the Old English <hw> (or <hƿ>) has been analysed as a cluster of /x/ and /w/ (e.g. Lass & Laing 2016 and the references therein). As such, this would not be considered a case of pre-aspiration by most researchers.

2.7 How is pre-aspiration measured?

The way pre-aspiration is counted and measured is also important for our understanding of how frequent the phenomenon is. Limiting ourselves to the relatively narrow definition of pre-aspiration (i.e., "true" or "genuine" pre-aspiration, and one limited to the phonetically voiceless obstruent environment), we still find that different authors quantify this phenomenon differently. Most researchers count the number of cases of pre-aspiration in a sample, i.e. its application frequency, or measure its duration, or both. While the methodological aspects of durational measurements are relevant for a range of typological considerations (Hejná 2019), they are not relevant for the discussion of how widespread pre-aspiration is cross-linguistically, at least not directly.

Most work on pre-aspiration (e.g. Clayton 2017, Morris 2010) presents us with the following logic: if the duration of pre-aspiration is 0 ms – i.e. if there is no trace of it in the acoustic signal – it is counted as absent in a given token. Any durations above 0 ms are counted as positive cases of pre-aspiration (cf. Hejná 2019 for an overview and references). Not everyone adopts this approach, however. Notably, Helgason (2002: 152) counts tokens as pre-aspirated only if the pre-aspiration reaches at least 15 ms. I have not been able to identify a rationale for this analytical decision beyond the following statement: "[w]hile such a temporal criterion for the presence of preaspiration is necessary, the 15 ms limit is somewhat arbitrary" (2002: 152).

In the same vein, Gordeeva & Scobbie (2010: 13) count tokens as pre-aspirated only if "the time delay from the preaspiration onset to the onset of the following fricative [is] longer than 30 ms (independent of the duration of [the vowel] or [the fricative])". The researchers provide an explanation for this decision, which stems from the findings reported by van Dommelen (1998). In his perceptual study focusing on Norwegian, van Dommelen (1998) found that speakers produced voiceless pre-aspiration values between 13–87 ms in their /k/ tokens (other fortis obstruents were not analysed). He also reported a perceptual experiment, the scope of which was to establish the role of pre-aspiration as a cue to the fortis-lenis contrast (specifically that of /k/ vs /g/). Van Dommelen used stimuli with pre-aspiration with durations of 0 ms, 30 ms, and 60 ms long. The results provided by van Dommelen's study do not however seem to justify Gordeeva & Scobbie's (2010) decision to count only cases of pre-aspiration reaching at least 30 ms as pre-aspirated, and less so in a study analysing pre-aspiration in Scottish English (i.e., not Norwegian).[11] This is because van Dommelen worked with three categories (0 ms, 30 ms, 60 ms) which do not enable conclusions about intermediate values such as 10, 15, and 20 ms. Furthermore, different experimental designs yield different results (Hejná & Kimper 2019). The approach found in the work by Helgason (2002) and Gordeeva & Scobbie (2010) therefore necessarily contains lower frequency of the application of pre-aspiration in the data, as compared to other pre-aspiration studies.

It is certainly a valid point to use one's values of pre-aspiration based on Just Noticeable Difference (JND, Stern & Johnson 2010). However, according to Weber's Law (see Lehiste 1977 and Stifelman 1994 for a discussion with phonetic examples), JND depends on the overall durational properties of the stimulus.[12] To the best of my knowledge, such perception-related information is not available for the vast majority of pre-aspirating languages (see Section 4.1), and, perhaps more importantly, if we want to understand the mechanisms of pre-aspiration fully, i.e. including production and perception and its phonological as well as social functions, even relatively short instances should not be disregarded from the analyses.

[11] In their later work, Gordeeva & Scobbie (2013) distinguish "long" and not long cases of pre-aspiration, with values exceeding 50 ms categorised as "long".

[12] See also the discussion in Kuznetsova et al. (2023), who draw attention to modern neuroimaging findings concerning the minimum threshold of response needed for the perception of a phonological contrast.

Another important issue in typological overviews is whether researchers distinguish two components of pre-aspiration: a voiced breathy transition from a modal sonorous segment to a phonetically voiceless obstruent, and voiceless glottal (and/or oral) friction (referred to as "truly voiceless pre-aspiration" by Ní Chasaide 1985a: 134). Ní Chasaide (1985a: e.g. 92–95, 134, 139) and Hejná (2015: Chs. 3&7) have shown that these two components of pre-aspiration are subject to a range of very similar segmental and prosodic, and social constraints, but notably they can also differ in their sensitivity to some of these constraints. This poses interesting challenges. On the one hand, there is no doubt that local breathiness goes hand in hand with voiceless pre-aspiration, as they are both part of an abducting laryngeal gesture (e.g. Ní Chasaide 1985a: Chapter 3, 185, 231[13]). On the other hand, Hejná (2015) has shown that locally restricted breathy voice, or breathiness, can occur without voiceless pre-aspiration, as shown in Figure 4 below.

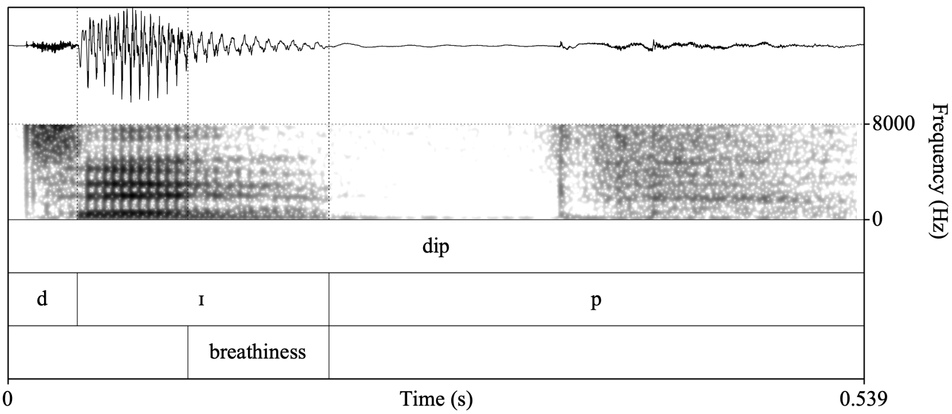

Figure 4: Pre-aspiration realised as local breathiness in the word *dip*, as produced by a speaker of Welsh English. See Hejná (2015, 2016c,a) for more details

In addition, Ní Chasaide (1985a: 185, 373, 393) has demonstrated that local breathiness can cue a contrast between an aspirated and an unaspirated plosive. This being the case, should cases that show local breathiness but no voiceless pre-aspiration not be considered cases of pre-aspiration as well? Even fewer researchers have commented on locally restricted breathiness (e.g. as a correlate of a fortis-lenis plosive contrast) than on voiceless pre-aspiration. A notable example is a study by Ní Chasaide & Gobl (1993: 310–315), in which the authors

[13]I also observed this in the endoscopic inspection of my own production of a pre-aspirated /p/ (unpublished).

report local breathiness in vowels preceding fortis obstruents in Swedish, Italian, and variably in English, but not in German and French. Researchers have discussed cases of contrastive breathiness (e.g. Maddieson 1984: 132, Ladefoged & Maddieson 1996: 57–58, 317), but this tends to be the case with vocalic and consonantal sonorants. In case of plosives, this is an aspect discussed for the release phase rather than the pre-closure phase. The question is how widespread local breathiness might be in the absence of voiceless aspiration in contexts which have been traditionally associated with pre-aspiration. A phenomenon such as local breathiness might be very easy to miss in the data. Some of the more general reasons for this are discussed in Section 4.3.

3 But is pre-aspiration phonologically relevant?

When the rarity of pre-aspiration is discussed, it is frequently done through the lens of phonology: phonological pre-aspiration is "an extremely rare phonological feature" (Clayton 2010: iii) and it is rarely contrastive (e.g. Ladefoged & Maddieson 1996: 70). More specifically, Ladefoged & Maddieson (1996: 70) list Icelandic, Faroese, Scottish Gaelic, and Lule Sámi as languages with contrastive pre-aspiration "on the surface level". They further add that the phenomenon "is said to occur in Amerindian languages, such as the Algonquian language Ojibwa […] and the Arawakan language Guajiro" (1996: 72). Four (plus) languages certainly do not present a particularly staggering number. However, we need to ask how contrastiveness and phonological relevance are established. These issues are discussed below.

3.1 "Normative" pre-aspiration

The literature available on pre-aspiration leaves the reader with the impression that pre-aspiration is seen as relevant if it is phonological, and that it is phonological only if it is contrastive. It also seems that in order to be seen as contrastive, pre-aspiration needs to function as a primary (perceptual) cue to a contrast and as the most important – if not the sole – (production) correlate of the contrast in question. For instance, Ladefoged & Maddieson (1996) make the following statements:

> Despite its importance in specifying the phonetic characteristics of some languages, we do not know of any language in which it is necessary to regard pre-aspiration as a feature required for distinguishing underlying forms. (1996: 73)

> Pre-aspiration has been put at the bottom of the chart because it probably never forms the basis for contrasts among underlying forms. (1996: 99)

The issue at hand is complicated by a very wide range of theoretical approaches available for the phonological analyses of contrasts. The first challenge to be encountered in the literature on pre-aspiration is an assumption that only obligatory pre-aspiration can be phonologically relevant.

For example, in his PhD thesis, Helgason (2002) introduces a dichotomy of "normative" and "non-normative" pre-aspiration, adopted also by other scholars working on pre-aspiration (e.g. Morris 2010, among others). This dichotomy is nevertheless defined in two different ways in different works by Helgason.[14] Helgason (1999: 1854, 2002: 8) defines normative pre-aspiration as phonologically conditioned and obligatory. Importantly, "phonologically conditioned" and "obligatory" are put on par in this definition. However, an obligatory application of a phenomenon is not a precondition for its phonological relevance, since phonological rules can be variable (and phonetic rules can be obligatory, as one of the reviewers notes). Furthermore, it is not clear what rate of application should be considered obligatory pre-aspiration.

The second definition is linked to the consistent rate of application within a speaker community (Helgason 2002: 21). If all speakers within a community pre-aspirated, for instance, 33% of the times in the same contexts, this would fall within the category of "normative pre-aspiration" because we find a consistent rate of application across speakers. Most researchers adopting the normative and non-normative dichotomy use the second definition.

If we adopt the first criterion of pre-aspiration being phonological only if applying obligatorily, it is perhaps not particularly surprising that the conclusion seems to be that pre-aspiration is not phonologically relevant. This assumption nevertheless strikes me as somewhat misguided, because pre-aspiration can function as a correlate and/or a cue to a range of contrasts, the most frequently discussed of which are the fortis-lenis contrast and the quantity contrasts, reviewed in Section 3.3. Before inspecting the literature on pre-aspiration as a correlate of and/or a cue to a phonological contrast, we first need to briefly note on the phonological relationship between pre-aspiration and post-aspiration (Section 3.2).

3.2 Pre-aspiration does not contrast with post-aspiration

As one of the reviewers points out, pre-aspiration never contrasts with post-aspiration: aspiration is contrastive, rather than pre- or post-aspiration as such.

[14]The two different definitions are also found within his PhD thesis itself.

It has been claimed that pre- and post-aspiration do not contrast with one another due to reasons related to prosodic licensing and sonority hierarchy and due to perceptual motivations (e.g. Blevins 2004: 90–91, 94, 98, 101–103, Golston & Kehrein 1998: 327, 2013, Kehrein 2002: Chapter 3, Kehrein & Golston 2004; see also Section 4.1). As such, pre-aspiration and post-aspiration have been assumed to have identical phonological representations by a number of scholars (e.g. Blevins 2004: 94). At least one exception to this typological generalisation might be Huautla Mazatec, which has been claimed to contrast pre- and post-aspirated word-initial obstruents on surface (Steriade 1994). Golston & Kehrein (1998) nevertheless present an account whereby "pre-aspiration [has been] reanalyzed out of Mazatec phonology" (1998: 327), which means that "there is no need to contrast [ht] and [th] in Huautla" (1998: 324).

As Blevins (2004: 94) states, however, "this phonetic difference [between post-aspirated and pre-aspirated stops] appears to determine the general sound patterns of aspirated stops both within and across languages". Indeed, although Kehrein & Golston (2004: 327) and Kehrein (2002) argue that pre-aspiration and post-aspiration are phonologically indistinguishable, they also fully acknowledge the fact that the two can be very distinct phonetically. Apart from the relevance of the distinction between pre-aspiration and post-aspiration to typologists, the fact nevertheless remains that pre-aspiration and post-aspiration can contrast with other properties of speech, such as the lack of pre-aspiration and post-aspiration, respectively. This, then, renders them potentially contrastive, and this is the subject of Sections 3.3–3.4.

3.3 Fortis-lenis and quantity contrasts

The categories "fortis" and "lenis" are used here for purely practical reasons, in line with Ní Chasaide (1985a: 105), "as convenient phonological terms to avoid the potentially confusing situation where one speaks of voiceless voiced stops, i.e. phonologically voiced stops with no phonetic voicing. The fortis/lenis labels are in no way intended to imply that either stop series is characterised by tense or lax qualities" (1985a: 105). Namely, "fortis" is used in this chapter to cover consonants such as the English obstruents /p, t, k, f, θ, s, ʃ, tʃ/ and "lenis" to cover consonants such as the English obstruents /b, d, g, v, ð, z, ʒ, dʒ/.[15]

In terms of phonological contrasts, pre-aspiration has been most often discussed in terms of its potential role in the fortis-lenis contrast of plosives (e.g. /p, t, c, k/ vs. /b, d, ɟ, g/). As already mentioned, Ladefoged & Maddieson (1996:

[15] This then differs from the definition of the fortis-lenis contrast as proposed by Trubetzkoy (1939).

70) list four languages as having contrastive pre-aspiration: Icelandic, Faroese, Scottish Gaelic, and Lule Sámi. The importance of this source cannot be overstated. Research conducted since then has found that pre-aspiration is a robust correlate of a fortis-lenis contrast in more languages, which belong to eleven language families (Afro-Asiatic, Algic, Arawakan, Austronesian, Indo-European, Mongolic-Khitan, Otomanguean, Tucanoan, Uralic, Uto-Aztecan, and two isolates: Urarina and Yuchi). The presence of such research is marked in the final column of Tables 1–19 in the Appendix. Yet, as we will see in Section 5, various typological databases do not reflect this recent research on pre-aspiration.

Furthermore, apart from the plosive context, pre-aspiration has also been documented as a correlate of the fortis-lenis contrast in fricatives in Scottish Standard English (Gordeeva & Scobbie 2010, 2013), Forest Nenets (Salminen 2007), and Wanano (Stenzel 2004: 50–51).

Most studies which look into whether or not pre-aspiration may function as a correlate of the fortis-lenis contrast do so by looking into whether pre-aspiration is present in one of the two series and, if so, how frequently. However, some of the production studies of the phenomenon intriguingly show that it is not necessarily the presence and absence of pre-aspiration which distinguishes the fortis and lenis plosives but its duration (longer in one series than in the other, comparably to VOT, cf. DiCanio 2012, Morris & Hejná 2020, Nance & Stuart-Smith 2013). Thus, DiCanio (2012) reports two phonological groups which both contain pre-aspiration, but this pre-aspiration is consistently longer in one of the two series than the other. It is rare for studies that investigate whether or not pre-aspiration functions as a correlate of a contrast to compare pre-aspiration with other potentially relevant correlates of the same contrast. Engstrand (1987) presents one of these not very frequent studies. Comparing pre-aspiration and VOT, Engstrand (1987: 103) explicitly states that, unlike pre-aspiration, VOT is irrelevant in the word-medial contrast of fortis-lenis in Lule Sámi.

We might wonder to what extent pre-aspiration functions also as a perceptual cue to the fortis-lenis contrast in the languages in question. Unfortunately, the research on this topic is considerably limited. That pre-aspiration can function as a cue to a fortis-lenis contrast has been shown for English (Hejná & Kimper 2019), Icelandic (Ní Chasaide 1985a: Ch. 5), Norwegian (van Dommelen 1999), Scottish Gaelic (Clayton 2010, Ní Chasaide 1985a: Ch. 5), and Swedish (Helgason & Ringen 2008: 625). Interestingly, Ní Chasaide (1985a: 435) shows that pre-aspiration can cue the contrast in Icelandic and Scottish Gaelic at much shorter durations than what her production data might suggest. The exact durations and their perception as pre-aspirated however depend on a range of factors in her study, including the amplitude of pre-aspiration and the duration of the closure of the plosive.[16] Hejná & Kimper (2019) show that discrimination and identification tasks yield somewhat different results. Voiceless pre-aspiration duration of 80 ms was needed to increase the identification of a pre-aspirated plosive as fortis. On the other hand, in the discrimination task, the listeners could reliably tell a difference between pre-aspiration durations of 0 ms and 20 ms, 20 ms and 40 ms, and 40 ms and 60 ms, but longer durations did not lead to higher "fortis" responses.

Discussions of the fortis-lenis contrast also include considerations of quantity contrasts, as the two can be very closely intertwined. For instance, DiCanio (2012) presents the case of San Martín Itunyoso Trique (Otomanguean) and argues that what has been approached as a fortis-lenis contrast should instead be considered a singleton-geminate contrast. Another intriguing case is presented in Wretling et al.'s (2002) analysis of pre-aspiration in Swedish dialects. The fortis/geminate obstruents are consistently associated with (more frequent) pre-aspiration. In addition, discussions as to whether pre-aspiration is part of the vowel or the consonant might also have implications for the analyses of vowel length. Pre-aspiration has been documented as a correlate of quantity contrasts in languages such as Icelandic and Lule Sámi. Most frequently, this involves a singleton-geminate contrast (e.g. Blackfoot – Reis Silva 2008; Icelandic – Silverman 2003; Italian – Stevens 2010, Stevens & Reubold 2014; for the intriguing case of Southern Paiute, see Silverman 2003: 587–588). Lule Sámi and Skolt Sámi present very interesting cases where three quantity degrees correlate with the presence and duration of pre-aspiration (Engstrand 1987, McRobbie-Utasi 2003).

Some perceptual evidence has been provided on the role of pre-aspiration in quantity contrasts. The reader is referred to Helgason (2002: Ch. 3), Pind (1996a,b) and Stevens & Reubold (2014).

3.4 Other contrasts

Varieties of English, such as Manchester English (Hejná & Scanlon 2015) and Scottish Standard English (Gordeeva & Scobbie 2013), also show that pre-aspiration may be a correlate of manner contrasts. If pre-aspiration consistently applies in word-final fortis fricatives (e.g., *mass* [ma^{h}s]) and (pre-)glottalisation consistently applies in word-final fortis plosives (e.g. *mat* [ma^{ʔ}t^{s}]), pre-aspiration can be said to function as one of the correlates of the /s/ – /t/ contrast. Depending on the analysis, this might also be the case in Menominee (Gathercole 1983).

Another type of contrast is mentioned by Silverman (2003: 590), who discusses pre-aspiration in Huautla Mazatec, in which the cluster [sk] contrasts with [^{h}k].

[16] Ní Chasaide only investigated plosives.

This is not the case for /t/, as there is no cluster /st/ in the language. Such type of a contrast involving pre-aspiration would belong to the contrasts of the place of articulation.

Finally, in some languages (e.g. Silverman 2003: 589, who mentions Hopi, Tarascan, Scandinavian languages, Scottish Gaelic, and Chamicuro), pre-aspiration is restricted to stressed syllables. In this case, pre-aspiration is involved in the complex web of correlates of stress and prominence.

3.5 Other criteria of phonological relevance

Hejná (2015: Ch. 4, 2019) discusses criteria which can be used to establish whether pre-aspiration is conditioned phonologically in a language even beyond the most widely established diagnostic of contrastiveness. To summarise, pre-aspiration in Aberystwyth English (i.e. Welsh English) shows variation which cannot be explained solely by phonetic (or social) factors. Firstly, it is phonological rather than phonetic vowel height (as in *kit* /kɪt/ vs *cat* /kat/) which predicts the duration of pre-aspiration in this data. Namely, while pre-aspiration is sensitive to the phonemes with different (phonological) height, it is not sensitive to F1 (the acoustic correlate of height) within these vowel phoneme categories. Secondly, phonetic vowel duration positively correlates with the duration of pre-aspiration, but this is only the case in phonologically short (or lax) vowels. A negative correlation is, in turn, found in phonologically long (or tense) vowels.[17]

Thirdly, the duration of pre-aspiration consistently shows a bimodal distribution, which has been used to diagnose phonological relevance (e.g. Hejná 2015: Chapter 4 for an overview). In case of Aberystwyth English pre-aspiration, the phenomenon reveals the presence of two categories: some words have no pre-aspiration (0 ms) while others have pre-aspiration of durations which form a mode, or indeed a category, of their own (clustered around ~20–70 ms, depending on the speaker). These two categories remain present even when a relatively wide range of segmental and prosodic factors is controlled for, and, therefore, cannot be explained by the influence of other phonetic factors.

Although determining the phonological status of pre-aspiration is essential in the discussions of its typological features (or distribution), I would like to conclude this section by pointing out the value of phonetic and sociolinguistic (more below) descriptions of pre-aspiration, which are equally important for a comprehensive understanding of its typology (e.g. Cho & Ladefoged 1999, Moisik et al. 2022, Morris & Hejná 2020). The implication in typological studies seems to

[17]The strength of these correlations is speaker-specific.

be that unless pre-aspiration is phonological, it may not be worth discussing or even acknowledging at all, which possibly underrates its presence in the world's languages. The discussions brought to light here are ultimately linked to those surrounding the phonetics-phonology interface, and to what Iosad (2025 [this volume]) refers to as analytical indeterminacy.

Finally, although social aspects of speech communities may not be seen as having a place in typological descriptions (as inferred from a number of typological discussions of pre-aspiration), sociophonetic work can offer cross-linguistically relevant understanding of the conditioning of specific phenomena, also but not only because sociophonetics has to address the biology of the speakers. Regarding pre-aspiration more specifically, different groups of pre-aspirating speakers can produce different frequencies, durations, and noisiness levels of pre-aspiration (e.g. Clayton 2017, Hejná 2021, Hejná et al. 2020, 2021, Morris 2010, Morris & Hejná 2020, Nance & Stuart-Smith 2013). Age and sex/gender have been shown to condition pre-aspiration (see Hejná 2015, Morris & Hejná 2020 for overviews), and research is yet to show to what extent these patterns are due to biological age and sex, social age and gender, or a mixture of the biological and the social.

4 Should pre-aspiration be rare and why?

4.1 Difficult to perceive?

The main reason put forward to account for the rarity of pre-aspiration in the world's languages is that it is difficult to perceive. In his chapter arguing for the importance of the hearer (or the listener) in phonetics, Bladon (1986: 7) states that, in the case of pre-aspiration, "[i]t would be hard to imagine a speech pattern less favourably designed for the hearer", and "given that preaspiration suffers from an accumulation of auditory handicaps, it would not be a risky prediction that languages would rarely make use of this auditory-phonetic dinosaur".[18] As discussed in Section 2.2, Silverman (2003) explains the fact that pre-aspiration is often accompanied by oral frication (pre-spirantisation) or substituted by it because this makes it perceptually more audible. The potentially weak perceptibility of pre-aspiration is what Clayton (2010: 87) has titled the Perceptual Inferiority Hypothesis. The overall explanation put forward in his work maintains that post-aspiration is easier to perceive than pre-aspiration because "it is easier to hear the onset of a stimulus than its end" (Clayton 2010: 88, paraphrasing

[18] It is Clayton (2010: 19) who first drew attention to Bladon's claims about the perception of the phenomenon in work focusing primarily on pre-aspiration.

Bladon 1986). A plosive burst is in itself an acoustically and perceptually more salient phenomenon than a segmental offset. Kingston labels this "the problem of pre-aspirates" (Kingston 1990: 410, also Silverman 2003: 593–594).

As discussed in Section 3, however, there are too few experimental studies directly testing the perceptibility of pre-aspiration. Firstly, one can consider the literature presented in the discussion of pre-aspiration as a correlate of a phonological contrast (Section 3), which fairly consistently shows that pre-aspiration does function as a correlate of a contrast where researchers specifically investigate this possibility. This being the case, we may wonder why pre-aspiration should serve as a correlate of any phonological contrast if it is not perceptible as a cue of the contrast in question.

The most direct test is presented by Clayton (2010: 95–107). He uses L1 English, Polish, and Scottish Gaelic listeners in his discrimination experiment, in which initial (fortis/lenis) plosives are distinguished by post-aspiration, and the medial and final ones by pre-aspiration. Crucially, this experiment uses Scottish Gaelic words for all participants. Both post- and pre-aspiration have long been established as correlates of the fortis-lenis contrast in the language (e.g. Nance & Stuart-Smith 2013). It is not surprising, then, that the Scottish Gaelic listeners performed the best. Interestingly, their confusion rate was the highest in the final position. The English listeners performed better with initial post-aspiration than medial pre-aspiration and the worst with final pre-aspiration. On the whole, their confusion rates were higher than is the case for the Scottish Gaelic listeners. Finally, the Polish listeners showed higher confusion rates for initial post-aspiration than either the Scottish Gaelic or the English listeners. However, they performed better in cases of medial and final pre-aspiration in comparison with the English listeners, and in the medial position their confusion rates were very close to those of the Scottish Gaelic listeners. Clayton interprets these results to indicate that the Perceptual Inferiority Hypothesis is not confirmed, and proposes instead that the answer to why pre-aspiration is rare lies in the availability of historical precursors (see Section 4.2).

However, more perceptual experiments are needed, including those in which post-aspiration and pre-aspiration are compared in the same prosodic position.[19]

[19] One of the reviewers notes that, according to the proposals by Kehrein & Golston (2004), Golston & Kehrein (2013), "that won't happen because the [pre-aspiration and post-aspiration] distinction is usually prosodically determined". Irrespective of what "that" refers to exactly here, while there is no doubt that pre-aspiration and post-aspiration show strong distributional differences determined by prosody, including both in the same prosodic condition nonetheless remains essential to test the claims put forward about the disadvantaged status of pre-aspiration as a cue.

4.2 Difficult to innovate?

Rather than being difficult to perceive, Clayton proposes instead that the main reasons for the rarity of pre-aspirated plosives are the low rates of innovation and the competition with multiple rephonologisation candidates rather than the low transmission rates (2010: 86–87). More specifically, pre-aspiration is rare because the conditions under which it innovates are restricted. The number of paths of innovation that lead to pre-aspiration is a more likely explanation than perceptual biases. This explanation is also in line with the observation that pre-aspiration has been fairly stable diachronically in, for instance, Nordic languages.[20] Five cross-linguistically attested antecedents of pre-aspiration have been proposed:

1. geminates: pre-aspiration has developed from originally degeminate consonants in some languages (e.g. Nordic languages, Scottish Gaelic, Sámi, Forest Nenets, Bora; cf. Clayton 2010: Chs. 2&3, and Sect. 3.1.2 in particular);

2. nasal-stop clusters: nasals can give rise to pre-aspiration in clusters (Central Algonquian languages, possibly some instances in Nordic languages, Hopi; cf. Clayton 2010: Chs. 2&3, and Sect. 3.1.2 in particular);

3. spontaneous appearance in singleton voiceless stops (Clayton 2010: Chapter 3);

4. borrowing/contact (Helgason 2002: 61–62);

5. /s/-stop clusters (Silverman 2003: 593, also Suzuki 2011).

Clayton (2010) adds an important detail: pre-aspiration "tends to occur in languages featuring two stop series that contrast through aspiration, not voicing" (2010: 33). This is echoed in Hejná (2015: e.g. 42), who discusses local breathiness as a potential diachronic step towards the development of voiceless pre-aspiration through the anticipation of the laryngeal abduction associated with post-aspiration.

In addition, Hejná (2015: 242) suggests that pre-aspiration is more likely to innovate in stressed syllables. While Hejná (2015: 42) also mentions the possibility of pre-aspiration developing from pre-glottalised consonants, this suggestion is, at this point, too speculative (see also Section 2.5 above and Hejná 2023).

[20] Clayton (2010) uses the term "Nordic languages", which is what this section of the chapter therefore uses as well.

In addition to drawing attention to the number of phonetic precursors, Clayton (2010: 70) also mentions the importance of "the abundance of antecedent structures" – in other words, a question of how common the precursors themselves are. In order to understand whether the rarity of pre-aspiration could be explained through the low abundance of the necessary precursors, it first needs to be established how rare the precursors are. Is post-aspiration more common than pre-aspiration because the contexts under which pre-aspiration is likely to innovate are more restricted than those for post-aspiration, for instance? Considering the precursors listed above, at least the following, more specific, questions should be explored in future research:

1. How many languages have phonetically voiceless obstruents, and ideally post-aspirated ones, either in a coda (e.g. Welsh English *mat* [$\mathrm{ma^ht^s}$]) and/or in a foot-medial syllabic onset (e.g. Welsh English *matter* [$\mathrm{ma^ht^s}$ə])?
2. How many languages have clusters of /s/ and voiceless plosives, and ideally in post-tonic environments?
3. How many languages have geminates, and ideally post-tonic ones?
4. How many languages have clusters of nasals and voiceless plosives, and ideally in post-tonic environments?

The next section focuses on the last category of reasons which might lead to the conclusions that pre-aspiration is cross-linguistically rare.

4.3 The limitations of the analyst

In addition to what has been discussed in Section 4.1 and Section 4.2, there are also other aspects that may explain the rarity of pre-aspiration. These are related to the limitations of the analyst.

4.3.1 Quality of the data

Firstly, pre-aspiration is often of low-amplitude and occurs following a highly sonorous segment. Because pre-aspiration often includes glottally produced low-intensity friction, it is particularly prone to being acoustically (i.e., both visually and audibly) masked in the acoustic signal. This might therefore happen not only due to the acoustic properties of pre-aspiration, but also due to the types of segmental combinations in which pre-aspiration is found. I limit the discussion here only to acoustic echoing in the sequences of vowels and phonetically voiceless obstruents (a prototypical context for pre-aspiration). A sonorous segment which is echoed into what might be a period of pre-aspiration and/or closure of a plosive might mask the potential presence of pre-aspiration in the acoustic signal. Figures 5–6 show such instances of echoing.

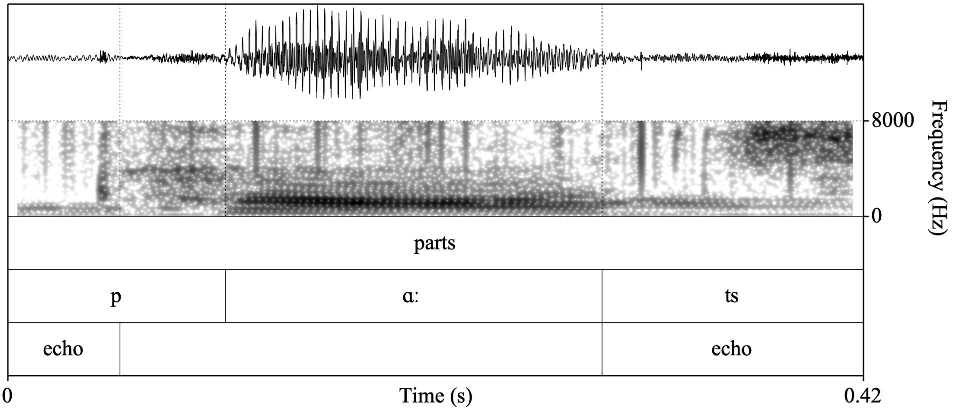

Figure 5: Example of acoustic echoing. The word *parts*, as produced by Queen Elizabeth II in her 1952 Christmas speech. The segmentation of the boundary between /pɑː/ and /ts/ is also approximate as a result. Data kindly provided by Jonathan Harrington

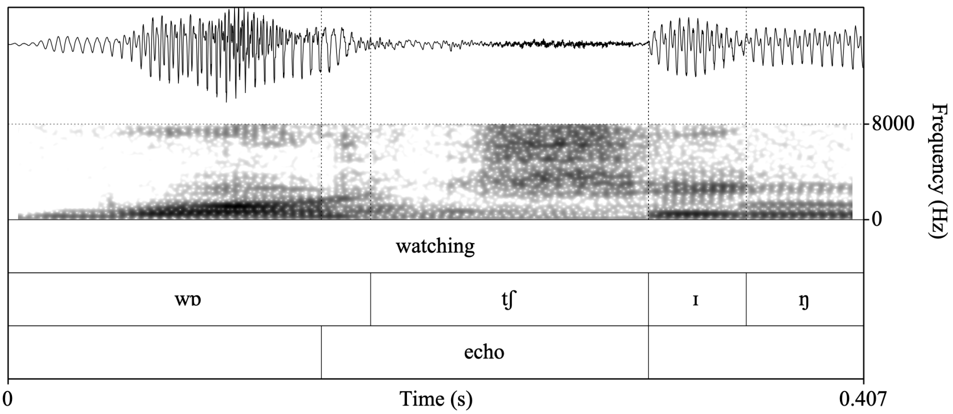

Figure 6: Example of acoustic echoing. The word *watching*, as produced by Queen Elizabeth II in her 1988 Christmas speech. The segmentation of the boundary between /wɒ/ and /tʃ/ is also approximate as a result. Data kindly provided by Jonathan Harrington. The message can also be accessed here: https://www.youtube.com/watch?v=LvpFJesl5hE

Figures 5–6 show examples of ambiguously pre-aspirated tokens from Queen Elisabeth II's Christmas broadcasts, which are of fairly good quality but not good enough for the reliable identification of what may be short and weak pre-aspiration in various places. In Figures 5–6, the ambiguous case of pre-aspiration appears in a sequence of a vowel and a plosive/affricate (/ɑːt/ in *parts* and /ɒtʃ/ in *watching*). The vowel is necessarily produced with a considerably higher intensity than potential pre-aspiration. If echoing occurs, it follows the original (unechoed) vowel, exactly where we would expect to find pre-aspiration. The consistency and the magnitude of the echoing depend on a range of factors. These include not only the quality of the equipment and its stable placement, but also the positioning and movements of the speakers, and the general acoustics of the surroundings in which the data is obtained

4.3.2 Confirmation bias

Biases of researchers are another challenge we have to tackle as analysts (including our own biases). The scholarly literature available, just like any type of text, presents us with specific discourses. As a result of such discourses, researchers may not even look for pre-aspiration in their data a priori, especially if it is known and frequently discussed as a rare phenomenon. Not expecting pre-aspiration a priori is one form of confirmation bias (see Klayman 1995 for a general overview). However, researchers may also fail to detect pre-aspiration if they deem it phonologically irrelevant.[21] Nonetheless, whether or not a phenomenon is contrastive does not mean that speakers do not employ it for various functions. Yet, frequent claims about the rarity of pre-aspiration (as contrastive) can easily lead one to expect it to be rare even in data which may be of interest to researchers who are not necessarily concerned with questions of contrastiveness. The issue of a potential confirmation bias is also linked to the bias raised by Maddieson (2021): "Familiarity with dominant languages can distort ideas about the phonological patterns of language in general and lead the linguistic community away from valuing all languages equally". We could easily substitute "languages" with "phenomena" in this quotation.

[21]Another case in point is voicing in obstruents. One of the reviewers commented on Figure 1, which originally included the /b/ of *bat*. The phoneme /b/ is partially voiced: partial voicing functions as one of the correlates of the fortis-lenis plosive contrast in Aberystwyth English (e.g. Hejná 2016a). The reviewer's suggestion was to "chop [this voicing] off as irrelevant to [b] which is probably just a voiceless (unasp) stop" and likely "part of something that precedes [the /b/], or *ambient noise*" (emphasis mine). The reason why this voicing should not be "chopped off" is because it consistently occurs in the lenis series – and not in the fortis series – in the variety in question, and in data where no acoustic echoing is present.

4.3.3 Language skills of the analyst

Furthermore, it is also likely that some languages are documented as pre-aspirating in literature which is available only in the languages in which most researchers are not sufficiently proficient. To give one example, my former student Wenyu Guo, an L1 speaker of Chinese, brought my attention to work on pre-aspiration in Chahar (Mongolic) by Qascimeg (Hāsīqímùgé) (2008), available in Chinese only.

5 How rare is pre-aspiration?

Quantifying occurrences of pre-aspiration in the languages of the world is far from straightforward, as should have become apparent by this point. Pre-aspiration presents us with several thorny issues of a diverse nature. While we are extremely fortunate to have open-access databases, such as UPSID (based on 451 languages, Maddieson & Precoda 1990) and its follower LAPSyD (676 languages, Maddieson et al. 2016), these databases do not present the level of detail which is needed in case of pre-aspiration.

For example, when we use LAPSyD, the "search for contrast" function can be employed. If pre-aspiration is selected, 2 out of 676 languages included in the database are listed as containing contrastive pre-aspiration (for plosives and affricates), in contrast to 109 languages listed as having post-aspiration. The two pre-aspirating languages are Tunica (/p, t, k, tʃ/) and Hopi (/p, t, k, q, kw, ts/). The database also offers a Boolean operator function, which provides us with the same results. The two pre-aspirating languages present 0.3% of the database, which is considerably lower than the percentage of post-aspirating languages reported in the database (24.2%).[22] Anyone familiar with the recent research on pre-aspiration would nevertheless be hesitant to draw solid conclusions about the rarity of pre-aspiration in the languages of the world based on LAPSyD, because it seems to be heavily underrepresented in this resource.

Based on the evidence gathered in this chapter, it can be concluded that pre-aspiration has been reported in at least 19 language families, and ~84 languages,[23] bearing in mind that the discussion of whether all of these languages do have pre-aspiration (as opposed to, for example, clusters with /h/) and whether this pre-aspiration is contrastive will depend on future research and the analyst's biases and decisions about the criteria to be used. According to Glottolog 4.5

[22] Readers like myself might be surprised that post-aspiration – considered to be quite widespread – is still represented by only 24.2% of languages.

[23] See Iosad (2025 [this volume]), for pre-aspiration and phonological areality.

(Nordhoff & Hammarström 2011), there are 427 language families in the world, represented by 4,775 languages. Absolute counts of language families and those of individual languages/varieties are bound to be contentiously debated. Bearing this in mind, and bearing in mind that the number of 84 pre-aspirating languages is itself subject to contentious debates, we get a number of 4.45% of the language families which have been documented to contain at least some more or less confirmed cases of pre-aspiration. As for the concrete languages, 84 amounts to 1.8% of a total of 4,775.[24]

These numbers are rather low indeed, despite the lax approach to pre-aspiration adopted here, which includes even the languages in which the presence of pre-aspiration has been contested in one or more sources, so pre-aspiration can indeed be considered to be a phonetic/phonological rarity.

6 Where does this leave us?

This chapter started with the following questions related to pre-aspiration:

- RQ1: How is pre-aspiration defined?
- RQ2: Is pre-aspiration rare?
- RQ3: Why should(n't) pre-aspiration be rare?

As we could see, pre-aspiration has been defined in many ways. Some of the definitions also include other phonetic and phonological phenomena related to pre-aspiration such as pre-affrication, pre-spirantisation, debuccalisation of /s/, vowel devoicing, sonorant devoicing, and others. Some definitions – the most common ones – restrict pre-aspiration to voiceless obstruents, while others extend the potential occurrence of the phenomenon also to sonorant consonants. From a diachronic perspective, many of these phenomena are often intertwined. On a synchronic level, the definition of pre-aspiration as broad or narrow may depend on the analyst's aims and the scope of intended research. Different approaches to the definition of the phenomena will necessarily impact our answer to RQs 2 and 3.

Regarding RQ2, the position taken in this chapter is that pre-aspiration can be phonologically relevant in a range of ways. Even in cases when it is not, it may be subject to the conditioning by sociolinguistic factors in the few languages where

[24]This is a conservative number, which is ultimately linked to issues related to distinctions between dialects and languages.

those have been looked into. Ultimately, if we want to understand the maximal scope of the rarity of pre-aspiration in the languages of the world, the cases of non-contrastive pre-aspiration should also be taken into account.

In response to RQ3, I documented a range of cases where pre-aspiration does contribute to the phonetic implementation of certain contrasts. I also discussed ways to diagnose the indirect phonological relevance.

In addition, I touched upon several biases which likely contribute to seeing pre-aspiration as a rare or very rare phenomenon. Those biases are related to the a priori expectations of researchers about the absence of pre-aspiration and to the low quality of the acoustic data itself. Finally, structural prerequisites for pre-aspiration were discussed in connection with the claimed rarity of the phenomenon.

In conclusion, I would like to invite the readers to join me and so many others in providing more information about pre-aspiration so that we better understand this fascinating and complex phenomenon from a typological perspective. To help us in this endeavour, I formulate the following research questions and goals.

1. In order to understand what pre-aspiration is and where it is, we also need to agree on what it is not. What are the differences between pre-aspiration and vowel devoicing? Which languages have pre-aspiration and which languages have vowel devoicing? Which languages have both? Why should at least some types of debuccalisation (not) be considered as sources of pre-aspiration? Why should some clusters but not others (not) be considered potential sources of pre-aspiration? How common is local breathiness occurring on its own, i.e. in the absence of voiceless glottal friction, in contexts typically associated with pre-aspiration?

2. Are pre-aspirated fricatives less common than post-aspirated fricatives, similarly to the situation observed in plosives?

3. How do we establish whether pre-aspiration is phonological? Is pre-aspiration a correlate of a contrast (not necessarily a fortis-lenis or a voicing contrast) in a language where it has been reported? Is it a cue to a contrast? If so, is it one of the primary and secondary correlates and cues? Is pre-aspiration conditioned by phonetic factors or also phonological ones?

4. Should we report if pre-aspiration is present only if we suspect that it is phonological (whatever that means to the researcher in question)? What are the social functions of pre-aspiration, and how diverse are these in pre-aspirating languages? Is pre-aspiration subject to biological types of conditioning, and if so, what are these?

5. What are the spectral properties of pre-aspiration in pre-aspirating languages? Do these relate to the spectral properties of the post-aspiration in the same language, if these have post-aspiration, and how exactly?

6. Which and how many languages of the world have the most common preconditions for pre-aspiration to innovate? Which and how many languages have phonetically voiceless obstruents, and ideally post-aspirated ones, either in a coda (e.g. Welsh English *mat* [$\text{ma}^{\text{h}}\text{t}^{\text{s}}$]) and/or in a foot-medial syllabic onset (e.g. Welsh English *matter* [$\text{ma}^{\text{h}}\text{t}^{\text{s}}\text{ə}$])? Which and how many languages have clusters of /s/ and voiceless plosives, and ideally in the environments just described above? Which and how many languages have geminates, and ideally in the environments described above? Which and how many languages have clusters of nasals and voiceless plosives, ideally in the environments described above?

7. Once the numbers of languages with these environments are established, how do these fare with those where post-aspiration is found?

Pre-aspiration comes out as rare based on the evidence available. However, it needs to be borne in mind that just because it is not reported to be present in a specific language, it may not be the case that it is not there. Absence of evidence does not equal evidence of absence. Undoubtedly, documenting evidence of absence might be a more challenging task, but one which is nonetheless important. Although pre-aspiration may not be quite as rare as believed, the current literature nevertheless suggests that it takes its place next to other phenomena considered to be very rare, such as ejective fricatives.

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Table 1: Afro-Asiatic languages reported to have pre-aspiration

Languoid	Reference	F/L contrast	Code
San'ani Arabic	Watson & Heselwood (2016)	Watson & Heselwood (2016) for /t/ vs emphatic /ṭ/	sana1295 / ayn
Śḥerɛt/Jibbali	Watson et al. (2025 [this volume])	Watson et al. (2025 [this volume])	sheh1240 / shv

Table 2: Algic languages reported to have pre-aspiration

Languoid	Reference	F/L contrast	Code
Amuesha/ Yanesha	Silverman (2003)		yane1238 / ame
Blackfoot	Reis Silva (2008)	Reis Silva (2008)	algo1256
Plains Cree	Hewson (1993)		plai1258 / crk
proto-Algonquian	Hewson (1993)		
(Swampy) Cree	Silverman (2003)		swam1239 / csw
Eastern Ojibwa	Silverman (2003)		east2542 / ojg
Fox (Kickapoo)	Silverman (2003), Gathercole (1983)	Gathercole (1983); ? (Silverman 2003: 586)	kick1244 / kic
Menominee	Clayton (2010)		meno1252 / mez
Montagnais	Craioveanu (2025 [this volume])		mont1268 / moe
Natick (Massachusee / Wampanoag)	Hewson (1993: 30)		wamp1249 / wam
Penobscot	Hewson (1993: 30)		peno1243

Table 3: Arawakan languages reported to have pre-aspiration

Languoid	Reference	F/L contrast	Code
Chamicuro	Silverman (2003)		cham1318 / ccc
Guajiro (Goajiro / Wayuu)	Silverman (2003)	? (Silverman 2003: 584)	wayu1243 / guc

Table 4: Austronesian languages reported to have pre-aspiration

Languoid	Reference	F/L contrast	Code
Ngadha/Ngad'a	Djawanai (1983: 114,117)	Djawanai (1983)	ngad1261 / nxg

Table 5: Indo-European languages reported to have pre-aspiration

Languoid	Reference	F/L contrast	Code
English	Hejná et al. (2021)	Gordeeva & Scobbie (2013); Hejná (2015: Chapter 6); Hejná (2016a); Hejná & Jespersen (2019); Hejná & Kimper (2019)	stan1293 / eng
Faroese	Helgason (2003)		faro1244 / fao
German	Tronnier (2019: 2081-2082)		stan1295 / deu
Icelandic	Silverman (2003)		icel1247 / isl
Irish	Ní Ní Chasaide (1985a)		iris1253 / gle
Italian	Stevens (2010)	Stevens & Hajek (2004)	ital1282 / ita
Norwegian	Ringen & van Dommelen (2013)	van Dommelen (1999); Ringen & van Dommelen (2013)	norw1258 / nor
Old/Shetland Norn	Knooihuizen (2013)		oldn1246 / nrn
Sanskrit	Silverman (2003)		sans1269 / san
Scottish Gaelic	Silverman (2003)	Ní Chasaide (1985b); Nance & Stuart-Smith (2013)	scot1245 / gla
Spanish	Torreira (2007)		stan1288 / spa
Swedish	Helgason (2002)	Helgason & Ringen (2008)	swed1254 / swe
Welsh	Morris & Hejná (2020)	Morris & Hejná (2020)	wels1247 / cym

Iosad (2025 [this volume]) discusses the possibility of the Kos dialect of Greek as potentially pre-aspirating. I also note that I have discovered regularly occurring pre-aspiration in Jutland Danish when I started processing our new Danish corpus for the "Ageing in Language Variation and Change" project in August 2022.

Table 6: Mongolic-Khitan languages reported to have pre-aspiration

Languoid	Reference	F/L contrast	Code
Baarin	Karlsson & Svantesson (2012)	Karlsson & Svantesson (2011)	
Chahar	Svantesson et al. (2005: 17)		chah1241
Halh (Mongolian)	Svantesson et al. (2005: 17)	Karlsson & Svantesson (2011)	halh1239
Horc(h)in	Karlsson & Svantesson (2012)	Karlsson & Svantesson (2011)	
Jalaid	Karlsson & Svantesson (2012: 7)		
Naiman	Karlsson & Svantesson (2012)	Karlsson & Svantesson (2012) [a]	
(Old Mongolian)	Karlsson & Svantesson (2012)		
Shiliin Gol	Karlsson & Svantesson (2012)	Karlsson & Svantesson (2011)	shil1261
Torguud	Karlsson & Svantesson (2012: 7)		torg1245

[a]The authors also mention that pre-aspiration is used contrastively in Oirad Torguud and Jalaid, or at least this is the interpretation I have arrived at from some of the discussion. However, their graphs displaying the presence of pre-aspiration in the languages in question do not show pre-aspiration in Oirad Torguud and Jalaid.

Table 7: Nakh-Dagestanian languages reported to have pre-aspiration

Languoid	Reference	F/L contrast	Code
Chechen	Catford (1977: 114)		chec1245 / che
Inguish (Ingush)	Catford (1977: 114)		ingu1240 / ink

Table 8: Otomanguean languages reported to have pre-aspiration

Languoid	Reference	F/L contrast	Code
(Eastern) Highland Otomi	Blight & Pike (1976)		east2556 / otm
Tenango Otomi	Blight & Pike (1976)		tena1241 / otn
Huautla Mazatec	Silverman (2003)		huau1238 / mau
Mazatlán de Flores	Silverman (2003)		maza1296 / vmz
Northern Otomi	Palancar (2013)	Palancar (2013: 4)	
San Jerónimo Teocatl	Silverman (2003)		Sanj1286 / maa
San Martín Itunyoso Trique/ Triqui	DiCanio (2012)	DiCanio (2012)	sanm1298 / trq
Santa María Jiotes	Silverman (2003)		

Table 9: Sino-Tibetan languages reported to have pre-aspiration

Languoid	Reference	F/L contrast	Code
Amdo Tibetan	Suzuki (2011)		amdo1237 / adx
Khams Tibetan	Suzuki (2011)		kham1282 / khg
Shar Tibetan	Suzuki (2011)		

Table 10: Sioun languages debated to have pre-aspiration

Languoid	Reference	F/L contrast	Code
Dakota	Rankin (2003)		dako1258 / dak
Hidatsa	Torres & Kasak (2019)		hida1246 / hid
Omaha	Rankin (2003)		omah1248
Osage	Rankin (2003)		osag1243 / osa
Proto-Siouan	Rankin (2003)		
Winnebago (Wenebago)	Rankin (2003)		winn1245

Table 11: Tarascan languages reported to have pre-aspiration

Languoid	Reference	F/L contrast	Code
Tarascan/ Purépecha	Silverman (2003)		pure1242 / tsz

Table 12: Tucanoan languages reported to have pre-aspiration

Languoid	Reference	F/L contrast	Code
Desano	Stenzel (2004: 51)		desa1247 / des
Siona (Sionan)	van 't Veer et al. (2025 [this volume])		sion1249
Siriano	Stenzel (2004: 51)		siri1274 / sri
Tuyuca	Stenzel (2004: 51)		tuyu1244 / tue
Wanano/Kotiria	Stenzel (2004: 51)	Stenzel (2004: 50-51)	guan1269 / gvc
Yuruti (Yurutí)	van 't Veer et al. (2025 [this volume])		yuru1263 / yui

Table 13: Tungusic languages reported to have pre-aspiration

Languoid	Reference	F/L contrast	Code
Evenki	Karlsson & Svantesson (2012)		even1259 / evn

Table 14: Turkic languages reported to have pre-aspiration

Languoid	Reference	F/L contrast	Code
Salar	Dwyer (2000)		sala1264 / slr
Tofa	Roos (1998)		tofa1248
Uighur	Dwyer (2000)		uigh1240 / ulg
West(ern) Yugur	Roos (1998)		west2402 / ybe

Table 15: Uralic languages reported to have pre-aspiration

Languoid	Reference	F/L contrast	Code
Forest Nenets	Clayton (2010)	Salminen (2007)	fore1274
Hungarian	Gráczi (2011: 761)	? (Gráczi 2011)	hung1274 / hun
Sámi languages (excepting Inari Sámi)	Iosad (2022)		
Lule Sámi	Engstrand (1987)		lule1254 / smj
Skolt Sámi (Skolt Sdini)	McRobbie-Utasi (1992)	McRobbie-Utasi (1992)	skol1241 / sms

Table 16: Urarina (isolate) reported to have pre-aspiration

Languoid	Reference	F/L contrast	Code
Upper-Chambira Urarina	Elias-Ulloa & Aramburú (2021)	? (Elias-Ulloa & Aramburú 2021)	urar1246 / ura

Table 17: Uto-Aztecan languages reported to have pre-aspiration

Languoid	Reference	F/L contrast	Code
Colorado River Numic	Miller et al. (2005)		numi1242
Oraibi Hopi	Silverman (2003)	? (Silverman 2003: 589-590)	
Toreva Hopi	Silverman (2003)	? (Silverman 2003: 589-590)	
“Other Hopi dialects”	Silverman (2003)	? (Silverman 2003: 589-590)	hopi1249 / hop
Southern Paiute	Elzinga (2014)		sout2969
Shoshoni	Elzinga (2014)		shos1248 / shh
Tohono O’odham	Clayton (2010)		toho1245 / ood

Table 18: Boran(/Witotoan) languages reported to have pre-aspiration

Languoid	Reference	F/L contrast	Code
Bora	Clayton (2010)		bora1263 / boa

Table 19: Yuchi (isolate) reported to have pre-aspiration

Languoid	Reference	F/L contrast	Code
Yuchi	Crawford (1973)	Crawford (1973: 174)	yuch1247 / yuc

Chapter 17

Weighing preaspiration

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This chapter addresses some long-standing contradictions in the phonology and typology of preaspiration, reassessing the prosodic status of this phenomenon and arguing that its traditional representation in the literature does not align with cross-linguistic phonetic and phonological patterns. Contra the commonly held assumption that preaspiration is a laryngeal property of the following segment (and thus a kind of mirrored postaspiration), preaspiration is shown to be prosodically associated to a preceding syllable in all attested cases, separately from the following segment. I argue that preaspiration consistently bears moraic weight, and that this property renders it indistinguishable in most cases from a discrete coda [h] segment. This is supported by a subset of a larger typological survey; 15 languages across four families are described, where preaspiration is shown to be consistently weight-bearing or otherwise associated with the preceding syllable. Given this prosodic patterning, I propose that preaspiration is a phonological length-preserving strategy akin to compensatory vowel lengthening, and that it is not necessarily dependent on the [spread glottis] status of the following consonant. The typology supports this, showing that preaspiration may sometimes appear before both aspirated and unaspirated consonants, or before a consonant with no contrastive laryngeal specification. This typological overview and reassessment of preaspiration requires us to revisit what is "rare" about preaspiration, if anything.

1 Introduction

Preaspiration, generally described as glottal frication preceding the onset of a particular set of segments, is considered much more unusual than postaspiration, and some work has been dedicated to describing the typology of the languages displaying this more marked property (e.g., Ní Chasaide 1985, Helgason 2002, Silverman 2003, Clayton 2010, Hejná 2025 [this volume]). Based on nomenclature

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and brief phonetic description, it is easy to assume a symmetry between pre- and postaspiration: due to the ubiquity of [spread glottis] as a featural component of oral segments, it seems intuitive to consider preaspiration and postaspiration as different phonetic implementations of aspiration, in which the relative timing of the oral and glottal articulations is reversed, but the underlying phonological status is the same. This is reflected in definitions of aspiration like that of Ladefoged & Maddieson, who say it can occur "before or after a stricture", and explicitly follow the gestural alignment approach: "it is obvious that glottal gestures in these two categories differ in their timing relationships with the associated oral gestures" (1996: 48, 72). Similar phonetic definitions and analyses have been provided by Catford (1968: 332) and Stevens (1975: 19), among others. In line with this perspective, virtually all previous work on preaspiration implies, assumes, or concludes that preaspiration must be a phonological property of the following stop, and thus be distinct from a heterosegmental sequence of *h*+C (e.g., Ní Chasaide 1985, Helgason 2002, Clayton 2010). This means that the common received view holds pre- and postaspiration to be either phonologically equivalent or phonologically symmetrical, depending on the level of subsegmental detail of the model. For instance, Kehrein & Golston's (2004) proposal that laryngeal features are properties of prosodic constituents rather than individual segments is intended to permit a flexible ordering of oral and laryngeal articulations under the same phonological representation.

This (implicit or explicit) assumption of equivalence or symmetry in aspiration is supported by an apparent lack of phonological contrast between pre- and postaspiration: "preaspirating" languages are generally reported to have postaspirated obstruents as well, and the alignment of the aspiration noise is claimed to be phonologically predictable (e.g., Ladefoged & Maddieson 1996, Silverman 2003, Kehrein & Golston 2004). Among the most frequently reported conditioning factors is position within the word or utterance: only medial and final consonants are preaspirated, while initial ones are postaspirated. This distribution is argued by Golston & Kehrein (2013) to be determined largely by sonority sequencing. Some typical examples of data used as support for this view are given in (1).[1]

[1]Linguistic data in this chapter is provided in the IPA as much as possible. Transcriptions and glosses are largely those given by the authors cited, and consequently there may be minor variations in transcription style or amount of morphological detail glossed from language to language. In cases where the cited source does not use IPA transcription, I have represented the data in IPA as faithfully as possible; this adaptation of the transcription is noted where applicable. Apart from the example of alleged laryngeal symmetry in (1), I render preaspiration consistently as [h] rather than [ʰ] throughout this chapter, regardless of the source's transcription.

(1)

a. Scottish Gaelic (Ní Chasaide 1985)

[p^{h}aː^{h}pə]	‘Pope’
[k^{h}a^{h}pəɫ]	‘mare’

b. Faroese (Árnason 2011)

[p^{h}ɔɑ^{h}pɪ]	‘daddy’
[t^{h}a^{h}kːa]	‘to thank’

c. Mongolian (Svantesson et al. 2005)

[t^{h}aɮ]	‘steppe’
[a^{h}ta]	‘camel gelding.REFL’
[a^{h}t]	‘camel gelding’

d. Purépecha (Foster 1965)

[k^{h}a^{h}tsɨkwa]	‘hat’
[te^{h}par]	‘canoe’
[i^{h}k^{w}an]	‘to bathe’

This positional allophony account goes hand in hand with the gestural alignment theory mentioned above: aspiration is phonetically realized before a constriction or after a constriction based on when the vocal folds open, depending on the surrounding phonological environment. Although this description is conceptually and representationally convenient, examination of the phonetic and phonological patterns of preaspiration across languages immediately shows some profound asymmetries between pre- and postaspiration: most notably, preaspiration has a consistent prosodic link to a preceding syllable that is not seen for postaspiration. Asymmetries have been reported previously for pre- and postaspiration (e.g., Clayton 2010: 13–15), and are visible in all relevant language descriptions, but nevertheless there has been no broad-scale work on the prosodic or segmental status of preaspiration to date. In many languages, the inherently moraic nature of preaspiration results in it being fundamentally indistinguishable from a discrete coda [h] segment, and a unified conception of pre- and postaspiration is thus a misrepresentation of the phonological facts.

This chapter therefore revisits the commonly cited examples of preaspiration and surveys others from the literature in order to illustrate a consistent association of preaspiration to phonological weight, and thus a prosodic affiliation with the preceding syllable. This moraic status is a defining property of preaspiration cross-linguistically, and means that preaspiration should not be viewed as a purely featural pre-consonantal phenomenon,[2] but rather as part of the prosodic

[2] Of course, a subsegmental analysis of preaspiration as a consonant feature is perfectly functional in some languages, and may be phonologically appealing for phonotactic or other reasons. However, in all of the cases seen in a wider typological survey (Craioveanu 2023), there is also a plausible analysis available in which preaspiration is synchronically associated to a mora of the preceding syllable, independently of the consonant that it supposedly “belongs” to. It is not always possible to prove that preaspiration in a given language *cannot* be underlyingly a feature of a consonant: this becomes a diachronic question of whether the moraic association is formed through an active phonological process or is the result of historical change (cf. Bals Baal et al. 2012 for an argument that preaspiration is underlyingly featural but undergoes fission from the consonant during the phonological derivation). The crucial observation presented here is that we never see preaspiration that is not affiliated with a mora or that is not syllabified separately from the following consonant.

system. In §2, I outline some foundational assumptions about phonology generally and preaspiration specifically that will be important to this discussion, followed by a typological survey of preaspiration in §3. In §4, I discuss patterns seen across the languages, proposing that preaspiration can serve as a phonological length-preserving strategy, along the lines of compensatory vowel lengthening but in a different domain.

2 Assumptions & definitions

Past research approaches preaspiration as a fundamentally rare phenomenon, with the reasons for its rarity being important to investigate (e.g., Silverman 2003). However, suggestions that preaspiration might be less rare than generally reported date back to at least Ní Chasaide (1985), who speculates that some languages that are broadly described as having a plain vs. aspirated laryngeal contrast might actually feature preaspiration. Hejná (2015, 2019, 2025) and Iosad (2017a, 2018, 2025) also express the opinion that the rarity of preaspiration may be overstated, possibly due to fieldworkers' expectations or phonological awareness. Either preaspiration went unnoticed because the researcher was not expecting to find it and did not hear it, or the researcher heard it but judged it (consciously or subconsciously) to not be phonologically relevant.

In any discussion of typology or rarity, it must be clear exactly what is being described as rare, be it a combination of articulatory gestures or a more abstract phonological representation like a segment, and the theoretical approach should be explicit and consistent. Thus, I argue that in research on preaspiration, its phonological and prosodic status should be either an explicit area of investigation or a core assumption underlying the theoretical analysis. In past work on preaspiration, this has not always been the case: some authors have vague or unclear assumptions, make conflicting statements, or remain deliberately agnostic to the phonological status of preaspiration. Helgason (2002) and Silverman (2003) both state that they are not following a segmental theory of phonology, and claim that therefore the distinction between preaspiration and an *hC* cluster is not relevant. Despite this declared position, their arguments and discussion of preaspiration align with a segmentally unary conception of preaspiration. They discuss alternations of preaspirated and postaspirated stops, as if these had an allophonic relationship, and describe preaspiration as a component of the following stop. Clayton (2010) presents arguments in favour of viewing preaspiration as a distinct segment but also in favour of it as a feature of the following stop, finding merits for both positions before settling implicitly on a segmentally unary conception of preaspirated stops.

Part of this equivocation is a result of the origins of preaspiration in the languages that have been most carefully studied – where it arises from loss of historical geminates and thus is still phonotactically and orthographically associated with them – in combination with a persistent association with prosodic weight that leaves it patterning like a coda segment in most cases. Thus, it is important to be clear on what we consider preaspiration to be, what its role is in the phonology, and what kind of phonetic and phonological evidence is important when discussing it.

In this chapter, I follow a generative approach to phonology that is strictly segmental. Segments can be expressed as bundles of features, which are generally based in articulation, although a phonetic basis is not strictly necessary. Phonemes are specified only for the features necessary to contrast them from other phonemes in the language's inventory. I specifically adopt the approach of Modified Contrastive Specification (Dresher 2009, Hall 2011), in which contrasts within an inventory are established through repeated featural division of sets of phonemes into smaller natural classes, until all phonemes are featurally distinct (the Successive Division Algorithm). Although a detailed description of this algorithm is not relevant here, the crucial proposal is that the phonemic contrasts within an inventory determine what properties of the segments are phonologically relevant. In other words, features that are not contrastive are not accessible to the phonological computation. To give a specific example, a language with the stop inventory /p, p^h, t^h, k, k^h/ requires a single feature like [spread glottis] to contrast its two laryngeal series of stops, but a language with the more limited inventory /p, t, k/ would not make use of any laryngeal features in its phonological system.

In the suprasegmental domain, I follow a version of Moraic Theory (Hyman 1985, McCarthy & Prince 1986, Hayes 1989), assuming a moraic tier that segments associate to directly without an intervening skeletal tier, and higher organization into syllables. As I am arguing for a weight-based prosodic analysis of preaspiration, I treat all of the languages discussed here as having moraic structure. Syllable onsets are considered to be non-moraic and syllable nuclei and codas are considered to be moraic, unless evidence shows otherwise in a particular language (e.g., onset geminates, Topintzi 2008; extrametrical final consonants, Kristoffersen 1999). I assume a moraic theory of geminates, in which these are single segments associated both to a syllable onset and to a moraic preceding coda (Hayes 1989, Davis 2011).[3] Syllables may be maximally bimoraic; even in languages with ternary length distinctions, there is no clear evidence that "superheavy" trimoraic syllables are theoretically necessary (e.g., Bye 2005, Bals Baal et al. 2012, Prehn 2012). Instead, I rely on a prosodic framework making use of mora sharing (Maddieson 1993, Hubbard 1994, Broselow et al. 1997), and this structural assumption in combination with the proposal that preaspiration is always moraic predicts that we should be able to capture all preaspiration patterns with one of the three structures shown in Figure 1.

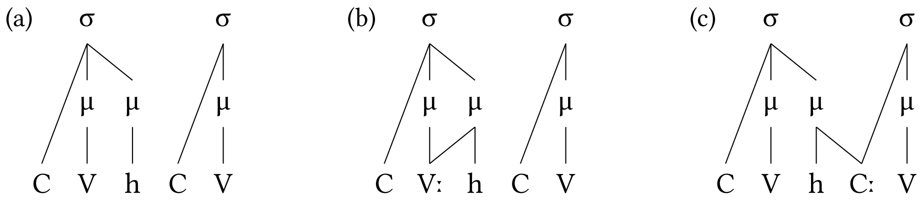


Figure 1: Typology of predicted moraic structures for preaspiration

These combinations capture the range of environments in which preaspiration can appear cross-linguistically, which always involve quantity in some way. This can be seen either through categorical alternation of preaspiration with long vowels or consonants, or through phonetic length complementarity (e.g., shorter vowels before longer preaspiration). Notably, I use the term "moraic" with reference to preaspiration to indicate that the [h] has some association to a mora, even if it is sharing this mora with another segment; a non-moraic consonant would be associated directly to the syllable tier, as an onset or an extrametrical consonant.

Following the assumption that moraic structure is reflected in the phonetic durations of segments (Broselow et al. 1997), we expect that different moraic association patterns would result in different ratios of segmental duration. For instance, the [h] in a structure like Figure 1a is expected to be phonetically longer than in Figure 1b and Figure 1c, and the long vowel that shares its second mora in Figure 1b is expected to be longer than a short (monomoraic) vowel but shorter than a fully long (bimoraic) vowel. Conversely, this assumption also means that we may interpret phonetic differences in segmental duration ratios as evidence

[3] Although it is possible to have long consonants that are not underlyingly a single segment (e.g., in multimorphemic words like English *bookcase*), I consider these sequences of identical consonants rather than "true" geminates.

for different underlying moraic structures. The use of phonetic evidence to support phonological structure allows us to assess the nature of preaspiration in languages that do not have phonological processes that are informative about preaspiration or prosodic structure, or in varieties that have limited published work. Crucially, we predict that prosodic structures with non-moraic preaspiration as in Figure 2 are unattested.

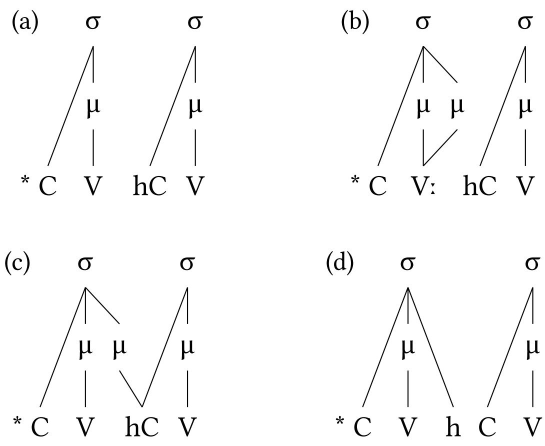


Figure 2: Possible but unattested prosodic structures in which preaspiration is non-moraic

It is worth clarifying here that the segmentally separate representation of preaspiration in the structures in Figure 1 is not strictly dependent on its prosodic separation into a separate syllable from the following segment. Notably, the structure in Figure 1c features preaspiration before a geminate, and this preaspiration is not treated differently because it shares a mora with the following consonant. Likewise, I do not consider the geminate to be two segments despite its association to two syllables.[4] In structures like Figure 1a–b, preaspiration bears moraic weight separately from the following consonant, and thus may be expected to lengthen independently of that consonant under stress, or to interact with preceding vowel length separately from the following consonant. In the structure in Figure 1c, the discrete nature of preaspiration would be harder to

[4]It is worth mentioning here that the stop and fricative components of geminate affricates like [tʃː] may also not lengthen proportionally. Although this is outside the scope of the current chapter, it would be worth comparing the phonological and phonetic patterns observed for geminate affricates as a potential area of contrast to preaspiration.

establish uncontroversially due to the shared mora. However, the languages discussed here that show evidence for this moraic structure (Faroese, §3.2; Central Standard Swedish, §3.3) do not use it exclusively, and show evidence of structure Figure 1a or Figure 1b in other words. The primary stance I am taking on preaspiration is that it is always moraic: although this strongly suggests it is a discrete segment, and I will treat it as such in all cases for consistency, the issue of segmenthood is secondary in my mind.

Finally, it is necessary to be explicit about the meaning of the term "preaspiration", as it is often a term of convenience for a diverse range of surface phonetic phenomena which can arise in a variety of ways diachronically. The phonetic realization of reported preaspiration often spans vowel breathiness, glottal frication, and oral frication (Silverman 2003, Hejná 2016, Hejná 2025 [this volume]), and its phonological status is heterogeneous as well, with preaspiration sometimes analyzed as a coda /h/ segment (Icelandic: Árnason 2011; North Sámi: Bals Baal et al. 2012; North Argyll Gaelic: Iosad et al. 2015) but more often analyzed as a featural component of a following segment. Past typologies of preaspiration have limited the scope of their survey to preaspiration before stops, often with the stipulation that this narrow distribution constitutes "true" preaspiration (Helgason 2002, Silverman 2003, Clayton 2010). In this view, the distribution of [h] is a diagnostic for its status as preaspiration, with presence of [h] before a more diverse set of consonants suggesting that it is better analyzed as a coda fricative. The typological survey of preaspiration in §3 does not support this restrictive definition of preaspiration, showing that the distribution of preaspiration is indisputably wider than just pre-stop contexts, and as is discussed later in §4, the reasoning behind this restriction is not well motivated. Preaspiration found before stops does not have a special status, and it does not depend in any (synchronic) way on the laryngeal properties of the following segment: preaspiration may be found before segments that do not have phonological laryngeal contrasts. Hejná (2025 [this volume]) takes a similarly broad approach to the question of what might be considered preaspiration, and discusses the breadth of the related phenomena.

For convenience and continuity with previous literature, I continue to use the term "preaspiration" here, despite the implication that the aspiration is inherently dependent on or affiliated with the following segment. For the purposes of the typology in §3, any instance of [h] directly before a consonant articulation may be considered "preaspiration", and in some cases voiceless dorsal fricatives in coda position may be considered aspiration as well, due to rampant fortition of [h] cross-linguistically. Although this may seem at first to cast a very broad net, and to conflate preaspiration as a phonological phenomenon with independent and unrelated coda /h/, this is in fact one of my core claims: synchronically, as a result of the moraic status of [h], most instances of preaspiration are indistinguishable from heterosegmental [hC] sequences.[5]

However, I avoid the terms "normative" vs. "non-normative", which are commonly used in some previous work to refer to phonologized vs. variable preaspiration patterns (e.g., Helgason 2002, Clayton 2010, Gordeeva & Scobbie 2007). These terms are used inconsistently and set up a false equivalence between invariance and phonologization. This concern is shared by Hejná (2015, 2019) and Iosad (2017a, 2025), and I align with their stance that the true phonological status of a pattern depends on its interactions with elements of phonological computation, and not on gradience or categoricity. Patterns in metrical constituency and prosodic association are part of the phonological "module" of the grammar (e.g., Bermúdez-Otero 2015), and if preaspiration involves these elements, it should be considered part of the phonological computation, regardless of variance. In the typological survey presented below, both variant and invariant preaspiration are shown to interact with phonological quantity, syllable structure, and phonemic length, challenging the idea that there is a fundamental difference in the phonological status of preaspiration in "normative" vs. "non-normative" cases.

3 Typology

3.1 Icelandic

Icelandic (`icel1247`; North Germanic; Iceland) is perhaps the best-known reported case of preaspiration, with linguistic discussion of the phenomenon going back more than a century (Sweet 1877, Ófeigsson 1920, Malone 1923, Einarsson 1931, 1949, Haugen 1941, 1958, Thráinsson 1978, Árnason 1986, 2011, *inter alia*). Arguments that preaspiration is a distinct coda [h] in the language have been made for just as long, but early work focuses on the duration of preaspiration alone.

[5] Although I do not discuss specific examples here where it might be possible to distinguish preaspiration from a coda /h/, this issue will depend on the definition of preaspiration and the boundary between phonology and phonetics. Iosad (2025 [this volume]) argues that a distinction between phonological preaspiration and phonetic preaspiration is desirable, and this distinction is not fundamentally at odds with the position I take here. As phonological phenomena typically begin their life cycle as phonetic trends, there is inevitably a stage at which glottal frication could be acoustically discernible but not available to the phonology as an independent moraic segment. I would anticipate that phonetic preaspiration of this kind would appear associated to a moraic segment, making it difficult to discern where it is purely phonetic and where it is accessible to the phonology. However, further research on the life cycle and emergence of preaspiration may clarify this.

There are two laryngeal series of stops in Icelandic, often labelled "fortis" and "lenis". The fortis stops are usually phonetically aspirated, while the lenis stops are unaspirated and sometimes voiced, which suggests that the relevant phonological contrast is in aspiration. Phonetic aspiration of the fortis consonants has been described as alternating between postaspiration and preaspiration. Word-initial fortis stops are always post-aspirated, and non-initial stops that either derive from geminates or are followed by /l/ or /n/ are preceded by preaspiration. This is illustrated below: data in (2a) show the laryngeal contrast in initial position, (2b) show contrasting historical fortis and lenis geminates, and (2c) show preaspiration before stop-nasal sequences. Examples are presented in pairs, with the fortis stop listed first and lenis stop second.[6]

(2) Icelandic fortis/lenis consonant pairs (Árnason 2011: 99, 106, 221)

a.	i.	*par*	[pʰaːr̥]	'pair'
		bar	[paːr̥]	'bar'
	ii.	*tal*	[tʰaːl̥]	'talk, speech'
		dal	[taːl̥]	'valley'
b.	i.	*koppi*	[kʰɔhpɪ]	'chamber pot.DAT'
		kobbi	[kʰɔpːɪ]	'young seal'
	ii.	*hattur*	[hahtʏr̥]	'hat'
		haddur	[hatːʏr̥]	'hair'
	iii.	*bakka*	[pahka]	'bank.ACC'
		bagga	[pakːa]	'bundle.ACC'
c.	i.	*opna*	[ɔhpna]	'open.INF'
		ofna	[ɔpna]	'radiator.PL'
	ii.	*batni*	[pahtnɪ]	'improve.SUBJ.SG'
		barni	[patnɪ]	'child.DAT'
	iii.	*sakna*	[sahkna]	'miss.INF'
		sagna	[sakna]	'story.GEN.PL'

In addition to the stops, Icelandic also has a laryngeal contrast in the sonorant series, with all liquids and nasals having voiceless counterparts. These voiceless sonorants are phonemic in onset position in Icelandic (Jessen & Pétursson 1998);

[6]However, it is important to note that the fortis/lenis contrast only really remains in initial position, and is largely historical or orthographic elsewhere. The distribution of preaspiration signals the historical identity of non-initial stops, but if it is analyzed as synchronically unproductive or a distinct segment (e.g., Árnason 2011), this means the stop contrast itself is now limited to word-initial position. This is also the case for Danish (Basbøll 2005).

they appear in codas as well, both word-finally and word-medially, where their phonemic status is contested. Word-medially, they are found in contexts where preaspiration would be expected, which has led some authors to argue that they should be considered an instance of preaspiration (e.g., Thráinsson 1978, Ringen 1999). In the interests of brevity, I do not discuss voiceless sonorants in this chapter, as they are clearly syllabified in the syllable before the stop.

Icelandic has length contrasts in both vowels and consonants, but these surface in a complementary way: word-initial syllables have primary stress and are phonologically heavy, requiring either a long vowel or a coda consonant. In other words, stressed vowels are long unless there is a moraic coda (e.g., a following geminate). In words of two or more syllables, this means that stressed vowels are long in open syllables. In monosyllabic words, vowels are long if there is no coda or if there is a simple coda, which is non-moraic word-finally in Icelandic. This pattern is illustrated in (3).[7]

(3) Weight complementarity in heavy syllables (Garnes 1976, Árnason 2011)

a.	*völur*	[ˈvøː.lʏr̥]	‘rod’ (archaic)
	völlur	[ˈvøt.lʏr̥]	‘field, airport’
b.	*mani*	[ˈmaː.ni]	‘young lady.DAT’
	manni	[ˈman.ni]	‘man.DAT’
c.	*man*	[maːn]	‘young lady.ACC’
	mann	[manː]	‘man.ACC’
d.	*ein*	[eiːn]	‘one.F’
	einn	[eitn̥]	‘one.M’

In the examples in (3a–b), medial clusters or geminates require the preceding stressed vowel to be short. In the examples in (3c–d), vowels are required to be short in monosyllables with moraic codas or coda consonant clusters, but may be long before simple non-moraic codas. The pattern in monosyllables is seen more generally across the Germanic languages, where word-final consonants have been analyzed as extrametrical. This creates a prosodic distinction between single final consonants and final clusters or geminates (Icelandic: Iverson & Kesterson 1989; Swedish: Riad 2014; Norwegian: Kristoffersen 2000; English, Dutch: Kager 1989).

I make use of the moraic structures in Figure 3 to represent this prosodic pattern. These representations are similar to those of Ringen (1999) and Morén

[7]Data and transcriptions in (3b–d) are from Árnason (2011). The word pair in (3a) is from Garnes (1976), with my own IPA transcription matching Árnason’s Icelandic conventions. Appropriate syllable boundaries have been added to all data.

(2001), and build on previous models of foot and syllable structure expressing the same insight (e.g., Iverson & Kesterson 1989, Árnason 2011).

Comparing the vowel length patterns of words with preaspiration, it is immediately clear that these behave like words with medial or final clusters, as long vowels never co-occur with preaspiration. The examples in (4) show that preaspiration is moraic and takes up the entire second mora of a stressed syllable in all cases.[8] Corresponding moraic structures are shown in Figure 4, illustrating the moraic association of preaspiration.

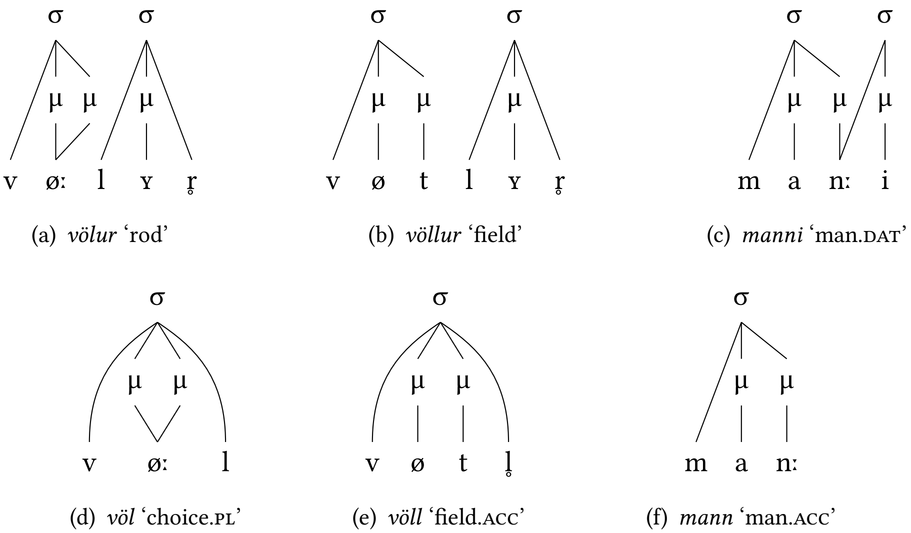
(4) Icelandic vowel length and preaspiration (Thráinsson 1978, Árnason 2011)[9]

a.	*leit*	[leiːt]	'search'
	heitt	[heiht]	'hot.N'
b.	*hatur*	[haː.tʰʏr̥]	'hate'
	hattur	[hah.tʏr̥]	'hat'
c.	*vekja*	[vɛː.kʰja]	'wake s.o. up.INF'
	vakna	[vah.kna]	'wake up.INF'
d.	*líta*	[liː.tʰa]	'look.INF'
	líttu	[lih.tʏ]	'look.IMP'
e.	*ljót*	[ljouːt]	'ugly.F'
	ljótt	[ljouht]	'ugly.N'

This phonological evidence of complementarity between long vowels and preaspiration is supported by phonetic measurements of segmental duration. A production study by Garnes (1976) shows that the duration of long vowels is similar to the combined duration of short vowels and preaspiration across a variety of

[8]According to the phonotactics of Icelandic as generally described in the literature, {pʰ,tʰ,kʰ}+{l,n} consonant sequences as seen in *vakna* in (4c) are not word-medial onset clusters (e.g., Árnason 2011). However, the traditional diagnostic for the set of word-medial onsets in the Icelandic literature is the ability to appear after a long vowel, where it is clear that the preceding syllable has no coda. Since {pʰ,tʰ,kʰ}+{l,n} sequences always have a preceding [h], the preceding syllable is always closed. There is compelling evidence elsewhere in the language that these also form medial clusters, an analysis which is acknowledged by Árnason (2011: 172) as well; however, this is not critical to the arguments here. This syllabification is confirmed by the lengthening patterns illustrated below in (6b), where the /h/ is moraic and not the /kʰ/.

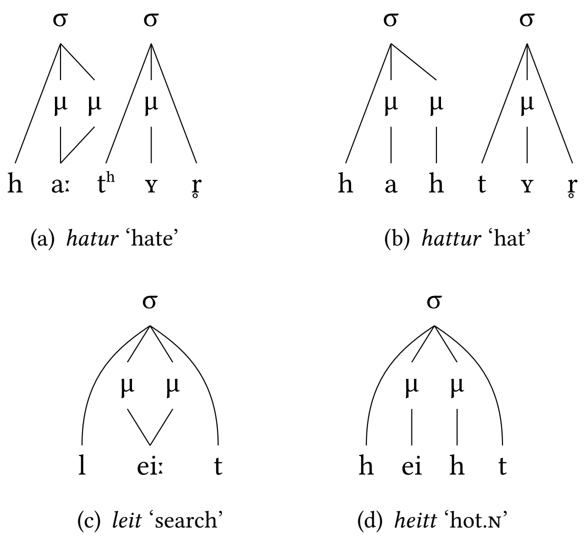
[9]As can be seen in this data, monophthongs and diphthongs show the same length alternations in open vs. closed syllables in Icelandic. Phonetic measurements of vowels and preaspiration in these contexts confirm that there are no differences between monophthongs and diphthongs in either vocalic duration or following preaspiration duration (Garnes 1976, Thráinsson 1978).



(a) *völur* 'rod' (b) *völlur* 'field' (c) *manni* 'man.DAT'

(d) *völ* 'choice.PL' (e) *völl* 'field.ACC' (f) *mann* 'man.ACC'

Figure 3: Moraic structures showing the weight complementarity pattern in heavy syllables in Icelandic



(a) *hatur* 'hate' (b) *hattur* 'hat'

(c) *leit* 'search' (d) *heitt* 'hot.N'

Figure 4: Moraic structures showing association of Icelandic preaspiration to the second mora of a stressed syllable

word types. This durational complementarity is the predicted outcome if preaspiration is taking up moraic weight within the syllable that would otherwise be associated to the vowel.

Additional phonetic evidence that preaspiration is prosodically situated within a stressed syllable comes from Árnason (1986, 2011). He observes that extra emphasis on a word, such as through contrastive focus, causes lengthening within the stressed syllable, specifically on the second mora of the syllable, as per the structures in Figure 1.[10] In words with a long vowel in the stressed syllable, the vowel lengthens under focus, while in words with a closed stressed syllable, the moraic coda lengthens. This is shown in the examples from Árnason (1986: 11–12) in (5). In words with preaspiration, the [h] lengthens under focus, as shown in (6), which confirms it is in the coda of the stressed syllable. I reproduce Árnason's transcriptions of the emphasized words at the right,[11] and have added transcriptions of the expected production in an unemphasized context for comparison.

(5)	a.	*Ég* HATA *fisk!* 'I HATE fish!'	[haːˑ.ta]	(cf. unfocused [haː.ta])
	b.	*Ég* ELSKA *fisk!* 'I LOVE fish!'	[ɛlː.ska]	(cf. unfocused [ɛl.ska])
	c.	*Ég bað um* OST. 'I asked for CHEESE.'	[ɔsːt]	(cf. unfocused [ɔst])
(6)	a.	*Þetta er* TAPPI. 'This is a TAP.'	[tahː.pɪ]	(cf. unfocused [tah.pɪ])
	b.	*Þú átt að* VAKNA. 'You are to WAKE UP.'	[vahː.kna]	(cf. unfocused [vah.kna])
	c.	*Mig vantar* HATT. 'I need a HAT.'	[hahːt]	(cf. unfocused [haht])

[10]As Árnason (1986, 2011) does not work within a moraic framework, I have rephrased this in terms of moras. Árnason's (2011) model of syllabic structure builds on a proposal by Haugen (1958) that the Icelandic syllabic nucleus is either Vː or VC. Árnason's prosodic representation consists of three constituents: onset, rhyme, and appendix. The last consonant of the syllable is typically the appendix, and considered extrametrical (i.e., non-moraic). The rhyme contains both the vowel nucleus and any following non-appendix consonant (i.e., the moraic segments in the syllable). Thus, Árnason's rhyme is always Vː or VC, and he observes that lengthening under focus occurs at the end of this constituent, increasing the duration of the consonant if it is present, or the vowel otherwise. Under a moraic model, this describes second mora lengthening.

[11]Apart from (5a), where Árnason (1986) merely says the word has a "very long [aː]".

The uneven increase in the duration of the [h] element rather than the following stop suggests that these are prosodically distinct segments rather than a single affricate-like heterogeneous segment. There is therefore strong evidence supporting the analysis of Icelandic preaspiration as a /h/ segment separately from the following stop, even though the historical development and morphology of the language make the original source of the preaspiration very clear.

One possible conclusion about Icelandic based on these data is that preaspiration is not a productive process in the phonology of the language; under this view, preaspiration cannot be interpreted as a synchronic instantiation of [spread glottis] on the consonant, or as a gestural misalignment. However, an alternate analysis in which preaspiration is phonologically active is also available, based on [h] alternations within paradigms as well as production of foreign words by Icelandic native speakers. Nonetheless, this analysis does not require preaspiration to be a feature of the following stop. I argue that as preaspiration has a moraic basis, the appearance of [h] in alternations and foreign words is a part of maintaining the desired prosodic structure of Icelandic words.

In the examples shown earlier in (4c–e), preaspiration was observed in morphophonological alternations (e.g., derived geminates: /ljout-t/ [ljouht] 'ugly.N'; C+N sequences: /vak-na/ [vahkna] 'wake up.INF'). With these kinds of data, it is hard to be certain whether the observed patterns are an active part of the phonology or are set of fossilized forms. However, we also see that loans from other languages into Icelandic contain preaspiration (Thráinsson 1978), and native Icelandic speakers have been observed for decades to produce preaspiration when speaking L2 languages like English and German (Haugen 1958, Thráinsson 1978, Sigurjónsson 2015). The data in (7) illustrate adaptation of foreign words to Icelandic phonology, with the first three rows showing the appearance of preaspiration. The words in (7a) are English loanwords into Icelandic (from Thráinsson 1978: 15 and Kvaran & Svavarsdóttir 2004: 12), while (7b–c) are productions of English and German words respectively by L1 Icelandic speakers (from Thráinsson 1978: 13).

(7) Loanwords and L2 productions of foreign words by Icelandic speakers

a.	*sjoppa*	[sjɔhpa]	'shop'
	lotterí	[lɔhtɛri]	'lottery'
	rokk	[rɔhk]	'rock'
	boddí	[pɔtti]	'body'

b.	*rip*	[rɪhp]
	met	[mɛht]
	block	[plɔhk]
	deep	[diːp]
	coke	[k^{h}ouːk]
c.	*Mitte*	[mɪhtɛ]
	mit	[mɪht]
	Acker	[ahkɛr]
	Miete	[miːt^{h}ɛ]
	Mut	[muːt^{h}]

Although these particular data are relatively old, productions of this kind are still typical of modern Icelandic learners of all ages (Sigurjónsson 2015). It is immediately apparent from the data in (7b–c) that foreign words with lax vowels followed by voiceless consonants (top three rows) are produced with short vowels and preaspiration, while words with tense vowels (bottom two rows) are produced with long vowels and no preaspiration. This is in line with restrictions on syllable shape in Icelandic: in order to have a short vowel, the syllable must have a moraic coda. Another possible adaptation of foreign words would have been to lengthen the following stop (yielding [rɪpp] for 'rip', for instance). In fact, this is how other English words with lax vowels are adapted, as seen in the final example in (7a) (data from Kvaran & Svavarsdóttir 2004). This fits the structure of native Icelandic words, e.g., *odd* [ɔtː] 'point.ACC' (Thráinsson 1978: 14). These data show that Icelandic speakers map laryngeal categories from other Germanic languages onto the Icelandic fortis/lenis contrast, and are able to make use of preaspiration for prosodic purposes to close syllables containing lax vowels.

Ultimately, we can make a few key conclusions about preaspiration in Icelandic: it takes up an entire mora in the syllable before the stop and thus only follows short vowels, and it appears to serve a prosodic role in closing a stressed syllable containing a lax vowel. It is also worth noting that preaspiration is invariant in Icelandic. As mentioned earlier in §2, variable appearance of preaspiration in other languages has often been interpreted as a sign that it is "merely" a phonetic effect. While I do not necessarily adopt this as a criterion for its phonological status, preaspiration clearly plays a phonotactic role in Icelandic.

The discussion around the segmental and prosodic status of preaspiration in Icelandic has illustrated the kind of evidence we can look for in other reported cases of preaspiration in order to determine its moraic status. Specifically, some of these telltale properties might be:

- affinity for stress, such as being limited to positions following a stressed vowel;
- lengthening under stress or emphasis of the preceding syllable;
- phonotactic restrictions on preaspiration after long vowels (or lower frequency of preaspiration after long vowels);
- complementary phonetic duration with a preceding vowel ([Vː]~[Vh]);
- complementary phonetic duration with a following geminate ([Cː]~[hC]).

Having set some expectations, we will next consider closely related Faroese, where preaspiration patterns are similar but have received a different phonological interpretation.

3.2 Faroese

Faroese (`faro1244`; North Germanic; Faroe Islands, Denmark) is very closely related to Icelandic, and phonologically quite similar in the consonantal domain, with voiceless aspirated fortis stops contrasting with unaspirated lenis stops that may be realized with voicing. The apparent positional allophony between postaspiration and preaspiration is present in Faroese as well, with initial fortis stops being phonetically postaspirated, and preaspiration found before fortis geminates and fortis stop-nasal sequences. This is illustrated by the Tórshavn Faroese[12] data in (8), where fortis stops are given first in each word pair and lenis ones second.[13] The first key difference between Faroese and Icelandic is already visible in the long medial stops in (8b): Faroese has retained the historical fortis geminates, while in Icelandic these have all undergone degemination (and only lenis geminates are still present).

[12]Helgason (2002) (following Petersen 1995) describes three main dialect regions for Faroese, which he labels numerically. I refer to these regions geographically: Helgason's Area 1 (Mykines, Vágar, Eysturoy, northern Streymoy) is the northwestern dialect, Area 2 (Norðoyar, southern Streymoy) is the central–eastern dialect, and Area 3 (Sandoy, Suðuroy) is the southern dialect. Tórshavn Faroese is one of the central–eastern dialects.

[13]As mentioned in Footnote 6 for Icelandic, this stop contrast is now limited to word-initial position in most Faroese dialects. Under an analysis of preaspiration as a distinct element that is no longer a feature of the stop laryngeal contrast, there is no laryngeal contrast in Faroese geminates. Both fortis and lenis stops are unaspirated following long vowels in the central–eastern dialect, and voiced following long vowels in the southern dialect. Only the northwestern dialect still contrasts aspiration after long vowels (Helgason 2002).

(8) Tórshavn Faroese fortis and lenis stops (Árnason 2011)

a.	i.	*peika*	[pʰaiːka]	‘to point’
		bera	[peːɹa]	‘to carry’
	ii.	*tosa*	[tʰoːsa]	‘to speak’
		dalur	[tɛaːlʊɹ]	‘valley’
	iii.	*kemur*	[tʃʰeːmʊɹ]	‘comes’
		geva	[tʃeːva]	‘to give’
	iv.	*kola*	[kʰoːla]	‘lamp’
		gamal	[kɛaːmal]	‘old’
b.	i.	*hoppa*	[hɔhpːa]	‘to hop’
		pabba	[pʰapːa]	‘father’
	ii.	*hatt*	[hahtː]	‘hat’
		hædd	[hatː]	‘height, level’
	iii.	*takka*	[tʰahkːa]	‘to thank’
		nagga	[nakːa]	‘to shiver’
c.	i.	*vatnið*	[vahtnɪ]	‘water.DEF’
		oynni	[ɔitnɪ]	‘island.DEF.DAT’
	ii.	*vakna*	[vahkna]	‘to wake up’
		eygna	[ɛkna]	‘eyes.GEN’

As in Icelandic, most dialects of Faroese only permit preaspiration following a short vowel. This is visible in the first word [pʰaiːka] in (8a), where there is no aspiration between the long vowel and the historically fortis stop, compared to the fortis examples in (8b), where preaspiration is seen between short vowels and geminates (e.g., [hɔhpːa]). This pattern immediately suggests that preaspiration bears moraic weight in Faroese. An exception to this pattern in the northwest dialect will be further discussed below.

Stress in native Faroese words is overwhelmingly on the first syllable of the word. This means that the examples of preaspiration seen above all occur immediately following a stressed vowel. In stressed syllables, Faroese also exhibits a complementary pattern in consonant and vowel duration, similar to that of Icelandic. The details of this length alternation are somewhat more complicated than in Icelandic due to historical vowel shifts in Faroese, as well as significant but underdescribed dialectal variation (Lockwood 1955, O’Neil 1964, Cathey 1997). Although the details of these vowel changes are outside the scope of this chapter, and I will largely cite data from the Tórshavn dialect of Faroese (Árnason 2011), some relevant dialectal variation in preaspiration is discussed later. Some examples of the quantity patterns are given in (9).

(9) Durational complementarity in heavy stressed syllables (Árnason 2011)

a.	i.	*mytisk*	[myː.tɪsk]	‘mythical’
		mystisk	[mys.tɪsk]	‘mysterious’
	ii.	*tola*	[tʰoː.la]	‘to endure’
		toldi	[tɔl.tɪ]	‘endured’
	iii.	*sleta*	[stleː.ta]	‘sleigh’
		hella	[hɛt.la]	‘flat rock’
	iv.	*gloyma*	[klɔiː.ma]	‘to forget’
		gloymdi	[klɔim.tɪ]	‘forgot’
	v.	*pápi*	[pʰɔɑː.pɪ]	‘father’
		hoppa	[hɔhp.pa]	‘to hop’
b.	i.	*jól*	[jɔuːl]	‘Yule’
		mjólk	[mjœl̥k]	‘milk’
	ii.	*blað*	[plɛaː]	‘page’
		hædd	[hatː]	‘height, level’
	iii.	*ljós*	[ʎɔuːs]	‘light’
		ljótt	[ʎœhtː]	‘ugly.N’

The interesting question here is whether preaspiration is limited to stressed positions, however this proves difficult to establish. Due to Faroese stress placement, morpheme size, and phonotactics, I have not found examples of definitively unstressed syllables where preaspiration might also be expected to appear. Native roots are generally monosyllabic or disyllabic, and disyllabic roots seem to have a limited set of possible word-final codas (/n, r, l, rt, st, sk/), none of which allow for assessment of preaspiration.[14] In compounds, roots tend to have at least secondary stress, making it difficult to find completely unstressed preaspiration (Lockwood 1955).[15]

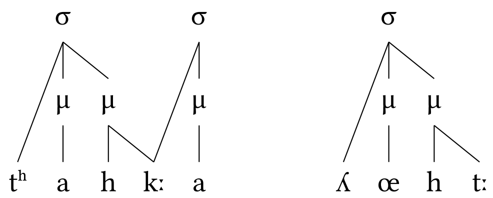
The one situation where I have come across preaspiration outside of a primary stressed syllable is in examples of words with non-initial primary stress: *aftaná* [aʰtaˈnɔɑː] ‘behind, afterwards’; *afturum* [aʰtəˈɹʊmː] ‘behind, rearwards’; *afturat* [aʰˈtrɛaːt] ‘furthermore’; *upprunaliga* [ʊʰpːˈruːnalija] ‘originally’ (Árnason 2011:

[14] The final /rt/ codas do surface as [ɹ̥t] or [ɻ̊ʈ], with a voiceless liquid, but as noted for Icelandic, even if this devoicing is analyzed as the same phenomenon as preaspiration synchronically, in a prosodic sense it is unambiguously a moraic coda consonant.

[15] For instance, Árnason (2011) does not transcribe preaspiration at the end of the place name *Klaksvík*, where it is theoretically possible. However, it is unclear to me whether *vík* [vʊik] ‘bay’ would be expected to have secondary stress, as this is a place name that may have been lexicalized. Additional data on secondary stress and preaspiration would be valuable here.

277).[16] In most of these words, the preaspiration is actually a lenited form of /f/, unlike "actual" preaspiration (found before [Cː] or [Cn]). I find it interesting that Árnason (2011) transcribes this debuccalized coda fricative with a superscript [ʰ], the same way that he transcribes preaspiration in [ʊʰpːˈruːnalija] and elsewhere. This equivalent transcription suggests that he finds these to be phonetically comparable. Establishing whether this fricative debuccalization has the same prosodic and durational properties as preaspiration elsewhere in the language is a promising avenue for future work. As far as stress is concerned, Árnason (2011) refers to these as unstressed prefixes, but the morphologically complex nature of these data means that it is difficult to establish whether secondary stress is truly absent.

The maintenance of fortis geminates in Faroese, alongside the appearance of preaspiration, indicates that the moraic structure of Faroese is different than that of Icelandic. Like Icelandic, Faroese has non-moraic final consonants, but the moraic association seen in stressed syllables is different, following the pattern of Figure 1b. Proposed moraic structures for Faroese preaspiration are given in Figure 5, which show the sharing of the second mora between preaspiration and the following stop.



(a) *takka* 'to thank' (b) *ljótt* 'ugly.N'

Figure 5: Proposed moraic structures for Faroese preaspiration

The absence of degemination in Faroese fortis stops leads Árnason (2011: 230) to conclude that preaspiration is a "subsegmental entity" in the language, unlike its status as a full segment in Icelandic. He supports this position with evidence from the same kind of "stress test" described above for Icelandic (5–6), in which words are produced with strong emphasis to lengthen the second mora and determine prosodic constituency (Árnason 2011, Schäfer & Árnason 2012). In Faroese,

[16]For consistency, and in line with my proposal that preaspiration is not the inverse of postaspiration and bears moraic weight, I consistently transcribe it as [h] throughout this typological survey. However, in this instance I reproduce Árnason's transcriptions as they are.

Árnason (2011) reports that the stop following preaspiration lengthens, which he interprets as supporting a subsegmental analysis of preaspiration.

Although this diagnostic yields different results in Faroese and Icelandic, this is unsurprising if the two languages have different moraic structures for preaspiration. In Icelandic, preaspiration occupies the entire second mora, and can lengthen independently of the following non-moraic consonant. In Faroese, following the proposed moraic structures in Figure 5, a lengthening of the second mora should result in longer durations for both the preaspiration and the stop closure, as the weight is distributed between the two. This is precisely the pattern seen in the preliminary data reported by Árnason (2011).[17] Although Árnason summarizes the results as stop lengthening under stress, both preaspiration duration and stop duration are seen to increase.

Árnason's analysis that preaspiration is "subsegmental" in Faroese does not predict this kind of coordinated lengthening. We do not necessarily expect a longer stop closure to imply a longer preaspiration duration. Following Shaw et al. (2021), multiple gestures associated to a single complex segment are coordinated at their onset, whereas gestures making up a segment sequence have the onset of the second gesture coupled to the offset of the first. If we interpret preaspiration as a [spread glottis] feature on the stop, the onset of the laryngeal spreading gesture should be coupled (with some offset) to the onset of the oral gesture, meaning that the duration of the consonant should not affect the duration of the laryngeal component. Therefore, an analysis in which preaspiration is segmentally distinct and has its own moraic weight is more appealing here.

For the varieties of Faroese described thus far, the evidence for the distinct prosodic status of preaspiration appears strong. One small complication in this picture comes from northwestern dialects of Faroese, where preaspiration is reportedly possible after non-high long vowels (Helgason 2002). In this dialect area, preaspiration is not found after long high monophthongs or long diphthongs ending with high vowels, but is found after other long vowels. Two of Helgason's four Faroese speakers display this pattern, for which he provides the transcriptions in (10).[18]

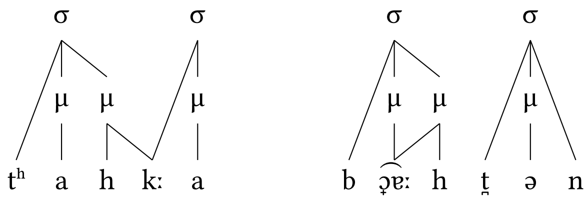
[17] The published data in Árnason (2011) is quite preliminary, and the subsequent work by Schäfer & Árnason (2012) does not appear to have been published yet. However, I am assuming that the trends reported by Árnason (2011) are upheld by the full experimental results of Schäfer & Árnason (2012).

[18] One of the two speakers also categorized /eː/ as a high vowel, and thus would not produce preaspiration in *eta* 'eat'.

(10) Northwestern Faroese preaspiration (Helgason 2002: 57)

a.	*bátin*	[bɔ̹͡ɐːht̪ən]	‘boat.DEF’
	eta	[eːht̪a]	‘eat’
b.	*vík*	[vʊ͡iːkʰ]	‘bay’
	lykil	[liːtʃəl]	‘key’

Although this height-based prosodic pattern is interesting, the data does not rule out a moraic account of preaspiration. It is possible that northwestern Faroese dialects allow the weight of preaspiration to be shared with the coda before geminates, or with the vowel after long vowels, with the constraint that long high vowels must take up a full two moras.[19] Since this preaspiration after long vowels is necessarily followed by a non-moraic consonant, the weight alternation in Figure 6 is possible, although this should be confirmed through phonetic investigation of segment duration ratios.



(a) *takka* ‘to thank’ (b) *bátin* ‘boat.DEF’

Figure 6: Proposed moraic structures for preaspiration in northwestern Faroese dialects, where it is attested following non-high long vowels

Helgason (2002) does report phonetic measurements for his Faroese speakers, but more data is needed on some crucial comparisons in order to confirm or reject this proposal. Helgason reports averaged segment durations for his four speakers, combining across the two dialect groups present, which he admits obscures some asymmetries in the data. On average, preaspiration appears to reduce the length of both the preceding vowel and the following stop, which might be a result of averaging the weight alternations in the structures above. Some trends are clear from his plots divided by speaker: northwestern dialect speakers show approximately similar preaspiration durations in both [VːhC] and [VhCː] words,

[19] This restriction could be based on vowel tenseness, which is correlated to length. Vowel tenseness shows interactions with preaspiration and laryngeal features in southeastern Welsh as well (Iosad 2023).

which is predicted by the consistent 0.5 μ weight that preaspiration has in both word shapes. Vowels are also indeed longer in [VːhC] words than [VhCː] words, when comparing words with similar preaspiration duration. However, what is missing as support for these specific moraic structures is a focused comparison of vowel length in words with and without preaspiration. We predict significant shortening of long vowels before preaspiration ([VːC] vs. [VːhC] environments), to a much greater degree than short vowels before preaspiration ([VCː] vs. [VhCː] environments). Helgason (2002) does report that preaspiration duration in Tórshavn Faroese is correlated with preceding vowel length for all of his speakers, which is to be expected if preaspiration is prosodically within the same syllable as the vowel.

Helgason (2002: 161–167) also has a lengthy discussion of phonetic variability and oral coarticulation in Faroese preaspiration.[20] He does not have a similar discussion about Icelandic (as he analyzes phonetic data from Faroese but not from Icelandic), and there is no work explicitly assessing the degree of oral coarticulation in Icelandic preaspiration, but it does appear that Faroese may be more prone to oral fortition of preaspiration than Icelandic is. Oral fortition of preaspiration is commonly reported cross-linguistically, and is sometimes judged to be a representative of a late stage of diachronic development or a step towards the loss of preaspiration (e.g., Silverman 2003, Clayton 2010). In the context of the moraic account of preaspiration discussed here, I suggest that the articulatory differences between Icelandic and Faroese could be the result of either the shorter duration of preaspiration (making it more prone to coarticulation) or some influence of mora sharing on coarticulation. Although ultimately language-specific phonetic implementation is somewhat idiosyncratic, it is worth examining in the future whether there are cross-linguistic trends between oral coarticulation of preaspiration and its phonetic duration or moraic association.

Finally, I will briefly touch on the issue of variability in Faroese preaspiration. Árnason (2015: 132) notes that preaspiration is variable on medial consonants, describing it as a "choice between preaspiration … or no aspiration". This description suggests that preaspiration is variable in its incidence, rather than in its phonetic realization, and the associated figure indicates that the appearance of preaspiration is particularly low in the southern dialect region.[21] However,

[20]Thanks to an anonymous reviewer for pointing this out specifically.

[21]The figure that Árnason (2015) provides only shows an average "grade" that speakers were given for their use of preaspiration, which I gather reflects average rate of use, but it is not clear to me exactly how the grading was done. It is also unclear whether the variability is within speakers or between speakers or both.

more precise details about the variability are difficult to determine from Árnason's description. For the issues discussed in this chapter, the most important questions concern the durations of the segments when preaspiration is present compared to when it is not. Based on the moraic structures proposed in Figure 1, I would predict that in utterances without preaspiration, either the preceding vowel would lengthen (occupying 1.5 μ) or the following consonant would lengthen (occupying the entire second mora). Crucially, as preaspiration is a prosodic phenomenon and associated with moraic weight, we expect some compensatory segmental length change when it is absent, and not just a shorter word. Variation in the rate of occurrence of preaspiration is not in any way troublesome for this theory, and does not inherently affect the status of preaspiration within the prosodic phonology (Iosad 2017a, Hejná 2019; see also the variability in Swedish preaspiration in §3.3).

In sum, phonetic evidence from duration ratios in Faroese provides support for the claim that preaspiration bears moraic weight in Faroese, and is not simply a featural property of the following stop. The prosodic structures proposed for Faroese preaspiration provide a phonological proposal about how this phenomenon differs from that seen in Icelandic, in a way that reflects the similarities between these systems and their durational relations with a preceding vowel. Future work on the patterns of Faroese preaspiration will hopefully help confirm or reject the structures proposed above.

3.3 Swedish & Norwegian

In both Swedish (`swed1254`; North Germanic; Sweden) and Norwegian (`norw1258`; North Germanic; Norway), stressed syllables are necessarily heavy, and long vowels and moraic codas are in complementary distribution (Kristoffersen 2000, Riad 2014). In both languages, preaspiration is generally reported before voiceless (or fortis) stops and affricates, particularly in medial post-tonic position. The fortis stops are postaspirated in initial position, unless they follow /s/ in an onset cluster (Kristoffersen 2000, Riad 2014). Preaspiration is widespread across Swedish and Norwegian dialects, but is more common and more prominent in some dialects than others, and its frequency of use varies by speaker and lexical item (Helgason 2002, Tronnier 2002, Wretling et al. 2002, 2003, Iosad 2018). This is summarized in (11) with data from Central Standard Swedish. Data for Norwegian are extremely similar and are not given here (see Kristoffersen 2000).

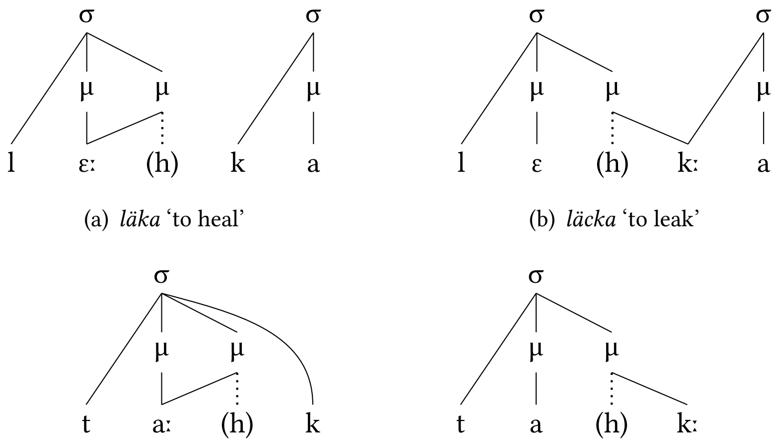
(11) Central Swedish quantity pairs (Schaeffler 2005: 59, Riad 2014: 159)

a.	i.	*tak*	[taːk] ~ [taːhk]	‘roof’
		tack	[takː] ~ [tahkː]	‘thanks’
	ii.	*låt*	[loːt] ~ [loːht]	‘song’
		lott	[lɔtː] ~ [lɔhtː]	‘fate’
	iii.	*dit*	[diːt] ~ [diːçt]	‘there’
		ditt	[dɪtː] ~ [dɪçtː]	‘yours’
b.	i.	*såpa*	[ˈsoː.pa] ~ [ˈsoːh.pa]	‘soft soap’
		soppa	[ˈsɔp.pa] ~ [ˈsɔhp.pa]	‘soup’
	ii.	*puta*	[ˈpʰʉ̟ː.ta] ~ [ˈpʰʉ̟ːh.ta]	‘to pout’
		putta	[ˈpʰɵt.ta] ~ [ˈpʰɵht.ta]	‘to push’
	iii.	*läka*	[ˈlɛː.ka] ~ [ˈlɛːh.ka]	‘to heal’
		läcka	[ˈlɛ̝k.ka] ~ [ˈlɛ̝hk.ka]	‘to leak’

The situation in Swedish and Norwegian is largely similar to that discussed for Icelandic and Faroese in §3.1 and §3.2. As in those languages, Helgason (2002) reports that the duration of preaspiration increases as the duration of the preceding vowel increases, suggesting that these are prosodically within the same syllable. The main differences are that preaspiration is much more variable[22] both between and within speakers in Swedish and Norwegian, with some speakers having frequent and significant preaspiration and others less or none at all, and that preaspiration is reported before both short and long vowels. Because of this degree of variability, and relatively short phonetic duration of preaspiration in the standard varieties, preaspiration is often not included in descriptions of these languages. In fact, the book-length phonological descriptions by Riad (2014) and Kristoffersen (2000) do not discuss preaspiration. However, as noted in §2, variability is not evidence that a phenomenon is not phonological, and as illustrated in Figure 1, under a mora-sharing approach, moraic preaspiration is structurally possible after both short and long vowels. The moraic structures necessary to represent this quantity distribution pattern are shown in Figure 7; they are essentially the same as those proposed in Figure 6 for non-high vowels in northwestern Faroese. In these figures, dotted lines represent associations that are only present when preaspiration is produced.

Different quantity patterns emerge for some other Swedish dialects, which help flesh out the quantity typology for this language. Two dialects in particular

[22]Of course, it is possible that preaspiration could be just as variable in Faroese, but the details of this are unclear.



(a) *läka* ‘to heal’ (b) *läcka* ‘to leak’ (c) *tak* ‘roof’ (d) *tack* ‘thanks’

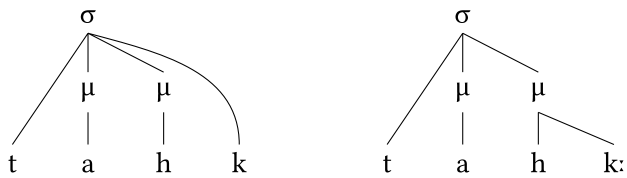
Figure 7: Moraic structures for preaspiration in Central Standard Swedish

have been subjected to closer investigation because of their notably long preaspiration: Vemdalen (in the central–west region of Härjedalen) and Arjeplog (in an eponymous northern region). In Arjeplog Swedish, there is a contrast between long preaspiration and short preaspiration, while in Vemdalen there is a contrast between long preaspiration and none at all (Wretling et al. 2002, 2003). The correspondences between forms in these dialects compared to Central Standard Swedish are given in Table 1. Transcriptions are based on the data in (Wretling et al. 2002, 2003).

Table 1: Preaspiration in Central Standard Swedish, Arjeplog, and Vemdalen

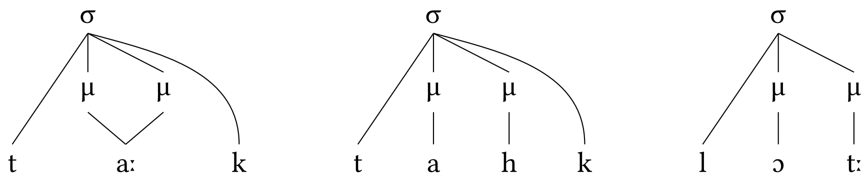
		CSS	Arjeplog	Vemdalen	
a.	*tak*	[taːhk]	[tahːk]	[taːk]	‘roof’
	tack	[tahkː]	[tahkː]	[tahk]	‘thanks’
b.	*låt*	[loːht]	[lohːt]	[loːt]	‘song’
	lott	[lɔhtː]	[lɔhtː]	[lɔtː]	‘fate’
c.	*dit*	[diːht]	[dihːt]	[diːt]	‘there’
	ditt	[dɪhtː]	[dɪhtː]	[dɪht]	‘yours’

Measurements show that vowel duration does not vary significantly in Arjeplog between forms that are [V:C] vs. [VC:] in Central Standard Swedish, but preaspiration does vary in duration significantly. This suggests that preaspiration following earlier long vowels has expanded to take up the whole second mora in Arjeplog. The opposite has taken place in Vemdalen, where preaspiration is no longer found after long vowels, but is significantly longer after short vowels. This change away from mora sharing proceeded in different directions in different words, being lost in *lott* in favour of a moraic coda (Wretling et al. 2002). These durational differences from Central Standard Swedish align well with a moraic account, which is given in Figure 8 for Arjeplog and Figure 9 for Vemdalen.



(a) *tak* ‘roof’ (b) *tack* ‘thanks’

Figure 8: Moraic structures for Arjeplog preaspiration



(a) *tak* ‘roof’ (b) *tack* ‘thanks’ (c) *lott* ‘fate’

Figure 9: Moraic structures for Vemdalen preaspiration

The pattern seen in Vemdalen also occurs elsewhere in Swedish. On Kökar Island in the southeast of the Åboland archipelago, preaspiration did not develop at all after long vowels (Karsten 1892, as cited by Helgason 2002).

Examination of the durational patterns in Swedish dialects has shown that the different patterns observed for different language varieties all fit into the typology of moraic association to preaspiration in different ways. We can interpret these durational alternations as reflecting an underlying difference in moraic structure, and conclude that preaspiration is weight-bearing in Swedish dialects as well. In Norwegian, preaspiration is just as widespread as in Swedish (Helgason 2002, Iosad 2018), but detailed phonetic investigation of preaspiration is still needed. Given its close relation to Swedish and its similar quantity system, it would be surprising to find dramatic divergence in this language.

3.4 Scottish Gaelic

Scottish Gaelic (`scot1245`; often simply Gaelic; autonym *Gàidhlig* [ˈkaːlɪkʲ]) is a Goidelic Celtic language spoken in northern Scotland. After Icelandic, it is the next most commonly cited example of preaspiration, and it is mentioned prominently in the typological overviews of Helgason (2002), Silverman (2003), and Clayton (2010). However, as in Icelandic, preaspiration in southern dialects of Scottish Gaelic has been convincingly argued to be a moraic coda (Iosad et al. 2015). After outlining the evidence for this, I will show that preaspiration in northern dialects also shows a prosodic connection to the preceding syllable.

Stops in Scottish Gaelic contrast in postaspiration word-initially, and are usually considered to contrast in preaspiration elsewhere in the word (Ladefoged et al. 1998, Nance & Stuart-Smith 2013, Nance & Ó Maolalaigh 2021). This echoes the pattern seen in Icelandic, and leads to the general assumption that there is complementary distribution between postaspiration word-initially and preaspiration word-medially and word-finally. Voicing plays no role in the stop inventory, and is largely absent phonetically (Nance & Stuart-Smith 2013). Examples of the initial aspiration contrasts and reported medial preaspiration contrasts are shown in (12), organized by place of articulation.[23] This data is from the Lewis dialect, which is commonly presented as an illustration of the language more generally.

(12) Gaelic stop contrasts (Nance & Ó Maolalaigh 2021: 263, 267)

a.	i.	*bò*	[poː]	‘cow’
		poll	[pʰɔul̪ˠ]	‘mud’
	ii.	*obair*	[opɪɾʲ]	‘work’
		capall	[kʰahpəl̪ˠ]	‘mare’
b.	i.	*duine*	[t̪in̪ʲə]	‘anyone’
		tuigsinn	[t̪ʰikʃin̪ʲ]	‘understanding’
	ii.	*fada*	[fat̪ə]	‘long’
		bata	[paht̪ə]	‘stick’

[23] As noted earlier in Footnote 6 for Icelandic, because of preaspiration there is effectively no laryngeal contrast in Gaelic stops outside of initial position.

	iii.	*bad*	[pat̪]	'bunch'
		cat	[kʰaht̪]	'cat'
c.	i.	*deoch*	[tʃɔx]	'drink'
		teòclaid	[tʃʰɔːhkl̪ˠɪtʃ]	'chocolate'
d.	i.	*geòla*	[cɔːl̪ˠə]	'yawl'
		ceòl	[cʰɔːl̪ˠ]	'music'
	ii.	*aige*	[ɛcə]	'at him'
		aice	[ehcə]	'at her'
e.	i.	*gaol*	[kɯːl̪ˠ]	'love'
		caol	[kʰɯːl̪ˠ]	'thin'
	ii.	*agad*	[akət̪]	'at you'
		aca	[ahkə]	'at them'
	iii.	*bog*	[pok]	'soft'
		boc	[pɔhk]	'male goat'

In the Lewis dialect region, preaspiration is reported before stops at all places of articulation, and is described phonetically as glottal frication. However, there is a great deal of variation across Scottish Gaelic dialects, both broadly and in the domain of preaspiration specifically. As a result of phonological differences between dialects, the moraic status of preaspiration is easier to demonstrate in more southern dialects than in the Lewis dialect. In the more southern dialects, preaspiration is commonly produced with oral fortition as [x], and is sometimes absent before certain places of articulation. These dialect patterns are summarized in Table 2.

Table 2: Gaelic preaspiration across dialect regions (Ó Dochartaigh 1997). Abbreviations refer to cardinal directions

Region 1	[	xp	xt	xk	]	SE Inverness, NW Perth, N Argyll
Region 2	[	p	xt	xk	]	small area around Aberfoyle
Region 3	[	hp	ht	xk	]	Hebrides except Lewis, W Inverness
Region 4	[	hp	ht	hk	]	Lewis, most of Ross-shire
Region 5	[	p	t	xk	]	South Argyll
Region 6	[	p	t	k	]	Kintyre, Isle of Arran

Overall, preaspiration is produced with glottal frication more often in northern dialects (R3, R4), while southern dialects have only a dorsal fricative articulation (R1, R2, R5). Preaspiration is present before labials in the fewest dialect regions, and is present before velars in all preaspirating dialects; dorsal fricative realizations of preaspiration also appear to be least common before labials and most common before velars (Clayton 2010, Iosad 2020, *inter alia*).

In the North Argyll dialect (Region 1), preaspiration is exclusively realized with dorsal frication ([x] or [χ]), rather than the glottal frication of Lewis (Region 4); furthermore, preaspiration is often absent after a long vowel (Iosad et al. 2015). This pattern is illustrated in (13).

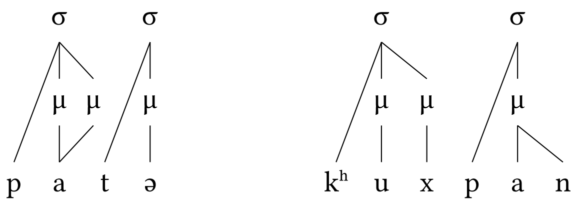
(13) North Argyll Gaelic preaspiration (Ó Dochartaigh 1997, Iosad et al. 2015)

a.	*cupan*	[kʰuxpan]	‘cup’
	pàpa	[pʰaːpə]	‘Pope’
b.	*putan*	[pʰuxtan]	‘button’
	bàta	[paːtə]	‘boat’
c.	*poca*	[pʰoxkə]	‘pocket’

Based on an acoustic study of North Argyll Gaelic, Iosad et al. (2015) argue that preaspiration in this dialect region is best analyzed as a distinct moraic segment. Operating under the usual assumption that preaspiration is an instantiation of the [spread glottis] feature of the following stop, Iosad et al. (2015) claim that the aspiration contrast is neutralized in the position after a long vowel, with preaspiration being inhibited when it is not prosodically within the head foot (e.g., *bàta* would be footed [(paː)tə], leaving no room for preaspiration within the foot). Under their analysis, feet are bimoraic, and a syllable with a long vowel takes up both moras and the entire foot. Since the foot licenses the [spread glottis] feature, preaspiration can only be realized after a short vowel, when the second mora is available to host the preaspiration.

This analysis crucially requires preaspiration to be moraic, and prosodically linked to the syllable preceding the stop; thus, it supports my claims about the inherently moraic nature of preaspiration more generally. The most significant point of difference between their analysis of North Argyll Gaelic and my own is in the relevance of foot structure. In my view, the crucial element in the realization of preaspiration is its linkage to moraic weight rather than to foot structure. Furthermore, apart from its distribution preceding fortis stops, there is no clear evidence of a synchronic phonological link between [h] and a following stop. My proposed moraic structures, shown in Figure 10, are largely the same as those of Iosad et al. (2015), apart from their introduction of the foot level and the indication of preaspiration as sharing [spread glottis] with the stop.

This analysis of preaspiration extends to other southern dialects of Scottish Gaelic, where there is additional data supporting its moraic affiliation. In the



(a) *bàta* [paːtə] ‘boat’ (b) *cupan* [kʰuxpan] ‘cup’

Figure 10: North Argyll prosodic structures (adapted from Iosad et al. 2015)

Gaelic dialects of Argyllshire, including those of the islands of Jura, Islay, Gigha, and Colonsay, there is a process of glottal stop insertion that is complementary with preaspiration (Ó Dochartaigh 1997, Smith 1999, Jones 2006, 2009, Scouller 2017, Morrison 2019, Iosad 2021). In these dialects, it appears that non-final stressed syllables must be heavy, with a glottal stop inserted in the coda to ensure this (Iosad et al. 2015). The alternation involving the glottal stop is illustrated in (14), where stress placement conditions the presence or absence of [ʔ]. In (14a), monosyllabic *sruth* /sru/ requires glottal epenthesis to form a heavy syllable. In the compounded form in (14b), stress is on the initial syllable of the second root, the initial syllable remains light, and glottal epenthesis does not occur.

(14) South Argyll Gaelic (Jones 2006)

a. sruth [ˈsruʔ] ‘stream’
b. sruth-lìonadh [sru.ˈtʃiː.nəɣ] ‘flood’ (*lit.* ‘stream-filling’)

This epenthetic glottal stop appears only following a short vowel in stressed syllables, but its insertion is blocked by the presence of preaspiration (Jones 2006).[24] As in North Argyll Gaelic, preaspiration is only found after short vowels, meaning that in South Argyll Gaelic, syllables can have either a glottal coda

[24] I appreciate a reviewer pointing out that some caution is necessary here: subsequent work by Morrison (2019) and Iosad (2021) observes that glottal coda epenthesis is not blocked only in cases where there is a medial preaspirated stop, but also in words with a medial voiceless fricative: we get *drochaid* [trɔxətʲ] ‘bridge’, *seasamh* [ʃesəv] ‘standing’, and *toiseachd* [tʰoʃəx], where we otherwise would have expected either *[trɔʔxətʲ] or *[trɔhxətʲ] (Morrison 2019). This is interpreted by Morrison (2019) and Iosad (2021) to be a result of the [+spread glottis] character of the voiceless fricative, which blocks the glottalization. This requires some additional research and ideally phonetic investigation in order to confirm that there is no preaspiration here after all.

or a long vowel, but not a combination of these. Examples of this distribution in Colonsay Gaelic, a variety of South Argyll Gaelic, are shown in (15).

(15) Colonsay heavy stressed syllables (Ó Dochartaigh 1997, Scouller 2017)

a.	*crùban*	[ˈkruːpan̥]	‘brown crab’
	tobar	[ˈtʰoʔpər̥]	‘well’
	cupan	[ˈkohpan̥]	‘cup’
b.	*bàta*	[ˈpaːtə]	‘boat’
	bradan	[ˈpraʔtan̥]	‘salmon’
	Cille Chatan	[kʲʰɪʎɪ ˈxahtan̥]	‘Kilchattan’
c.	*dh’fhaoidte*	[ˈɣøːtʃɪ]	‘perhaps’
	oide	[ˈøʔtʃɪ]	‘tutor’
	ite	[ˈihtʃɪ]	‘feather’
d.	*fàgail*	[ˈfaːkal̥ʲ]	‘leaving’
	lagan	[ˈlˠaʔkan̥]	‘little hollow, dell’
	paca	[ˈpʰaxkə]	‘pack’

In these examples, each set of examples shows the same medial stop. The first word in each set has a preceding long vowel, the second a preceding [ʔ], and the third a preceding [h]. Historically, the forms with [hC] had a fortis stop, which is still reflected in the orthography. However, this contrast has been neutralized, which has made an analysis of preaspiration as a distinct coda [h] very plausible in this dialect. The complementary relationship between the long vowels and the laryngeal codas strongly supports a moraic analysis of preaspiration.

One caveat to the pattern in (15) is that short vowels also appear to be attested in stressed initial syllables in Colonsay Gaelic, which casts some doubt on the account of glottal stop insertion as a synchronic phonological process. Examples of this are numerous, including *gainmheach* [kɛɲax] ‘sandy’, *soirbheas* [sɔras] ‘prosperity’, and *coileach* [kʰɤlʲəx] ‘rooster’.[25] Scouller (2017) notes some of these exceptions, and explains that glottal stops are not found in words where epenthesis took place historically, at a great enough time depth that the epenthesis is

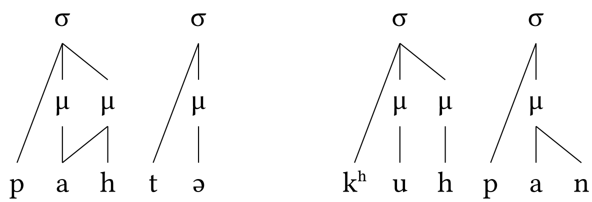
[25]These exceptions still exist even after setting aside words where the presence of a short vowel in an initial syllable might result from a different phonological process. For instance, in words with “hiatus”, a medial glottal stop separates a short vowel and a phonologically predictable “echo” vowel (e.g., *cridhe* [kriʔi] ‘heart’, *gobha* [koʔo] ‘blacksmith’). Similarly, words with *svarabhakti* vowel epenthesis (e.g., *dealg* [tʃalˠək] ‘pin’, *garbh* [karɪɣ̥] ‘rough’) appear to be disyllabic with a short first vowel, but are often analyzed as underlyingly monosyllabic (Scouller 2017).

reflected in the (fairly deep) orthography. This indicates that glottal stop epenthesis is likely not a synchronically productive process, and that it may have taken place historically in the Argyllshire varieties of Gaelic. However, this does not change the moraic analysis of the modern forms. Crucially, the glottal codas [h, ʔ] do not co-occur with each other or with a preceding long vowel in Colonsay Gaelic, which supports the claim that preaspiration behaves as a moraic coda. In fact, the historical nature of glottalization aligns with the historical nature of preaspiration. Although it is undeniable that the origin of preaspiration is related to the original laryngeal category of the following stop, there is no clear evidence that it is synchronically derived from or dependent on the stop, or clear evidence that a laryngeal contrast still exists on medial stops themselves.

The fact that this analysis extends across both North and South Argyll Gaelic also demonstrates that it is not limited to a particular type of preaspiration pattern. The North Argyll Gaelic studied by Iosad et al. (2015) is a [xp, xt, xk] variety (Region 1), while the South Argyll dialect of Colonsay Island is a [hp, ht, xk] variety (Region 3). This shows that the moraic status of preaspiration is not tied to its realization as [x], or to oral fortition of the fricative more generally.

Turning to Lewis Gaelic, and the [hp, ht, hk] varieties of Gaelic more generally, the phonological status of preaspiration appears to be slightly more difficult to establish. Preaspiration does not show the same categorical alternation with long vowels discussed in Argyllshire varieties, and glottalization is not a feature of this dialect, so the moraic structures presented earlier may not be applicable here. However, as this is one of the most studied dialects of Scottish Gaelic, there is substantially more phonetic research on preaspiration (Ní Chasaide & Ó Dochartaigh 1984, Ní Chasaide 1985, Ladefoged et al. 1998, Clayton 2010, Nance & Stuart-Smith 2013, Nance & Ó Maolalaigh 2021). The trends seen in aspiration duration display a prosodic relationship between preaspiration and the preceding vowel.

Across a variety of studies spanning several decades, preaspiration in Lewis Gaelic has been shown to be significantly shorter after long vowels than after short vowels (Ní Chasaide 1985, Clayton 2010, Nance & Stuart-Smith 2013). This trend is explicitly discussed as evidence of a prosodic complementarity between the vowel and the preaspiration within the syllable. Ní Chasaide (1985) suggests that vowel shortening before preaspiration could be a compensatory durational effect, serving to mitigate duration differences in syllables with and without preaspiration. Nance & Stuart-Smith (2013) say it is possible that preaspiration is phonologically part of the vowel length system: rather than being cued only by the duration of the vowel itself, phonemic vowel length might be cued by the length of the following preaspiration as well. These theoretical proposals approach the same fundamental insight I am pursuing from slightly different angles. The interdependence of vowel and preaspiration duration supports a prosodic model in which preaspiration is affiliated with the same syllable as the vowel, with the moraic weight of that syllable distributed across both elements. Rather than a categorical "all or nothing" preaspiration pattern dependent on vowel length, of the type in Figure 1a (seen in North Argyll Gaelic or Icelandic), a mora-sharing structure as in Figure 1c can capture a pattern in which vowel duration and preaspiration duration are complementary, as illustrated in Figure 11.



(a) *bàta* [paːhtə] 'boat' (b) *cupan* [kʰuhpan] 'cup'

Figure 11: Proposed moraic structures for Lewis Gaelic preaspiration

These structures capture the duration difference in preaspiration after short and long vowels, as well as the overall shorter phonetic duration of preaspiration in Lewis Gaelic as compared to more southern Gaelic dialects (Ní Chasaide 1985). Although the moraic representations above are categorical, the phonetic realization of preaspiration after a long vowel suggests that a more gradient distribution of weight across [Vh] may be possible, either phonologically or in the phonetic implementation. Ní Chasaide (1985) finds a strong negative correlation in Lewis Gaelic between the duration of preaspiration and the durational difference between long and short preceding vowels. As the preaspiration gets longer (takes up closer to one full mora), phonologically long and short vowels become more phonetically similar in duration.

Looking across a variety of Scottish Gaelic dialects, we have seen that different preaspiration patterns all show a connection between preaspiration and moraic weight, and that the proposed moraic structures in Figure 1 are able to capture the cross-dialectal variation in a satisfying way.

3.5 North Sámi

Preaspiration is commonly found in the Sámi languages, where it alternates within the morphological grade system. Bals Baal et al. (2012) present a compelling moraic account of preaspiration in North Sámi (`nort2671`; Uralic; Norway, Sweden, Finland) in their analysis of the language's phonology. Although the prosodic system is quite complicated, here I will simply show that preaspiration bears moraic weight in North Sámi, as the duration of preaspiration changes with the addition of a mora to the word.

The North Sámi quantity system is generally described as having three degrees, often referred to as Q1, Q2, and Q3 based on the length of the medial consonant, as illustrated in (16). These consonants are also described as short (C), long (CC), and overlong (C:C). Within individual pairs that alternate in quantity, one form is usually referred to as the "strong" grade and the other the "weak" grade. The difference between these grades can be represented by the association of moraic weight within the word: grade alternations within a root are the result of the addition of a single mora in the strong grade. In some cases, the difference between these quantity degrees is expressed through segmental duration, as shown in (16), but this quantity distinction can be expressed in other ways as well, including through preaspiration.

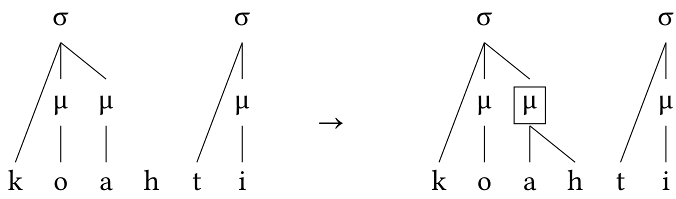
(16)	Q1	[ruosa]	'Sweden.ACC'
	Q2	[ruossa]	'cross.ACC'
	Q3	[rŭos:sa]	'cross.NOM'

In the examples in Table 3, words in the nominative case are in the strong grade (marked by addition of a mora), and words in the accusative case are in the weak grade. There are, among others, visible alternations in both the presence of preaspiration and its phonetic length, resulting in a [∅~h~h:] alternation from Q1 to Q3.

Under Bals Baal et al.'s (2012) analysis, preaspiration requires a moraic association in order to surface phonetically. In Q1 forms, seen in the accusative column in Table 3a–b, this does not happen. In contrast, in the strong grade forms in the nominative column, the preaspiration receives either half a mora or a full mora of weight, surfacing as phonetically short or long. This is reflected in Bals Baal et al.'s moraic structures, which are shown in Figure 12. In these structures, $\boxed{\mu}$ represents the affixal mora that marks the nominative singular case in their analysis.

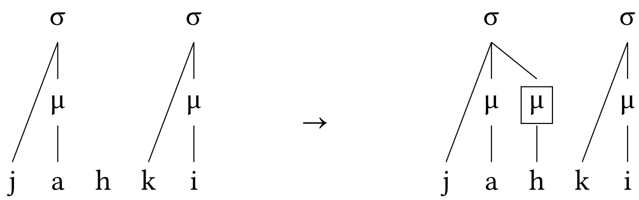
As these patterns and structures show, preaspiration is intrinsically linked to moraic weight in North Sámi, with two possible surface lengths depending on the moraic association. This is reminiscent of the pattern seen earlier in Arjeplog Swedish (§3.3), which (coincidentally or not) is spoken in a Pite Sámi area.

As noted earlier, Bals Baal et al. (2012) nonetheless still consider preaspiration to be a feature of the following stop. This unary analysis relies on a claim



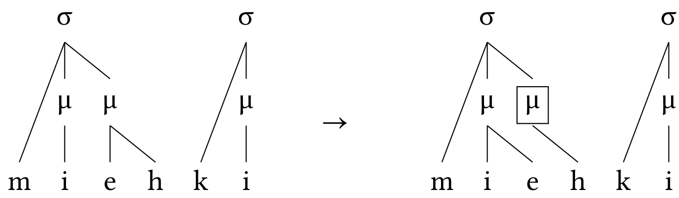
[goaði] ‘big tent.ACC’ [goahti] ‘big tent.NOM’

(a) Q1–Q2 alternation



[jagi] ‘year.ACC’ [jah:ki] ‘year.NOM’

(b) Q1–Q3 alternation



[miehki] ‘sword.ACC’ [mĭeh:ki] ‘sword.NOM’

(c) Q2–Q3 alternation

Figure 12: Alternations in preaspiration quantity (Bals Baal et al. 2012)

Table 3: Preaspiration quantity in strong and weak grade (Bals Baal et al. 2012)

	NOM	ACC	
a.	[neahpi]	[neabi]	‘nephew, niece’
	[goahti]	[goaði]	‘big tent’
	[tʃiehka]	[tʃiega]	‘corner’
	[aːhtsi]	[aːdzi]	‘hay-rack’
	[geahtʃi]	[geadʒi]	‘end’
b.	[ruhːtaː]	[ruðaː]	‘money’
	[jahːki]	[jagi]	‘year’
	[ohːtsu]	[odzu]	‘search’
c.	[ŏahːpa]	[oahpa]	‘teaching’
	[lahːti]	[laːhti]	‘floor’
	[mĭehːki]	[miehki]	‘sword’
	[bihːtsi]	[biːhtsi]	‘frost’
	[gĕahːtʃu]	[geahtʃu]	‘surveillance’

that preaspiration shows different grade alternations than those seen in underlying consonant clusters. Words with a sequence of a glide, liquid, or nasal before another medial consonant have length alternations in both consonants, unlike words with preaspiration, where only the [h] changes in length. However, this claim overlooks words with medial voiceless fricative codas. These do not follow the pattern seen in sonorant codas, but instead pattern like words with preaspiration. These patterns are shown very briefly in Table 4.

The words with a Q2–Q3 preaspiration pattern in Table 4a have long [hː] in the nominative and short [h] in the accusative, while the following consonant remains a non-moraic onset. This parallels the length changes seen with other coda fricatives in Table 4c. Crucially, fricative codas do not follow the same pattern as non-fricative codas, seen in Table 4b. If they did follow the non-fricative length pattern, we would expect the unattested accusative forms in the third column of Table 4c. This means that there is no basis to consider preaspiration phonologically distinct from other medial clusters in which the first consonant is a fricative. Although a more detailed discussion of North Sámi is beyond the scope of this brief overview, the data shown here demonstrate that North Sámi preaspiration both has a moraic association and can reasonably be analyzed as a coda [h].

Table 4: Grade alternations in medial clusters in North Sámi (Bals Baal et al. 2012)

	NOM	ACC		
a.	[lah:ti]	[la:hti]		‘floor’
	[bih:tsi]	[bi:htsi]		‘frost’
b.	[doaj:vu]	[doajv:u]		‘belief’
	[gŭow:lu]	[gŭowl:u]		‘area’
	[gum:pe]	[gump:e]		‘wolf’
c.	[bas:te]	[ba:ste]	*[bast:e]	‘spoon’
	[lŭos:ku]	[luosku]	*[luosk:u]	‘loose snow’
	[ʃuʃ:mi]	[ʃu:ʃmi]	*[ʃuʃm:i]	‘heel’

3.6 Spanish

Spanish is well known for a process commonly referred to as *s-aspiration*, which involves lenition or deletion of voiceless fricatives (most frequently /s/) in coda position. This lenition often results in [h] or phonetic breathiness, which has given the phenomenon its name (Torreira 2012). It is often summarized as a process in which /s/ has one of three allophones [s], [h], or ∅ (often with compensatory lengthening of the preceding vowel; e.g., Lipski 1984, 1994, O’Brien 2012, Walker et al. 2014) when it occurs in coda position. Thus, a word like *pasta* /pasta/ might be phonetically realized as [pasta], [pahta], or [pa:ta], depending on the dialect and speaker. Although productions like [pahta] are not usually termed “preaspiration”, the main reason for this comes down to analytical tradition rather than a principled structural argument. In the typological literature on preaspiration, it is stereotypically viewed as a property of a stop or the result of degemination, whereas here it clearly originates as a discrete consonant. However, it is phonologically indistinguishable from preaspiration in other languages from a synchronic perspective, and serves a prosodic role in maintaining the weight of the coda consonant.

The simplified description of s-aspiration as /s/ becoming [h] is the basis for theoretical analyses that depict it as a debuccalization process (e.g., Goldsmith 1981, Vaux 1998, O’Brien 2012). The oral features or supralaryngeal articulation of the fricative are lost in coda position, but its laryngeal features remain. However, the facts of s-aspiration are much more complex. The phonetic outcome of the coda /s/ lenition is quite variable, both within and across dialects, and it is often only a part of a larger phonological pattern of coda lenition, which may involve other segments as well, complicating a theoretical analysis. Most importantly for the arguments made here, some of these phonetic outcomes involve gemination of a following consonant (i.e., [hC] → [Cː]).

Andalusian Spanish (anda1279) has been an area of particular focus for research on coda lenition and s-aspiration, because of the diversity of phonetic realizations that have been reported. Lenition of syllable codas may result here in lengthening of the preceding vowel or the following consonant, pre- or postaspiration of that consonant, or even coalescence of a new post-consonantal fricative on the other side (e.g., Gerfen 2002, Torreira 2007a,b, 2012, Herrero de Haro & Hajek 2021). In Western Andalusian Spanish, the realization of an underlying coda /s/ depends primarily on the phonological environment. If there is no following consonant, /s/ is deleted or produced as [h], but if there is a consonant then gemination often occurs. The patterns are illustrated below, where (17a) shows /s/ utterance-finally, (17b) shows /s/ in word-final prevocalic position, and (17c) shows /s/ in pre-consonantal position.

(17) Realization of Western Andalusian Spanish coda /s/ (Torreira 2012: 49, 50)

a.	∅	*gatos*	[gato]	'cats'
b.	[h]	*los otros*	[lohotro]	'the others'
c.	gemination	*los martes*	[lomːarte]	'on Tuesdays'
		los lunes	[lolːune]	'on Mondays'
		las flores	[lafːloɾe]	'the flowers'
		los gatos	[loɣːato]	'the cats'

This gemination is essentially the reverse of the process that yielded preaspiration in Icelandic and other languages, and highlights the behaviour of [h] as a moraic coda, where it participates in a variety of diverse quantity-related prosodic changes. However, degemination is often connected to a debuccalization analysis, in which [h] is derived phonologically from the laryngeal features of a fortis stop. Conversely, the gemination process in Western Andalusian Spanish does not involve the features of [h] at all, and can result in sonorant geminates that would not share laryngeal features with [h]. This shows that preaspiration can fulfill a role as a length compensation mechanism in the prosodic phonology, irrespective of its featural content.

An anonymous reviewer notes that postaspiration being one of the outcomes of s-aspiration (e.g., /pasta/ → [paht^{h}a]~[pat^{h}a]; Parrell 2012, Ruch & Peters 2016) may be unexpected for the moraic account described here. Although the appearance of postaspiration is not necessarily predicted by this moraic model, it is not problematic for the model either, so long as we do not actually see variation between [ht] and non-moraic onset [t^h]. Phonetic data from Torreira (2007a) shows that stop closure duration is longer on average following underlying /s/ in Andalusian Spanish, while preaspiration is quite short. In other words, post-aspirated productions of words like /pasta/ might more accurately be [$pat{:}^h a$] or [$paht{:}^h a$]. The appearance of postaspiration in this context could be interpreted as spreading of the [spread glottis] feature to the stop, but this is tangential to the phonological account of preaspiration. Gemination of the following segment (as an alternative to preaspiration) supports the idea that either gemination or preaspiration can compensate for the loss of the moraic coda /s/ (cf. §4).

In Dominican Spanish (`domi1242`), s-aspiration is part of a larger pattern of coda lenition, in which other fricatives and also voiced segments like /r/ are reduced to [h] in coda position. This is illustrated in (18).

(18) "Debuccalization" of [ɾ] in Dominican Spanish (Núñez Cedeño 2014: 58)

di[f]*teria*	*di*[h]*teria*	'diphtheria'
a[f]*gano*	*a*[h]*gano*	'Afghan'
ca[ɾ]*ne*	*ca*[h]*ne*	'meat'
O[ɾ]*lando*	*O*[h]*lando*	'Orlando'

The fact that /r/ reduces to [h] in this context shows that this is not straightforwardly a lenition process in which voiceless coda fricatives debuccalize, as there is no [spread glottis] feature to be left behind by debuccalization. Rather, it appears that [h] serves as a general lenited consonantal coda. In this case, use of coda [h] in this way can be interpreted as a structure-preserving alternative to full deletion and compensatory vowel lengthening. Although this would not typically be called "preaspiration", the process is consistent with preaspiration patterns seen elsewhere, and thus the term seems equally applicable here. We are dealing with a period of glottal frication appearing before another consonant, which serves to maintain the prosodic structure of the word in the same way as in Icelandic degemination.

3.7 Algonquian languages

The term "preaspiration" is widely used in research on Algonquian languages, in spite of a widespread recognition that what is being described is a heterosyllabic [hC] cluster (Will Oxford, p.c.)[26]. For instance, the syllable templates given by Wolfart (1996) for Cree show that [h] and [s] are the only possible syllable codas. Most Algonquian languages have [hC] sequences, with the following consonant

[26] I am deeply grateful to Will Oxford for sharing many observations and data about these patterns in Algonquian languages.

being most commonly a stop or affricate, but with following fricatives or sonorants attested in some languages as well. The attested “preaspirated” consonants are summarized in Table 5 (based on Bloomfield 1925, 1946, Davis 1962, Pentland 1979, Ellis 1983, Greensmith 1985, Hayes 1995, Wolfart 1996, Starks & Ballard 2003, Schmirler 2016, Flynn et al. 2019).

Table 5: [hC] in Algonquian

Proto-Algonquian	hp	ht	htʃ	hk	hs	hʃ	hθ	hl	
Plains Cree	hp	ht	htʃ	hk				hj	
Woods Cree	hp	ht	hts	hk				hð	
Moose Cree	hp	ht	htʃ	hk				hl	
Swampy Cree	hp	ht	htʃ	hk				hn	
Meskwaki	hp	ht	htʃ	hk					
Menominee	hp	ht	htʃ	hk	hs				hn
Ojibwe	hp	ht	htʃ	hk	hs	hʃ			
Massachusett	hp	ht	htʃ	hk	hs	hʃ			
Delaware	hp	ht	htʃ					hl	hm
Cheyenne	hp	ht	htʃ	hk				hn	
Blackfoot	hp	ht		hk	hs				

Table 6: Emergence of preaspiration in Cree and Menominee. Reconstructions are from Hewson (1993), Cree data from Wolvengrey (2011), and Menominee data from Bloomfield (1962)

Proto-Algonquian	Cree	Menominee	
*teːnteːwa	teːhteːw	teːhtew	‘bullfrog’
*aloːθkana	ayoːskan	anoːhkan	‘raspberry’

Although many [hC] sequences are reconstructed back to Proto-Algonquian (Hewson 1993), some have been innovated. Diachronic loss of coda consonants has created additional instances of preaspiration before sonorants in Cree and Menominee (`cree1272`, `meno1252`; Bloomfield 1946, Pentland 1979), as shown in Table 6. These examples show [h] appearing through loss of both fricatives and nasals. This indicates that a debuccalization account is not appropriate here: [h] is being used as a moraic filler for the lost coda.[27]

[27]The same process is shown for Hopi in the next section, and is also seen historically in North

Loss of coda consonants is also the historical basis for preaspiration in Meskwaki (mesk1242). In the example below, the final /t/ of the prefix 'with' is maintained prevocalically (19a) but has become [h] before the root-initial [p] (19b).

(19) a. *wi:tapike:wa*
wi:t- api -ke: -wa
with- sit -INDEF.OBJ -3SG
's/he sits with people' (Hewson 1993)

b. *wi:hpe:wa*
wi:t -pe: -wa
with -sleep -3SG
's/he sleeps with someone' (Bloomfield 1946: 91)

In other cases, preaspiration may be lost diachronically. In Sheshatshiu Innu (mont1268; also Innu-Aimun or Montagnais), loss of preaspiration caused compensatory lengthening of preceding vowels. This shows that prosodic readjustment was necessary after the loss of [h]. In Table 7, pre-Cree reconstructions are compared with modern Plains Cree (plai1258) forms where preaspiration is retained, and with Sheshatshiu Innu forms where preaspiration has been replaced by vowel length.

Table 7: Loss of preaspiration in Sheshatshiu Innu. Pre-Cree and Sheshatshiu Innu forms are from MacKenzie (1980: 68); Cree forms are from Wolvengrey (2011)

Pre-Cree	Cree	Sheshatshiu Innu	
*akuhp	akohp	aku:p	'dress, blanket'
*miht	mihti	mi:t	'firewood'
*ispimihk	ispimihk	ispimi:t	'above'
*atihkw	atihk	ati:kw	'caribou'

In Munsee (muns1251), word stress follows a Weight-by-Position pattern, with coda [h] creating a heavy syllable (Hayes 1995: 212, with data from Goddard 1982). Feet in Munsee are iambic and built from the left edge of the word, with word-final feet being extrametrical. Stress appears on the final parsed foot. Degenerate

Germanic through the derivation of Old Norse (ON) geminates (later degeminated) from nasal–stop sequences: e.g., Latin *campus* '(battle)field' > ON *kapp* 'contest' (Page 1997). I am grateful to an anonymous reviewer for pointing out this parallel.

feet appear to be permitted so long as they are heavy syllables. The example that Hayes provides is the word *awasáhkame:w* 'in heaven', where stress falls on the heavy syllable [sah]. Following Hayes (1995), if this were not a heavy syllable, we would expect it not to be footed, and word stress would appear on [wa] instead. This is illustrated in (20), where the first line shows Hayes's metrical parse, and the second an unattested hypothetical parse in which [sah] does not form a degenerate foot. Parentheses delimit feet and angled brackets delimit final extrametrical syllables.

(20) Weight-by-Position in Munsee (Hayes 1989: 212)
 (a.wà) (sáh) <ka.mè:w> 'in heaven'
 *(a.wá) sah <ka.mè:w>

Finally, in Ojibwe (`ojib1241`), we find the reverse of the diachronic degemination seen in Icelandic. Most Ojibwe dialects underwent a shift in which the obstruents /p t k tʃ s ʃ/ split into a lenis and fortis series: some segments remained voiceless unaspirated singletons, but obstruents after /h/ became geminate /pː tː kː tʃː sː ʃː/ (Rhodes & Todd 1981).

From this very brief overview of a few Algonquian languages, it is clear that preaspiration in the family is also in all respects a coda [h] segment. Its moraic affiliation is seen in weight-sensitive stress assignment and diachronic development into long vowels or long consonants.

3.8 Hopi

In Toreva Hopi, preaspiration resulted from loss of historical coda consonants, which were usually nasals (Manaster-Ramer 1986). As in the Algonquian languages, this particular pathway of development poses difficulties for a conception of preaspiration as a [spread glottis] feature, and more strongly suggests preaspiration as a mechanism for maintaining weight within a syllable. Preaspiration was already in the process of being lost in Toreva Hopi around the time of early fieldwork by Whorf (1936, 1946), as it is absent before fricatives in his transcriptions. Later work on the language shows long vowels (as well as tonogenesis) resulting from loss of earlier preaspiration. Some illustrative data is given in Table 8.

3.9 Other languages

There is not enough space here for a full detailed discussion of every language where preaspiration is attested: these cases are far more numerous than is gener-

Table 8: Loss of preaspiration in Toreva Hopi (Whorf 1936, Malotki 1983)

Whorf (1936)	Malotki (1983)	
[wɨʰti]	[wɨ́ɨ̀ti]	'woman'
[leʰpe]	[léèpe]	'to fall'
[kɨʰkɨ]	[kɨ́ɨ̀kɨ]	'foot'

ally thought. Preaspiration is also attested in English, Irish, Welsh, Italian, Mongolian, Bora, Achumawi, and Purépecha, as well as in multiple languages in the Tibetan, Pomoan, Panoan, Tucanoan, Oto-manguean, Iroquoian, Cariban, Arawakan, Uralic, and Uto-Aztecan families. However, similar prosodic patterns are seen in many of these instances of preaspiration, and similar arguments for the phonological distinctness of preaspiration from the following stop and for its moraic weight can be made in all cases. The patterns of preaspiration in Ecuadorian Siona (van 't Veer et al. 2025 [this volume]) are also largely compatible with a view of [h] as a prosodic element. More detailed discussion of other languages and supporting evidence can be found in Craioveanu (2023). See also Hejná (2025 [this volume]) for a typological database of attested cases of preaspiration.

One issue that must be abbreviated here, but which recurs in some of the omitted languages and is worth mentioning, is that of initial preaspiration. As noted in §1, traditional accounts of positional allophony in aspiration describe aspirated phonemes, which are realized with postaspiration word-initially, but with preaspiration in word-medial or word-final positions (e.g., Ladefoged & Maddieson 1996, Silverman 2003, Clayton 2010). However, preaspiration is also found in word-initial position (although not in utterance-initial position) in languages like Mongolian (Svantesson et al. 2005, Svantesson & Karlsson 2012) and Bora (Thiesen & Thiesen 1998, Thiesen & Weber 2012), among others. In these cases, preaspiration is only found word-initially if there is another syllable before it to "host" the [h]. This is the case for Mongolian, where preaspiration is phonetically realized through partial devoicing of a preceding segment: preaspiration appears before fortis stops in all positions except the very beginning of an utterance, where there is no preceding segment (Svantesson & Karlsson 2012). Preaspiration is phonetically shorter in this word-initial position, but co-occurs there with postaspiration; thus, it is not quite accurate to say that preaspiration alternates with postaspiration.

In Bora, preaspiration appears before some aspirated stops. This is lexically determined, and not all aspirated stops have a preceding [h]. This preaspiration is also found root-initially, appearing before some root-initial postaspirated stops. However, preaspiration only surfaces when there is a preceding CV syllable within the same phonological word, such as in genitive constructions or with proclitic pronouns (Thiesen & Weber 2012). This is illustrated in (21), with initial preaspiration marked in bold when it surfaces. The root has no initial preaspiration when in isolation in (21a), but [h] appears when immediately preceded by a short vowel from a pronoun (21b) or in a genitive construction (21c). The appearance of initial preaspiration is clearly dependent on the (morpho)phonological structure of the word, as the same demonstrative does not permit preaspiration to appear when it is structurally more distant from the root (21d).

(21) Root-initial preaspiration in Bora (Thiesen & Weber 2012: 41, 51)

   a. [tsʰɨ̀ːmɛ̀nɛ̀] ‘child’
   b. [tʰá-**h**tsʰɨ̀ːmɛ́nɛ̀] ‘my child’
   c. [áːnɯ́ **h**tsʰɨ́ːmɛ́nɛ̀] ‘this one’s child’
   d. [áːnɯ́ tsʰɨ́ːmɛ́nɛ̀] ‘this one is a child’

There is complementary distribution in Bora between long vowels and codas, which can only be glottal [h] or [ʔ]. If initial preaspiration is preceded by a long vowel or a coda, only one of these can surface. In some cases the appearance of the root-initial [h] is blocked, and in other cases it surfaces but replaces a [ʔ] coda (Thiesen & Weber 2012). These patterns are not illustrated here as they are complex and poorly understood, but it is clear from the complementary distribution of codas, long vowels, and initial preaspiration that these all fully take up the second mora of a syllable. Therefore, Bora illustrates a case where initial preaspiration exists underlyingly but cannot be realized phonetically unless associated to a mora. Furthermore, postaspiration and preaspiration appear to be completely independent and do not show positional allophony: postaspiration appears in all cases, and preaspiration is entirely lexical in its distribution.

4 Discussion

The widespread conception of preaspiration is that it is a property of stops, and specifically an unusual phonetic implementation of the contrast between fortis and lenis stops. This is a result of a focus within previous research on preaspiration, which has centered around languages where preaspiration appears only before stops and is frequently the result of historical degemination. Based on a small typological survey and in line with Helgason (2002), Clayton (2010: 32) stipulates that “true” preaspiration “should be phonotactically associated with stops to the (near) exclusion of other types of consonants”. The intention behind this narrow definition of preaspiration is to exclude cases of coda [h], which are assumed to be inherently different. However, I argue that this viewpoint has excluded other examples of preaspiration from phonological consideration. Preaspiration occurs before a wider range of segments than just stops, and does not show different phonological properties in those contexts. In some cases, preaspiration has only been described before stops, even when it occurs before other segments as well. This is the case for southwestern Welsh, where only fortis stops are reported to be preaspirated (Iosad 2017b), but examination of the corresponding open-source dataset shows that voiceless fricatives are preaspirated as well (Iosad 2017c).

If preaspiration is not in fact a phonetic or featural property of a following stop, the dichotomy between preaspiration and coda [h] falls apart. The alternate view, that preaspiration is “merely” a coda [h] or other voiceless segment, and not the mirror image of postaspiration at all, should not make preaspiration seem mundane or phonologically uninteresting. Such a view allows us to investigate phonological patterns from a different angle and see broader patterns. It also means that the restricted distribution of preaspiration in languages like Icelandic is simply the result of a historical sound change: if degemination of fortis geminates conditioned the appearance of preaspiration, then finding it only before fortis stops in the modern language is unsurprising. Restrictions on coda inventories and distribution are not unusual within languages, so having preaspiration be part of the shape of the syllable rather than part of the stop contrast is no less desirable.

In the typological survey in §3, preaspiration is shown to be complementary with vowel or consonant length, and is seen across numerous languages to fulfil a role in making a syllable heavy or compensating for the loss of an oral consonant. In some of these instances, it shows parallels with vowel lengthening and glottal stop insertion. Given this prosodic patterning, I propose that (at least in some languages) preaspiration may serve as a phonological lengthening strategy, used wherever vowel lengthening is not desirable, or where multiple systems of prosodic weight are necessary to preserve quantity contrasts. In South Argyll Gaelic, preaspiration is complementary with glottal stop insertion and vowel lengthening as a (historical) strategy to ensure heavy stressed syllables. In Spanish, coda debuccalization is a form of preaspiration for weight preservation, where compensatory vowel lengthening and gemination also exist as an alternative weight preservation strategy. In this case, it is also clear that preaspiration is not the realization of an underlying [spread glottis] feature, as it may appear in place of voiced sonorants as well.

The consistent moraic association observed across cases of preaspiration aligns well with previous proposals by Kehrein & Golston (2004) and Golston & Kehrein (2013), in which the feature [spread glottis] is dependent directly on prosodic structure rather than being a segmental feature. This interpretation of aspiration allows Golston and Kehrein to account for the absence of laryngeal contrasts between two segments in the same syllabic constituent, and the alignment of laryngealization at word edges. It also easily accounts for segment devoicing as a phonetic outcome of (pre)aspiration. Although in the present work I have suggested that preaspiration can be understood as a distinct coda consonant, the facts I have discussed here are also compatible with a model where [spread glottis] shifts to, or is inserted to fill, an empty moraic position, and is thus directly dependent on prosodic structure in a way that echoes Kehrein & Golston's (2004) syllable-structure-dependent aspiration. This may allow a more streamlined and unified analysis of the wide range of different types of phenomena associated with preaspiration (see Hejná 2025 [this volume]). In particular, patterns of vowel devoicing (e.g., Udihe: Kuznetsova 2022) and sonorant devoicing (e.g., Mongolian: Svantesson & Karlsson 2012) have been set aside here but are areas where association of [h] to levels of prosodic structure may prove insightful. Ultimately, the key insight of this research is that preaspiration should be approached phonologically as a distinct element that has moraic association, and not a feature of a weightless onset consonant. In some cases, this will mean preaspiration is for all intents and purposes a distinct segment, and this will be the simplest way of viewing it. However, full segmental status is not mandatory for moraic association.[28]

One issue relating to the origins of preaspiration that remains to be investigated more fully is the phonologization of this phenomenon. The boundary between phonetic and phonological phenomena is blurred somewhat in this chap-

[28] Regarding the segmental status of aspiration, a reviewer notes that in southeastern Welsh dialects, [h] has been lost in all contexts other than preaspiration (Iosad 2023), so declaring it to nonetheless be a distinct consonant may be undesirable. This is similar to the case of Italian, which is traditionally described as lacking aspiration or phonemic /h/, but where preaspiration nonetheless appears before voiceless geminates in several dialects (Stevens & Hajek 2004, 2007, Krämer 2009, Stevens 2011). In instances like this, I am not claiming that phonemic /h/ is necessary within the language's inventory: in fact, patterns like these support the idea that preaspiration can be used as a strategy for occupying prosodic space, regardless of whether [h] is otherwise a contrastive element in the inventory. These may be instances in which the preaspiration is part of the phonetic module of grammar, since otherwise we expect the phonology to only make reference to contrastive features (Dresher 2009).

ter by the use of phonetic evidence to establish formal phonological structures. Under a modular view of phonetics and phonology, we expect that preaspiration should have a phonetic origin and become more regularized and categorical over time. Therefore, both phonetic and phonological preaspiration should be attested. It is possible that languages with a variable realization of preaspiration (e.g., Central Standard Swedish, Faroese) reflect a preaspiration pattern within the phonetic module of grammar, while languages with categorical preaspiration (e.g., North Sámi) reflect phonological preaspiration. Critically, however, a conception of phonetic preaspiration must still capture the affinity of preaspiration for moraic positions, as its emergence in these positions is not coincidental.

Given this reinterpretation of preaspiration as a compensatory prosodic mechanism, and the broader scope of the typological surveys in Craioveanu (2023) and Hejná (2025 [this volume]), it is worth considering whether preaspiration is actually a rare phenomenon at all. Iosad (2025 [this volume]) approaches this question at length as well. As noted in §2, speculation that preaspiration is underreported is not new (Ní Chasaide 1985, Hejná 2015, 2019, Iosad 2017a, 2018). I follow this previous work in suggesting that preaspiration is much less rare than previously thought. Thorough recent phonological descriptions of languages like Norwegian, Swedish, and Welsh do not discuss preaspiration or include it in transcriptions, even though it is widespread in each of these languages (Kristoffersen 2000, Riad 2014, Hannahs 2013), so it is quite plausible that it has been overlooked in other languages as well. Why might this be?

One possibility is that fieldworkers simply did not notice it, were not expecting to find it, or did not consider it important to mention; Iosad (2018) discusses these possibilities for Norwegian. Regarding expectations, the general impression of what preaspiration is and of what counts as "real" preaspiration are important here: since preaspiration is thought to be rare, it might not be considered as a possibility in a given language. Alternately, it is quite possible that restrictive definitions of preaspiration in previous literature have limited the degree to which preaspiration is identified. There are also linguistic factors that could contribute to this rarity: competition from alternative prosodic weight-marking strategies like gemination and compensatory lengthening could reduce the frequency of preaspiration, or replace it in a given language. There may also be a general dispreference for glottal [h] in coda position, which would be balanced against (or at odds with) the moraic affinity shown by preaspiration. This coda [h] dispreference underlies the tendency for preaspiration to undergo fortition to an oral fricative or to be deleted, as well as a tendency in some languages to avoid glottal /h/ geminates intervocalically (e.g., Swedish: Riad 2014: 45; Maltese: Mitterer 2018).

In this chapter, I have presented a critical reassessment of the phonological status of preaspiration, revisiting well known examples of preaspiration and outlining some new ones in an abridged typology. The patterns described here show that preaspiration has intrinsic phonological weight, and is prosodically distinct from the following segment rather than a feature of it.

Abbreviations

ACC	accusative	INDEF	indefinite	PL	plural
DAT	dative	INF	infinitive	REFL	reflexive
DEF	definite	M	masculine	SG	singular
F	feminine	N	neuter	SUBJ	subjunctive
GEN	genitive	NOM	nominative		
IMP	imperative	OBJ	object		

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Chapter 18

Pre-aspiration in Ecuadorian Siona

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Ecuadorian Siona (Tukanoan) has been put forth as a language which potentially manifests pre-aspiration (Bruil 2014), but the phonemic status of voiceless pre-aspirated obstruents in the language has, as of yet, not been established. Earlier analyses of related languages have proposed an analysis in terms of vowel devoicing (Wheeler 1987a: 90), but we propose that a consonantal analysis is superior. In this study we examine the distribution of pre-consonantal [h] in Ecuadorian Siona, and conclude that it is best analyzed as the result of a prosodically driven enhancement process which causes pre-aspiration of non-laryngealized obstruents in foot-head onsets.

1 Introduction

Ecuadorian Siona (sion1247) is a Western Tukanoan language, spoken in the North East of Ecuador (Bruil 2014; see Figure 1 below). A quite common phonological phenomenon in Tukanoan languages is pre-aspiration (see, for example, Stenzel 2007, on Kotiria). In Ecuadorian Siona, too, a pre-consonantal glottal fricative occurs frequently. However, as noted in Bruil (2014), there are certain complicating factors that mean an analysis of pre-consonantal [h] in Ecuadorian Siona as pre-aspiration is not straightforward.

In this study, we closely examine the occurrence of pre-consonantal [h] in light of three alternative analyses. First, since /h/ freely occurs in onsets, we consider that the segment has a phonemic, consonantal status, also in pre-consonantal

Marijn van 't Veer, Martine Bruil & Oleksandra Damonte-Matveienko. 2025. Pre-aspiration in Ecuadorian Siona. In Natalia Kuznetsova, Cormac Anderson & Shelece Easterday (eds.), *Rarities in phonetics and phonology: Structural, typological, evolutionary, and social dimensions*, 755–794. Berlin: Language Science Press. DOI: 10.5281/zenodo.15148196

positions. This analysis is rejected on the basis of the predictability of pre-consonantal [h]. Then, we analyze pre-aspiration as the result of phonological processes. We first consider the coda epenthesis hypothesis first, but find that it is inadequate in certain respects. We then turn to the pre-aspiration hypothesis, and argue that this is the best analysis: not only do its predictions correspond to the observed facts, but it is also motivated in terms of prosodic strength. We conclude the chapter with a diachronic overview of pre-aspiration in Ecuadorian Siona and in its Tukanoan cognate languages.

The chapter is organized as follows. In Section 2 we investigate the typology, phonetics and phonology, and genesis of pre-aspiration, before turning to the synchronic and diachronic analyses in Section 5, while Section 6 presents some concluding remarks. First, however, we briefly provide an overview of some general characteristics of Ecuadorian Siona (Section 1.1), and the conventions we adopt in representing the data (Section 1.6).[1]

1.1 Language background

Ecuadorian Siona is a Western Tukanoan language, closely related to Sekoya (seco1241) and Colombian Siona, spoken in the rural areas of the Sucumbíos province of Eastern Ecuador. Most of the speakers live in seven Siona villages: Puerto Bolívar, San Victoriano, Tarabëaya, Sototsiaya, Orahuëaya, Aboquëhuira and Bi’aña. A publication on Ecuador’s indigenous languages from 2001 estimates the number of Siona speakers to be between 200 and 250 (Mejeant 2001). A more recent, albeit informal survey (conducted by the second author together with the community members in 2016), established a number of roughly 300 speakers. This means that the language is severely endangered. The data reported in the current study are based on fieldwork performed by the second author in 2010–2015 (Bruil 2014), in the Puerto Bolívar and Sototsiaya villages (see Figure 1). The Siona people refer to themselves as *bãĩ*, which means ‘people’, and to their language as *bãĩkoka* ‘the language of the people’.

A number of classifications have been proposed for the Tukanoan language family; here, we adopt the one by Chacon (2014), with an additional distinction between Ecuadorian Siona and Colombian Siona (Bruil 2014: 11). In Chacon’s classification, Tukanoan branches into two major subgroups: Western Tukanoan and Eastern Tukanoan. Whereas the latter is further subdivided into Southern, Western, and Eastern, the former is proposed to be a single group, consisting of the languages Kueretu (cure1236), Máihíki (orej1242), Koreguaje (kore1283), Sekoya, and Siona (Chacon 2014).

[1] Parts of this study are built on the third author’s undergraduate thesis, completed in 2021 under the supervision of the first two authors, at the University of Amsterdam.

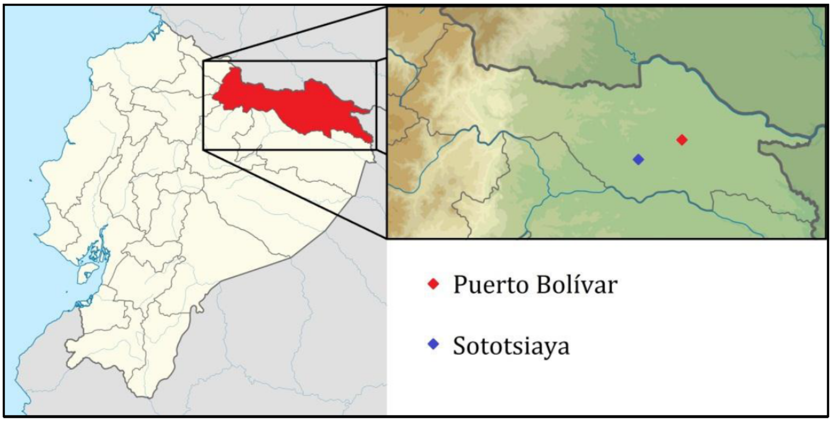


Figure 1: Map of the fieldwork sites (adapted from Bruil 2014: 5)

Earlier studies on Siona have focused on the Colombian variety (Wheeler 1967, 1970, 1987a,b, 2000, Wheeler & Wheeler 1975), but the Ecuadorian variant differs considerably from it in phonological, lexical and morphosyntactic aspects. In fact, Ecuadorian Siona is in some ways more similar to (closely related) Sekoya than to Colombian Siona. For example, unlike Colombian Siona, both Ecuadorian Siona and Sekoya lost the word-internal voiced velar stop. On the other hand, Ecuadorian Siona shows a type of vowel assimilation that is absent in both Colombian Siona and Sekoya (see Bruil 2014: 10–12, for a more detailed discussion). Therefore, Bruil (2014) proposes that the two varieties of Siona, together with Sekoya, can be seen as a tripartite dialect continuum.

1.2 A brief sketch of Ecuadorian Siona phonology

1.2.1 Phoneme inventory

The consonantal inventory of Ecuadorian Siona is given in Table 1. The coronals [d, ɾ] are not included in Table 1, as their status as potential allophonic variants of /t̪/ is a topic currently under investigation (see also Table 3). Figure 2 presents the Siona vowel system, which has six contrastive vowel qualities and in addition, nasality as a distinctive feature (transcribed with a tilde above the vowel). Contrary to many other Tukanoan languages, Ecuadorian Siona has phonemic nasal consonants and nasal vowels (Bruil & Stewart 2022). Underlyingly, there is no length contrast for vowels, but long vowels may appear in some surface forms. This is due either to a number of active vowel coalescence processes (Bruil 2014: 115–117), or lengthening due to the bimoraic stem constraint (see Section 1.4).

Table 1: Consonants of Ecuadorian Siona (adapted from Bruil 2014: 87 and Bruil & Stewart 2022)

	Labial	Coronal	Dorsal		Laryngeal	
			Plain	Lab.	Plain	Lab.
Plosives						
Plain	p	t	k	k^{w}		
Lar.	p̰	t̰	k̰	k̰^{w}	ʔ	
Affricates		ʧ				
Fricatives						
Plain		s			h	h^{w}
Lar.		s̰				
Nasals						
Plain	m	n				
Approximants		j		w		

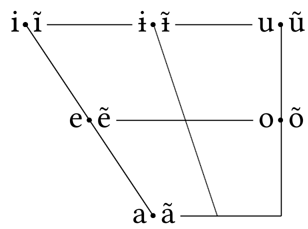


Figure 2: Vowels of Ecuadorian Siona

1.2.2 Laryngeality

Table 1 shows that Ecuadorian Siona contrasts obstruents not in terms of voiced and voiceless, but rather in terms of plain and laryngealized. The non-glottal obstruent system displays near-perfect symmetry in terms of this contrast (only the affricate /ʧ/ lacks a laryngealized counterpart). An in-depth study on the phonetics of laryngealized obstruents is still lacking. However, based on the preliminary analysis in Bruil (2014), we can make a number of observations.

First of all, there are four laryngealized stops: /p̰, t̰, k̰, k̰^{w}/. All of these may occur word-initially, but only the first two are allowed in other positions (i.e., intervocalically).[2] The realization of the laryngealized stops is variable, but gen-

[2]The dorsal laryngealized stops /k̰, k̰^{w}/ can be found in intervocalic positions, but only in the context of compounds, the phonological interpretation of which is uncertain for now.

erally predictable: in word-initial position, laryngealization is realized as creak, with its partial spreading as creaky voice onto the following vowel. Intervocalically, /p̰, t̰/ are realized as sonorant-like [β, ɾ] respectively (see Bruil 2014: 93–95 for more details on this allophonic relationship).[3] Table 2 provides examples of the four stops in various positions. For the coronal /t̰/, the range of allophonic realizations in different morphophonological positions is more varied (e.g., it can be realized as [d], as indicated in Table 3), but an in-depth discussion of this is beyond the scope of the current chapter. A preliminary sketch can be found in Bruil (2014), and more research is currently underway.

Table 2: Positional variants of laryngealized stops (from Bruil 2014: 93)

	Word-initial	Word-internal	Suffix-initial
/p̰/	[p̰eo.je]	[ho.βo]	[wɨo-βi]
	‘to not be/have’	‘the middle’	‘he began’
/t̰/	[t̰ai.je]	[we.ɾo.je]	[ho-ɾo]
	‘to come’	‘to buy’	‘flower’
/k̰/	[k̰o.he]		
	‘hole’		
/k̰ʷ/	[k̰ʷiː.je]		
	‘to scream’		

Next, the laryngealized sibilant /s̰/ is similar to the laryngealized dorsal stops in terms of distribution: it only occurs in word-initial position. Unlike in the case of the laryngeal dorsals, however, laryngealization is lost when /s̰/ appears as the first segment of a non-initial member of a compound, in which case the contrast between /s/ and /s̰/ is neutralized (in favour of /s/). Finally, both /s/ and /s̰/ are subject to optional but frequent affrication, by which they change into affricates [t͡s] and [t͡s̰] respectively (examples from Bruil 2014: 100):[4]

(1) a. [sai.je] ~ [tsai.je]
‘to go’

b. [s̰ia.ja] ~ [ts̰ia.ja]
‘river’

[3]See also Botma & van ’t Veer (2013) for an analysis of intervocalic voicing as weakening, which is especially pertinent in combination with Golston & Kehrein (2015)’s proposal for the relative sonority of laryngeals.

[4]The phonetic transcriptions throughout this chapter are presented in and adapted according to IPA. More conventions, specifically pertaining to Siona examples, are discussed in Section 1.6.

In Section 1.3.1 below, we consider the phonemic status of /h/ in relation to pre-aspiration in more depth. However, some remarks regarding the glottal stop in Ecuadorian Siona are necessary here. Phonologically, it stands apart from the other consonants by being barred from word-initial position.[5] In intervocalic position, it is contrastive, and apart from the issue of pre-consonantal /h/, it is the only consonant that may occur in word-internal codas. In terms of articulation, Bruil (2014) notes that the glottal stop rarely causes full occlusion, and in intervocalic position, is often realized as a period of creaky voice in the vowel.

1.3 Laryngeal segments

In this section, we briefly introduce the status of the glottal fricative, which is phonemic in onset positions and, we argue, non-phonemic in pre-consonantal positions. Although the glottal stop is by no means the focus of the current chapter, its close affinity to the glottal fricative (both in its phonetic content and in its distributional properties) prompts us to briefly discuss it below, in Section 1.3.2.

1.3.1 The status of the glottal fricative

As seen in Table 1 above, the glottal fricative /h/ is part of the underlying phonemic inventory of Ecuadorian Siona. An important argument for the phonemic status of /h/ is that it is not *restricted* to pre-consonantal position. It occurs in onsets, too: both in word-initial (2a), root-internal (2b), and suffix-initial (2c) contexts (adapted from Bruil 2014: 102):

(2)

	a. Word-initial:	b. Root-internal:	c. Suffix-initial:
	[hɨo.je]	[jaʔ.hi.je]	[kaː.hi]
	/hɨo-je/	/jaʔhi-je/	/kaː-hi/
	slash-CLF.GEN	ripen-CLF.GEN	say-3S.M.PRS.ASS
	‘to slash’	‘to ripen’	‘he says’

Examples of words presenting difficulty in determining the status (or affiliation) of [h] are given in (3).[6]

[5] Bruil (2014: 95) notes that the glottal stop may be epenthesized in word-initial position, but is never contrastive there.

[6] Examples from (Bruil 2014: 102). Note that trisyllabic [ahpasi] ‘sapote’ is a rare exception to the bimoraic stem constraint, potentially due to it being a loanword. Some other examples exist, see for instance footnote 97 in Bruil (2014: 148) for animal names that consist of three moras and that appear to be historically multi-morphemic.

(3) a. [ah.pa.si]
ahpasi
sapote
'sapote (fruit sp.)'

b. [soh.to]
sohto
clay
'clay'

c. [ah.ʧa.je]
ahʧa-je
listen-clf.gen
'to listen'

d. [nãɦ̃.so]
nahso
wooly.monkey
'wooly monkey (monkey sp.)'

e. [p̰ah.ku]
p̰ah.ku
pomfret
'pomfret (fish sp.)'

The main question, thus, is how to decide on the status of the glottal fricative in such cases, and how to best analyze such a status phonologically. The matter of coda-h versus pre-aspiration in Ecuadorian Siona was first identified in Bruil (2014: 102–106), and is further taken up in the current study in Section 5.

The initial analysis of pre-aspiration in Ecuadorian Siona made a distinction between root-internal and root-external cases (Bruil 2014). In our analysis, we argue that such a distinction is only a secondary effect of the smaller distributional freedom that suffixes enjoy when it comes to consonants. One important argument that was given in support of this dichotomy is the apparent difference in the distribution of pre-consonantal [h]. Inside roots, it may only occur before non-laryngealised obstruents, but outside roots, and in a limited number of cases, it may also precede [ɲ]. In our current analysis, we propose that this difference is only superficial, and that careful inspection of the different phonological processes at work reveals that underlyingly, there is no fundamental difference in the distribution of pre-consonantal [h] between root-internal and root-external cases. Secondly, in her initial exploration of Ecuadorian Siona pre-aspiration, Bruil (2014) proposes that in root-external position, pre-aspiration only occurs at morpheme boundaries. This observation would suggest that pre-aspiration would be sensitive to morphological structure beyond the distinction between root-level phonology and word-level phonology. However, on closer inspection, we propose that regardless of morphological context, pre-aspiration is still a prosodic process. Most, if not virtually all, suffixes in Ecuadorian Siona are monosyllabic, rendering the morpheme boundary approach and the prosodic approach to largely make identical predictions.[7] Since the root-internal versus root-external cases are superficially different, however, we will use the distinction to guide the discussion of data below in Section 4.

1.3.2 The matter of the glottal stop

One of the major issues that we have not addressed specifically in this chapter is the fact that pre-consonantal [h] is not the only laryngeal that can occur post-vocalically in Ecuadorian Siona: so can [ʔ]. In fact, Bruil (2014) proposes that [h] and [ʔ] constitute the only consonants that may occur in codas.

In this study, we have argued that this is not the case, at least for [h]; rather, when it occurs pre-consonantally, it is better analyzed as a case of pre-aspiration. This begs the question of whether Ecuadorian Siona allows for codas at all, since in that case, only one segment (the glottal stop) may occur in that position. On the one hand, it is tempting to group both [h] and [ʔ] in one and the same group, based on their apparent positional distribution (although we now know that this is not correct) but also based on them being the only (bare) laryngeals in the language.[8] There are important differences, however, not least of which is that [h] can readily occur in onset positions and hence must be phonemic /h/ there.

The distribution of of the glottal stop in Tukanoan languages in general is special, however, to the degree that it has been proposed to be a "suprasegmental" feature, which is not directly attached to a skeletal slot but rather to a higher order constituent in the prosodic hierarchy.

This is precisely the analysis put forward by Stenzel (2007) with regard to Kotiria (guan1269). While not predictable, there is good evidence to consider the glottal stop not as a "regular" phoneme in the language, but rather as a moraic dependent, to be syllabified as necessitated by the morphophonological context. One particularly strong argument is that the glottal stop in Kotiria displays a

[7]There is one bisyllabic suffix [wesɨ] 'for ever', and on close inspection, the second consonant [s] does indeed receive some pre-aspiration.

[8]Bare, as opposed to the laryngealized consonants.

degree of independence that is typical of suprasegmental features, such as tone or nasality in some cases of nasal harmony.

Kotiria is not Ecuadorian Siona, however, so we cannot blindly adapt the suprasegmental analysis of the glottal stop here. For one thing, there is no tone in Ecuadorian Siona, and thus no interactions between glottalisation and tone either. A further difference between the assignment of the glottal stop in Kotiria and Ecuadorian Siona is that in Kotiria glottal stops generally only occur in the root, whereas in Siona they are also found in suffixes. Finally, pre-aspiration is more complex in Ecuadorian Siona, primarily because of the root-truncation process that we have seen interacts with pre-aspiration.

However, we are sympathetic to the idea of a suprasegmental glottal stop, and there is good reason to assume that it is, indeed, a viable avenue of further research in Ecuadorian Siona. Importantly, a prediction of such an analysis, in combination with our prosodic analysis of Ecuadorian Siona pre-aspiration, is that we would not expect to see the two phenomena occur simultaneously. In other words, words of the form [CV.^{ʔh}CV] are predicted to be ungrammatical. Stenzel (2007) shows that this prediction is borne out in Kotiria, and in (4) we see that in Ecuadorian Siona, too, no such words exist.

(4) a. i. [ah.pa.si]
ahpasi
sapote
'sapote'
(Bruil 2014: 102)

ii. [pũʔ.pu.je]
pũʔpu-je
smoke-CLF:GEN
'to smoke'
(Bruil 2014: 90)

b. i. [wah.ti]
wahti
'bad spirit'
(Bruil 2014: 84)

ii. [waʔ.ti]
waʔti
'machete'
(Bruil 2014: 84)

c. i. [p̰õɦ̃.sa]
bõhsa
‘achiote’
(Bruil 2012: 20120912elicr007)

ii. [mõʔ.se]
mõʔse
‘day’
(Bruil 2012: 20120919elicr005)

d. i. [kah.kao.ɲã]
kahka-o-jã
enter-2/3S.F.PST.N.ASS-REP
‘You (F)/she entered, they say’
(Bruil 2012: 20120918elicr003)

ii. [ʧaʔ.kao.ɲã]
ʧaʔka-o-jã
jump-2/3S.F.PST.N.ASS-REP
‘You (F)/she jumped, they say’
(Bruil 2012: 20120918elicr003)

e. i. [ĩɦ̃.ɲõ]
ĩhjõ
here
‘here’
(Bruil 2012: 20120912elicr007)

ii. [mãʔ.ɲõ.ko]
maʔjõ-ko
star-CLF:ANIM.F
‘star’
(Bruil 2012: 20120919elicr005)

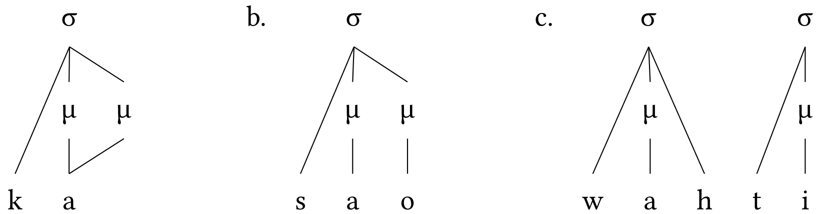
At first glance, then, it looks like the suprasegmental analysis of the glottal stop and the prosodic analysis of pre-aspiration complement each other well, but we cannot provide a conclusive synthesis within the scope of the current study.

1.4 Suprasegmental structures

Our analysis of pre-aspiration in Ecuadorian Siona below leans heavily on prosodic constituents. Before we proceed with the analysis (in Section 5), let us briefly consider the structure of syllables and feet in the language.

Syllables in Ecuadorian Siona consist of a (vocalic) nucleus, either simplex or branching, an optional onset, and an optional post-nuclear rhyme (coda), which may only be occupied by glottal consonants (Bruil 2014: 83–84). In other words, the *surface* syllable template appears to be (C)V(V/H).[9] Branching nuclei may be either long vowels (5a) or diphthongs (5b); in both cases, the nucleus projects two moras (examples adapted from Bruil 2014: 84–85).[10] The rhyme may maximally dominate two segmental positions, but we argue below that codas are not moraic (5c).[11] In fact, the representations in (5) should be taken as surface descriptions exclusively, since we argue below that pre-consonantal [h] is not a coda at all. Furthermore, we have reasons to believe that assigning the glottal stop to a coda position is also not as straightforward as it may initially seem (see Section 1.3.2). Finally, codas are not allowed in word-final syllables.[12]

(5) a. b. c.



a.	b.	c.
ka:-	sa-o-	wahti
say	go-CAUS	bad.spirit
‘to say’	‘to let go’	‘bad spirit’

Even if we accept that both laryngeal sounds can occupy coda position, this does not automatically entail moraicity; languages may associate moras with vowels, but not with codas (see Gordon et al. 2008 for an overview of this typology). An argument for this is an observation that, much like other Tukanoan languages, such as Barasana (bara1380), Tatuyo (tatu1247), Kotiria (Bruil 2014: 85–86), and Tukano (tuca1252) (Ramirez 1997), Ecuadorian Siona abides by what

[9]Where “H” stands for either of the two laryngeals [ʔ, h].

[10]In our description and analysis, we take the mora to be an abstract unit of quantity for non-onset segments, that plays a role in, for example, maximal stem size. Typologically, moras can potentially be associated with any vowel or consonant that is not in an onset. In the case of Ecuadorian Siona, we argue that only vowels are associated with a mora. Since an in-depth analysis of the prosodic properties of Ecuadorian Siona currently does not exist, we cannot yet stipulate whether moras play a role in, for example, stress assignment. For an in-depth exploration of the role of moras in language, see Hayes (1989, 1995).

[11]Example adapted from Bruil (2014: 149).

[12]An exception is made for borrowings such as [moh.tor] ‘motor’ from Spanish (Bruil 2014: 84).

can be described as a bimoraic stem constraint. This implies that stems must contain at least *and* at most two moras. Stems may consist of a bare root, or a root followed by no more than one derivational suffix.[13] Importantly, note that the single-root stem in (5c) does not violate the bimoraic stem constraint, even if it potentially consists of a closed syllable *plus* an open syllable.[14]

Independent evidence comes from the shape of vowel deletion processes. Where affixation would lead to overlong stems, deletion is triggered in order to repair a violation of the bimoraic stem constraint. In example (6a) we can see that the root-final, non-back vowels /ɨ, ɨ̃, e, ẽ, a, ã/ are deleted when a derivational suffix is affixed (Bruil 2014: 112). In example (6b), we see that the back vowels /u, o/ become glides (Bruil 2014: 120), hence losing their moraicity, whereas other vowels are deleted in this context.

(6) a. [jeʔ.ja.je]
/jeʔje-a-je/
learn-TRS-CLF:GEN
‘to teach’

b. [õh.kʷa.je]
/ũhku-a-je/
drink-TRS-CLF:GEN
‘to give someone something to drink’

In addition to the bimoraic stem constraint, our prosodic analysis rests on the observation that Ecuadorian Siona feet are iambic. This, we must concede, is slightly speculative, as stress in Ecuadorian Siona is not marked by particularly strong phonetic correlates (Bruil 2014: 86).[15] At the same time, secondary evidence gives some backing to an iambic classification of Ecuadorian Siona feet, as surrounding languages have been argued to be iambic. Both Wheeler (1987a: 90–94) and Johnson & Levinsohn (1990: 18–19) argue, for Colombian Siona and Sekoya respectively, that bisyllabic stems have stress on the second syllable, and that stress is alternating if and when enough suffixes are added. We therefore propose that Ecuadorian Siona is iambic, and that pre-aspiration is a property of (eligible) onset consonants in stressed syllables.

[13] Ecuadorian Siona has few to no prefixes (Bruil 2014).

[14] Further suffixation is possible, but leads to either stem reduction or the creation of a new foot (Bruil 2014: 112).

[15] Note, however, that a mention of a word-final rise in intonation reported by Bruil is not in contradiction with an iambic foot, but would be rather problematic for a trochaic analysis. Furthermore, preliminary analysis of prosodic patterns hints at a rising pitch on the second syllable of CVCV-stems. Further study on the prosody of Ecuadorian Siona and related languages will hopefully shed more light on this issue.

1.5 Nasal harmony

In the examples of this chapter, the reader may find more nasal sounds than the two listed for Ecuadorian Siona in Table 1. Most notably, we will come back regularly to the apparently exceptional role of the palatal nasal [ɲ], which is absent from the table of consonantal phonemic segments. The reason for the occurrence of [ɲ] in certain contexts is that Ecuadorian Siona has nasal harmony. This is a common feature of Tukanoan languages, although the variables (e.g. direction and domain) involved in the process are different (for more detail, see Bruil 2014: 124–125).

In Ecuadorian Siona, underlyingly nasal segments (being /ĩ, ɨ̃, ũ, ẽ, õ, ã/ and /m, n/) trigger nasal harmony, while most of the obstruents (namely [t, k, kʷ, p̰, t̰, s]) block its spread (Bruil 2014: 126–127). The segments targeted by nasal harmony are the vowels, the approximants and the glottal sounds. Consider the example in (7), where the glottal fricative is nasalized through progressive nasal harmony triggered by the initial /ã/, while the velar stop blocks the nasality from progressing further (Bruil 2014: 128).

(7) [ãh̃.kɨ]
/ãh-kɨ/
eat-2/3s.m.pst.n.ass
'did you(m)/he eat?'

Nasal harmony in Ecuadorian Siona applies bidirectionally, i.e. both rightwards (progressively) and leftwards (regressively), but each direction is subject to different domain restrictions. Progressive nasal harmony applies to the whole prosodic word, while regressive is restricted only to the syllable where the nasal vowel occurs. Progressive nasal harmony is illustrated by the examples in (8), where the suffix /-jɨ/ is only nasalized in (8b), not in (8a). These examples are from Bruil (2014: 125–126).

(8) a. [kaː.jɨ]
/kaː-jɨ/
say-n3s.prs.ass
'I/you/we/you (pl), they say'[16]

b. [ɲãː.ɲɨ]
/jãː-jɨ̃/
see-n3s.prs.ass
'I/you/we/you (pl), they see'

[16] The suffix /-jɨ/ is an underspecified subject marker that can stand for the first and second person in either singular or plural (Bruil 2014: 177).

Regressive nasal harmony is illustrated in (9): in the process of pluralisation from (9a) to (9b), nasality is spread from the plural suffix /-ã/ to the beginning of the syllable and not further (Bruil 2014: 108).

(9) a. [ui.jo]
/ui-jo/
spear-CLF:LONG.THIN
‘spear’

b. [ui.ɲõã]
/ui-jo-ã/
spear-CLF:LONG.THIN-PL
‘spears’

Note that the palatal approximant turns into a palatal nasal in (8b) and (9b), a process relevant to the analysis in Section 5.

The full details of nasal harmony in Ecuadorian Siona are beyond the scope of this chapter, but the reader is referred to Bruil & Stewart (2022) for further information. For our present purposes, it is most important to remember that surface [ɲ] is the derived allophone of /j/, under nasal harmony.

1.6 A note on conventions

Throughout this chapter, we will mostly consider the surface allophones of the language. This means that the symbols used in the examples may not correspond to the phonemes given in Table 1 and Figure 2 above. The most important allophonic relations are summarized in Table 3. Where applicable, morphological parsing is provided in the practical orthography described in Bruil (2014: 129–132), followed by corresponding morphological glosses. The major orthographic choices are also included in Table 3.

Table 3: Some phonemes, their allophones and orthography.

Phoneme	Allophone 1	Allophone 2	Orthography
p̰	pV̰	β	b
t̰	tV̰	d/ɾ	d/r
j	j	ɲ	j

In Table 3, for /p̰/ and /t̰/, the allophone in the third column is found intervocalically, and the allophone in the second column elsewhere. For /j/, the allophone [ɲ] is found only where nasal harmony applies. The tilde underneath /p̰/ and /t̰/ indicates that they impart creaky voice on the following vowel. Laryngealized consonants are lenited intervocalically (see Bruil 2014: 93–95). The case of the laryngealized /t̰/ is more complicated because it seems that at some morpheme boundaries laryngealized /t̰/ is realized as either /d/ or a tap (Bruil 2014: 94). Laryngeality in Siona is discussed in Section 1.2.2 and nasal harmony in Section 1.5.

The examples throughout this chapter are maximally presented in four lines. The first is always a broad phonetic transcription given in square brackets, and the last is always the translation. The second and the third line contain the morphological composition of the word and its gloss respectively. The second line is provided either in the practical orthography mentioned above, or as a phonological underlying form. In the latter case, the form is always presented between /slashes/. The lines with morpheme parsing are only present in morphologically complex examples.

2 Distribution and properties of pre-aspiration

In this section, we briefly introduce the reader to the typology, phonetic and phonological properties, and the diachronic emergence of pre-aspiration. However, as this chapter is a case study of pre-aspiration in Ecuadorian Siona, we refer the reader to Hejná (2025 [this volume]) for a typologically driven report on the subject.

Cross-linguistically, pre-aspiration has been considered a rare phenomenon, especially in comparison to post-aspiration (Silverman 2003). In a phonological database, PHOIBLE, which contains data on 2,186 languages, post-aspirated velar stops appear in 605 languages, while pre-aspirated velar stops appear only in 11 languages (Moran & McCloy 2019). Silverman (2003) provides an attempt to map out the typology of pre-aspirates based on various primary sources, concluding that (a) pre-aspirates are an internally diverse class when it comes to their phonetic realization, and (b) preaspirates are perhaps even rarer than previously understood.

However, the notion that pre-aspiration is an extremely rare linguistic phenomenon has been contested by a number of publications (Ní Chasaide 1985, Helgason 2002, Hejná 2015). Craioveanu (2025 [this volume]) suggests that the possibility of pre-aspiration in a given language may be overlooked because it is assumed to be so rare, and because of the strict definitions used for pre-aspiration that do not reflect the typological reality, such as those specifying that pre-aspirated segments are restricted to stops only. For a more in-depth discussion on the rarity of preaspiration and possible solutions towards a more uniform typological representation of the phenomenon, the reader can consult the chapters by Craioveanu (2025 [this volume]), Iosad (2025 [this volume]), and Hejná (2025 [this volume]).

In acoustic terms, pre-aspiration is generally defined as a period of frication produced exclusively in the glottis that is followed by (partial) oral closure. However, the manifestation of pre-aspiration cross-linguistically seems to be more diverse: for example, its articulatory location can vary between glottal and oral, and it is not always restricted to stop consonants (Hejná 2025 [this volume]). In Kotiria, for example, pre-aspiration occurs before [s], as in [dʉʰse] ‘mouth’, in addition to stops (Stenzel 2013: 25).

Huautla Mazatec (huau1238) provides a rather unusual case: pre-aspiration can surface word-initially, as in [ʰti] ‘fish’[17], and in addition to voiceless obstruents, nasals [m, n, ɳ] and approximants [w, j] can be pre-aspirated (Silverman 2003). Clayton (2010: 32–34), however, rejects the classification of Huautla Mazatec as a language manifesting pre-aspiration, and argues that this case is better analyzed as having hC clusters. According to Clayton’s criteria, [h] must appear before a restricted set of consonants (normally, voiceless non-continuants), as there is “a tight distributional relationship between the aspiration and [this] set of consonants” (Clayton 2010: 9). Siona, too, would constitute an unusual case since the glottal fricative appears before the palatal nasal [ɲ], in addition to voiceless obstruents.

The origins of pre-aspiration are not always known but when they are, two notable candidates to be their antecedents are often proposed: geminate stops and, less frequently, nasal–voiceless stop sequences (Clayton 2010, Helgason 2002). Pre-aspirates have been traced back to geminates in Sámi languages, North Germanic languages (Helgason 2002), Sienese Italian (ital1282, Stevens 2004, Stevens & Hajek 2007), Forest Nenets (fore1274, Helgason 2002, citing Hansson 1997), Bora (bora1263, Aschmann 1993), Scottish Gaelic (scot1245, Ní Chasaide & Ó Dochartaigh 1984), and a subset of Eastern Tukanoan languages (Stenzel 2013). The evolution of pre-aspirated stops from nasal-stop sequences has been described, for example, in Central Algonquian languages (Bloomfield 1925) and Hopi (hopi1249, Manaster-Ramer 1986). For Tukanoan languages, a similar diachronic analysis that involves vowel devoicing, instead of nasal devoicing, has been proposed (Waltz 2002). We return to this point in Section 3 below.

[17] Adapted from Pike & Pike (1947: 80).

3 Diachrony of pre-aspiration in Ecuadorian Siona

The occurrence of pre-consonantal [h] before voiceless consonants is generally a common phenomenon in Tukanoan languages. Among the Western Tukanoan branch, to which Ecuadorian Siona belongs, this phenomenon has been observed in Colombian Siona (Wheeler 1987a,b) and Ecuadorian Sekoya (Johnson & Levinsohn 1990). Among the Eastern Tukanoan branch, specifically among the languages spoken in the Vaupés region (Kotiria, Waʔikhana/Piratapuyo [pira1254], Tukano, Siriano [siri1274], Desano [desa1247], Tuyuka [tuyu1244], and Yuruti [yuru1263]), the restricted occurrence of pre-consonantal [h] is attributed to pre-aspiration (Stenzel 2013: 24–27). Unlike Ecuadorian Siona, these languages show a strong case of pre-aspiration as the occurrence of pre-consonantal [h] is fully predictable: it appears before voiceless obstruents and is restricted to morpheme-internal or root-internal position. The examples in (10) compare pre-aspiration in Kotiria and Yuruti to the occurrence of [h] root-internally before voiceless obstruents in Ecuadorian Siona. The example pair in (11) demonstrates the difference at the morpheme boundary, where [h] appears in Siona but not in Kotiria.

(10) a. Kotiria

i. (Stenzel 2013: 24–25)

[da^{h}pú]	‘head’
[di^{h}tá]	‘be alone’
[dʉ^{h}ká]	‘begin’
[dʉ^{h}sé]	‘mouth’
[di^{h}ʧá]	‘fruit’

ii. (Stenzel 2007: 355–356)

[da^{h}sá]	‘toucan’
[wa^{h}ʧú]	‘tapir’

b. Ecuadorian Siona
   i. (Bruil 2014: 102)
      [ahpasi] 'sapote'
      [wahti] 'bad spirit'
      [ohko] 'water'
      [ãɦ̃si] 'salt'
      [ahʧaoɲã] 'you (F)/she listened, they say'
   ii. (Bruil 2012)
      [ɲãɦ̃se] 'toucan'
      [w̃ẽɦ̃kɨ] 'tapir'
      [sõɦ̃kɨ] 'tree'

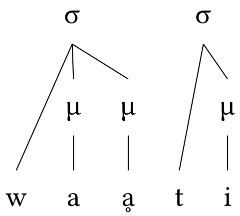
c. Yuruti
   i. (Stenzel 2013: 28)
      [o^{h}pí] 'tooth'
      [wa^{h}tí] 'come'
      [o^{h}kó] 'water'
   ii. (Kinch & Kinch 2000: 471)
      [jũhkɨ gɨ] 'tree'

(11) a. Kotiria (Stenzel 2013: 288)
   [hí.ka]
   hí-ka
   COP-ASS-IMPF
   'He is/it is/there are'

b. Ecuadorian Siona (Bruil 2014: 103)
   [ah.kɨ]
   ah-kɨ
   COP-CLF:ANIM.M
   'The one (M) from'

Because the glottal fricative has the same acoustic properties as a voiceless vowel, many researchers analyzed pre-consonantal [h] as a voiceless vowel in Tukanoan languages (Wheeler 1987a,b, Johnson & Levinsohn 1990, Barnes & Malone 2000, Waltz 2002). For example, Waltz (2002) analyzes the phenomenon as underlying geminate vowels in Kotiria, where the second vowel is devoiced before a voiceless consonant (e.g., *dapu* 'head' is represented as [daḁpú] instead of [da^{h}pú]). However, this analysis results in the violation of bimoraic stem structure, present in many other Tukanoan languages (Stenzel 2013). Inevitably, it also violates the bimoraic stem constraint. Both violations are illustrated in (3) for the Siona word [wah.ti].

(12)



According to Gomez-Imbert (2011), in Eastern Tukanoan languages with no pre-aspiration, geminate stops are derived from the underlying non-geminate stops in morpheme-internal position. As a result, surface lengthening and resyllabification occur where the geminated consonant is assigned to the coda position of the previous syllable. A similar diachronic analysis is applied to pre-aspiration in Eastern Tukanoan languages of the Vaupés region (Stenzel 2013: 26–27). In this view, pre-aspiration resulted from gemination of voiceless consonants, followed by resyllabification and debuccalization of the geminated consonant, followed by a readjustment from [-voice] to the [spread glottis] for laryngeals. The final steps of debuccalization and readjustment are illustrated in Figure 3.

The analysis of pre-aspiration as a reflex of geminated consonants is more favorable than the vowel lengthening and devoicing for two reasons. First, it preserves the basic bimoraic structure found in the majority of stems in Ecuadorian Siona, as well as other Tukanoan languages. Second, it provides a unified method to analyze related phenomena in Tukanoan languages. In addition, as discussed in the previous section, geminate stops have proven to be the most reliable antecedent of pre-aspiration cross-linguistically (Clayton 2010).

4 Distribution of *h*C sequences in Ecuadorian Siona

To complement the data presented in Bruil (2014), a detailed inspection was done on additional data. These data were recorded in 2012 in the fieldwork site Puerto Bolívar (see Figure 1). The original recordings are available through the Endangered Languages Archive (ELAR; Bruil 2012).[18]

[18]Recordings can be accessed via the following archived bundles: 20120918elicr003, 20120918elicr004, 20120918elicr005, 20120919elicr005, 20120912elicr007; examples cited directely from Bruil (2012) in this chapter include one of these bundle names in place of the page numbers.

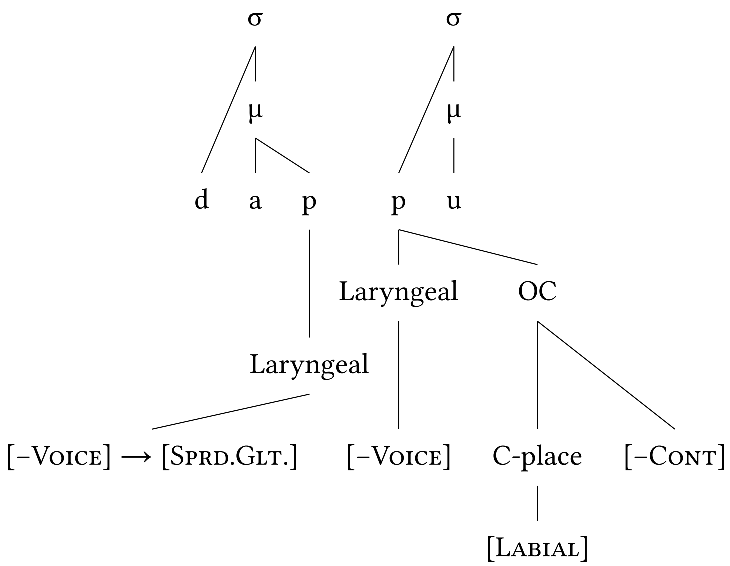


Figure 3: Geminates as a source of pre-aspirates in Kotiria (Stenzel 2013: 27)

4.1 Speaker and materials

From a corpus of recorded and annotated data, a total of 164 word tokens (92 noun phrases, 68 verb phrases and 4 other) were transcribed in IPA. The 164 word tokens comprise five different word lists gathered from the five corresponding audio files. All of the recordings belong to one native speaker of Ecuadorian Siona, who is female and was 51 years of age at the time of recording. One of the recordings consists of elicited noun pairs, while the other four carry elicited sentences in a form of an utterance frame. Each file contains a different utterance frame where word tokens are inserted into a phrase-medial position, as in e.g. *Go’je mo’se* ___ *do̯mio* “The woman ___ yesterday, they say”, where a verb is inserted. In addition to the word tokens inserted into the utterance frame, the words that comprise the utterance frame itself were added to the data.

4.2 Data description

Generally speaking, pre-consonantal [h] appears before [p, t, ʧ, s, k, kʷ, ɲ], while short vowels appear in non-overlapping environments, i.e. before [m, n, ɾ/d, w, j, h, ʔ]. Examples where pre-consonantal [h] appears before [p, t, ʧ, s, k, kʷ], in other words, before the non-laryngealized obstruents, are illustrated in (13). Examples where a short vowel appears before [m, n, ɾ/d, w, j, h, ʔ] are shown in (14). We will return to the case of pre-consonantal [ɲ] in Section 5.

(13) a. [ah.pa.si]
ahpasi
'sapote'
(Bruil 2014: 102)

b. [mõh̃.tor]
mohtor
'motor'
(Bruil 2014: 104)

c. [ĩh̃.si]
ĩhsi
'pineapple'
(Bruil 2012: 20120919elicr005)

d. [oh.ko]
ohko
'water'
(Bruil 2012: 20120912elicr007)

e. [ah.ʧao.ɲã]
ahʧa-o-jã
listen-2/3S.F.PST.N.ASS-REP
'She/you (F) heard, it is said'
(Bruil 2012: 20120918elicr003)

f. [ɲĩh̃.kʷɨ]
jĩhkʷ-ɨ
grandparent-CLF:ANIM.M
'grandfather'
(Bruil 2014: 214)

(14) a. [t̪õ.mĩõ]
dõmi-o
woman-CLF:ANIM.F
'woman'
(Bruil 2014: 164)

b. [p̰õ.nɨ̃õ.ɲã]
bõnɨ-o-jã
turn.around-2/3.F.PST.N.ASS-REP
'She/you (F) turned around, it is said'
(Bruil 2012: 20120918elicr003)

c. [wa.ɾe.do.wɨ]
ware-dowɨ
child-PL
'children'
(Bruil 2014: 150)

d. [a.jao.ɲã]
aja-o-jã
fill-2/3.F.PST.N.ASS-REP
'She/you (F) was filling, it is said'
(Bruil 2012: 20120918elicr003)

e. [wɨ.ʔe]
wɨʔe
'house'
(Bruil 2014: 119)

f. [mẽ.h̃ã]
meha
'sand'
(Bruil 2014: 139)

A comparison of the examples in (13) and (14) reveals that there is a complementary distribution, in that the eligible consonants are always pre-aspirated when in they are in the onset of the second syllable of the word (13), and when not in this position, for example, in the onset of an initial syllable (14), they never are.

Following Clayton (2010: 9), this kind of tight distributional relationship on its own strongly suggests pre-aspiration, but the fact that the target segments also appear before the palatal nasal seems to contradict his criteria for pre-aspiration. The cases where a pre-consonantal [h] appears before [ɲ] within roots are not only unpredictable, but these are also extremely rare. One such word representing the [hɲ] sequence is shown in (15) below.

(15) [ĩh̃.ɲõ]
ĩhjõ
'here'
(Bruil 2012: 20120912elicr007)

We will return to this specific issue in Section 5. For the present purposes, the main point is that we see pre-consonantal [h] before the onset of the second syllable of the root, provided (a) that onset is a non-laryngeal obstruent and (b) it is preceded by a short (monomoraic) nucleus, and it does so without exception.

In suffixes following the root, pre-consonantal [h] is found before [t, s, k, ɲ]. We find short vowels before [s, k, m, n, ɲ, ɾ/d, β, w, h, ʔ]. The segments [t, s, k, ɲ] may appear either pre-aspirated or not, and in Section 4.3, we will further examine to what degree this variation is predictable. Examples of word pairs where the target segment appears before [s] are shown in (16).

(16) a. i. [sah.si.βi]
sah-si-bi
go-FUT-3S.M.ASS
'He will/can go'
(Bruil 2014: 197)

ii. [ah.ʧa.sih.kɨ.βi]
ahʧa-sih-kɨ-bi
listen-CMPL-CLF:ANIM.M-SBJ
'The one (M) listening'
(Bruil 2012: 20140615swicr001.355)

b. i. [t̪ah.si.ʔi]
dah-si-ʔi
come-FUT-N3S.ASS
'I will come'
(Bruil 2012: 20110328slicr002.015)

ii. [aja.sih.kɨ.nĩ]
aja-sih-kɨ-ni
fill-CMPL-CLF.ANIM.M-OBJ
'…him who filled'
(Bruil 2012: 20150720selyi002.027)

Next, word pairs where pre-consonantal [h] and short vowels appear before [k] are presented in (17). Among the analyzed data, [maʔ.ɲõ.ko] presents the only example where a short vowel appears before [k]. While it is unclear whether the target appears at the morpheme boundary, we will argue that morpheme boundaries are not relevant for conditioning pre-aspiration in the first place.

(17) a. [ʧoh.ko.ɲã]
ʧoh-ko-jã
invite-2/3S.F.PST.N.ASS-REP
'You (F)/she invited, it is said'
(Bruil 2012: 20110328slicr001.028)

b. [mãʔ.ɲõ.ko]
maʔjo-ko
star-ELF:ANIM-F
'star'
(Bruil 2012: 20120919elicr005)

So far, then, we see a repetition of the pattern we saw above. Non-laryngealized obstruents are pre-aspirated if they occur in an onset position after a monomoraic (short vowel) nucleus.

Unlike in the root-internal case, however, we find pre-consonantal [h] before the palatal nasal, as well. The examples in (18) show near minimal pairs or the word pairs that were closest to near minimal pairs in the pre-[ɲ] condition.

(18) a. i. [k̰oh.ɲã]
goh-jã
hole-PL
'holes'
(Bruil 2012: 20120919elicr005)

ii. [t̪ah.ko.ɲã]
dah-ko-jã
come-2/3S.F.PST.N.ASS-REP
‘You (F)/she came, it is said’
(Bruil 2012: 20101202slicr001.005)

b. i. [toh.ɲã]
toh-jã
board-PL
‘boards’
(Bruil 2014: 153)

ii. [pe̪h.to.ɲɨ̃]
behto-jɨ̃
coco-CLF:TREE
‘coco palms’
(Bruil 2014: 348)

c. i. [k̰ɨ̃ɦ̃.ɲã]
gɨ̃h-jã
leg-PL
‘legs’
(Bruil 2012: 20120919elicr005)

ii. [sõɦ̃.kɨ.ɲɨ̃ã]
sõhkɨ-jɨ̃-ã
tree-CLF:TREE-PL
‘trees’
(Bruil 2012: 20120919elicr005)

The crucial differences (further discussed in Section 5.4) between the pre-aspirated cases of [ɲ], and the cases where that same segment is not pre-aspirated, are observed in the position within the word: the pre-aspirated cases always follow the root, and what is more, the roots in these cases appear to be monomoraic.

Turning now to the long vowels, we can see that they appear before [s, ɲ, ɾ/d, β, w, w̃, j, h] outside the root, which makes [(s), ɲ] the overlapping environment between pre-consonantal [h] and long vowels. The examples in (19) show (near) minimal pairs where pre-consonantal [h] and long vowels appear before [s], and examples in (20), where they appear before [ɲ].

(19) a. i. [sah.sio]
sah-si-o
go-FUT-3S.F.ASS
'She will go'
(Bruil 2014: 100)

ii. [saː.sio]
sa-a-si-o
go-CAUS-FUT-3S.F.ASS
'She will take'
(Bruil 2014: 100)

b. i. [sah.si.βi]
sah-si-bi
go-FUT-3S.M.PRS.ASS
'He will/can go'
(Bruil 2014: 197)

ii. [saː-sih.kɨ.βi]
sa-a-sih-kɨ-bi
go-CAUS-CMPL-CLF:ANIM.M-SBJ
'The one (M) who is taking (it with him)'
(Bruil 2012: 20120918elicr004)

c. i. [t̪̰ah.si.ʔi]
dah-si-ʔi
come-FUT-N3S.ASS
'I will come'
(Bruil 2014: 100)

ii. [t̪̰ai.sih.kɨ.nĩ]
da-i-sih-kɨ-nĩ
come-IMPF-CMPL-CLF:ANIM.M-OBJ
'…him who came'
(Bruil 2014: 345)

d. i. [t̪̰ah.si.ʔi]
dah-si-ʔi
come-FUT-N3S.ASS
'I will come'
(Bruil 2014: 100)

ii. [t̪̰aː.si.ʔi]
da-a-si-ʔi
come-CAUS-FUT-N3S.ASS
'I will bring'
(Bruil 2014: 100)

In example (19), we see that a pre-aspirated [s] only occurs after a short vowel, not after a long vowel or diphthong. In other words, it only occurs after a mono-moraic nucleus.

(20) a. i. [ɲãɦ̃.ɲã]
jãh-jã
thorn-PL
'thorns'
(Bruil 2012: 20120919elicr005)

ii. [ɲãõ.ɲã]
jãã-o-jã
see-2/3S.F.PST.N.ASS-REP
'You (F) / she saw, they say'
(Bruil 2014: 349)

b. i. [h̃ɨ̃h̃.ɲã]
hɨ̃h-jã
hand-PL
'hands'
(Bruil 2014: 105)

ii. [hɨo.ɲã]
hɨo-o-jã
clean-2/3S.F.PST.N.ASS-REP
'You (F)/ she cleaned, they say'
(Bruil 2012: 20140524slicr001.309)

c. i. [k̰ĩh̃.ɲã]
gɨ̃h-jã
leg-PL
'legs'
(Bruil 2012: 20120919elicr005)

ii. [tɨ̃õ.ɲã]
tɨ̃o-o-jã
weave-2/3S.F.PST.N.ASS-REP
'You (F)/she was weaving, they say'
(Bruil 2012: 20120918elicr003)

The cases of pre-aspirated [ɲ], as can be seen in the examples above, are highly restricted and mirror the description given earlier: they occur exclusively immediately after a root that is monomoraic, and what is more, the suffix in all these cases is the nominal plural marker /-jã/. This will be further explored in Section 5.4.

4.3 Iterative pre-aspiration

Finally, the examples in (21) illustrate that pre-aspiration is applied iteratively in a prosodic word of more than four syllables. Crucially, this happens in every alternating syllable. Since we argue below that this indicates a foot-based distribution, the transcriptions in (21) have the symbol "|" to denote the proposed foot boundaries.

(21) a. Two-syllable word
| to.ʰto |
tohto
board
'board'
(Bruil 2014: 105)

b. Three-syllable word
| sa.ʰsi | βi
sah-si-bi
go-FUT-3S.M.ASS
'He will/can go'
(Bruil 2014: 197)

c. Four-syllable word
| kʷaʔ.ku | ma.ʰka |
kʷa'ku-mahka
be.cooked-DIM
'…when it was semi-cooked'
(Bruil 2014: 165)

d. Five-syllable word
| a.ʰʧa | si.ʰkɨ | βi
ahʧa-sih-kɨ-bi
listen-CMPL-CLF:ANIM.M-SBJ
'The one (M) listening'
(Bruil 2012: 20120918elicr004)

4.4 Summary

In summary then, it would appear that pre-consonantal [h] appears before any non-laryngealized obstruent in alternating (even numbered) syllables, and, in a number of highly restricted cases, before [ɲ]. Table (4) provides a summary of the eligible consonants.

Table 4: Consonants eligible for pre-consonantal [h]

	p	t	ʧ	s	k	kʷ	(ɲ)
hC	✓	✓	✓	✓	✓	✓	(✓)

Furthermore, after short vowels, there is complementary distribution between pre-consonantal [h] and its absence. Pre-consonantal [h] is present only when the following syllable starts with one of these eligible consonants. Finally, when a consonant is preceded by a long vowel, pre-consonantal [h] is not found. A general overview of patterns can be found in Table (5).

Table 5: Summary of word-based positions of pre-consonantal [h]

	Pre-aspiration possible			
	C_1	C_2	C_3	C_4
$\#C_1$...	×			
$\#C_1VC_2$	×	✓		
$\#C_1VVC_2$	×	×		
$\#C_1VC_2VC_3VC_4$	×	✓	×	✓

Since we argue for a foot-based distribution, the pattern given in Table (5) can be generalized as illustrated in Table (6).

Table 6: Summary of prosodic positions of pre-consonantal [h]

	Pre-aspiration possible	
	C_1	C_2
$(C_1VC_2)_{ft}$	×	✓
$(C_1VV)_{ft}$	×	N/A

In Section 1.3.2, we mentioned the behaviour of the glottal stop, which in some ways is similar to, but in crucial ways differs from, the properties of pre-consonantal [h]. In Table (7) we summarise the contexts where pre-consonantal [h] may appear, contrasted with the distribution of the pre-consonantal glottal stop.

Crucially absent are the laryngealised obstruents, and when comparing the distribution of pre-consonantal [h] with that of pre-consonantal [ʔ], it becomes clear that (with an exception of [ɲ]), pre-consonantal [h] cannot appear before sonorants, in contrast to pre-consonantal [ʔ].

All these observations lead to the conclusion that pre-consonantal [h] in Ecuadorian Siona is not, in fact, underlying in these circumstances, but rather the result of some phonological process. We will consider the details of such a process in the next section.

Table 7: Summary of distributional patterns of pre-consonantal [h] and [ʔ]

	p	t	ʧ	s	k	kʷ	ɲ	ɾ/d	β	w	j	h
hC	✓	✓	✓	✓	✓	✓	✓					
ʔC	✓	✓		✓	✓		✓	✓	✓	✓	✓	✓

5 Analysis

In this section, we will propose what we deem to be the optimal analysis for pre-consonantal [h] from a synchronic perspective. After having concluded that pre-consonantal [h] in Ecuadorian Siona is not phonemic, two alternatives warrant consideration: it either results from coda epenthesis, or it arises due to a pre-aspiration rule. We will argue that the latter analysis matches better with the observed facts.

5.1 Recapitulation

It is clear that not all occurrences of the glottal fricative are of equal phonological status. As mentioned above, [h] occurs freely in onsets, and so we conclude that at least in those cases where [h] occurs in onsets, it is in fact the faithful allophone of phonemic /h/.

The situation is, of course, more complex when we turn to the pre-consonantal context, where there is a marked restriction on the sounds which pre-consonantal [h] may precede. These are repeated below in (22a), to be contrasted with those obstruents which are never preceded by pre-consonantal [h] in (22b). The sonorants in (22c) also never co-occur with pre-consonantal [h]. However, there are the aforementioned counterexamples where [h] appears to precede the sonorant [ɲ] (a nasalized allophone of /j/). We will return to this conundrum shortly.

(22) a. [p, t, ʧ, k, kʷ, s]
b. [p̰, t̰, k̰, k̰ʷ, ʔ, s̰, h]
c. [m, n, j, w]

Comparing these three sets, which together make up the full consonantal inventory of Siona (see Table 1 above), one can see that pre-consonantal [h] co-occurs exclusively with the set of the non-laryngealized obstruents. While this in itself does not provide conclusive evidence in favour of the pre-aspiration account, as opposed to the coda-based account, it does provide a very strong indication that the occurrence of pre-consonantal [h] is the result of some phonological operation.

5.2 Prosodic conditioning of pre-consonantal [h]

We propose that pre-aspiration in Ecuadorian Siona is the result of a process of enhancement, or fortition, of eligible onsets in stressed syllables.

This can be seen as analogous to how in languages like English (stan1293) and German (stan1295), voiceless plosives in word-initial and syllable-initial positions are phonetically enhanced by post-aspiration. A crucial difference here is that English enhancement applies to the foot-initial consonant, whereas in Ecuadorian Siona, it applies to the foot-medial consonant – a locus where we typically would expect lenition rather than fortition. We argue that the key to this conundrum lies in the distinction in foot-headedness in these two languages. English is (mostly) trochaic, whereas we propose that Ecuadorian Siona is best described as iambic. Seen from this perspective, enhancement applies the same way in both languages: the onset of the foot-head syllable.

One important argument in favour of the prosodic approach to pre-aspiration in Ecuadorian Siona is that it appears to apply iteratively (see Section 4.3), as one would expect for foot-level correlates. All in all, we propose that the optimal analysis for pre-consonantal [h] in Ecuadorian Siona is that it occurs as enhancement of foot-head initial consonants, manifesting as pre-aspiration on non-laryngealized obstruents.[19]

5.3 Codas or onsets

In the previous section, we have seen that pre-consonantal [h] in Ecuadorian Siona arises as a result of phonological fortition of the onset of a strong syllable.[20]

[19] While we do not touch on the status of the glottal stop in this chapter in full detail (but see Section 1.3.2), it is important to note that our analysis is not contradictory to Stenzel's proposal that glottalization must be a suprasegmental feature in Eastern Tukanoan languages (Stenzel 2007). Whether we opt to posit pre-aspiration as lexically specified as a foot-level suprasegmental feature, or as the phonetic correlate of phonological enhancement, the fact that it applies to the foot head remains unsurprising, as foot heads tend to attract such features (see, for example, Harris 1997).

[20] We thank an anonymous reviewer for pointing out that one of the potential diachronic precursors to pre-aspiration, gemination, can also be seen as fortition.

In other words, we are dealing with the result of a phonological operation. Let us now consider the precise nature of that operation.

Two options present themselves for such an operation. On the one hand, we could be dealing with a case of coda epenthesis, or, on the other, pre-aspiration of the onset proper.

One observation that would, at first glance, act in favour of the coda epenthesis approach is that pre-consonantal [h] never occurs following a long vowel or a diphthong:

(23) a. [kah.ka.sio]
/kaka-si-o/
enter-FUT-3S.F.ASS
'She will enter'
(Bruil 2011)

b. [saː.sio]
/sa-a-si-o/
go-CAUS-FUT-3S.F.ASS
'She will take'
(Bruil 2014: 100)

c. * [saːh.sio]

Conversely, if the second syllable of the stem starts with one of the eligible consonants and the first syllable is monomoraic, pre-consonantal [h] is always present.

The blocking of pre-consonantal [h] after long vowels appears to hint at a maximal rhyme size constraint. This constraint would limit the rhymal constituent of the syllable to either a long vowel (branching nucleus) or to a short vowel plus coda (branching rhyme). Such constraints are typologically highly common; not many languages allow for, for example, super-heavy rhymes (long vowel or diphthong *and* coda). The problem with these cases is that they, in fact, provide no counter-examples for the onset-based approach. In the example in (23), the second onset is outside the first (bimoraic) foot, and thus, not in the onset of a strong syllable. Hence, it would not be eligible for enhancement either under the onset-based approach, or under the coda-based analysis.

A further problem with the coda-epenthesis approach is that it cannot readily explain the failure of laryngealized consonants to trigger it. However, if we assume that pre-consonantal [h] is indeed the product of an onset pre-aspiration process, the observation that only non-laryngealized consonants are targeted can be straightforwardly explained. Now, this restriction stems from a co-occurrence constraint on multiple laryngeal specifications associated with one and the same root node, such as the one illustrated in (24) (see also Kehrein & Golston 2004, Golston & Kehrein 2015, for a more detailed proposal regarding prosodic restrictions on laryngeal specifications).

(24) a. *[Lar,Lar]
Any root node can have at most one laryngeal feature

b. Autosegmental representation:

Skeletal tier:	X	X	X	X	X	X	
Laryngeal tier:		[Lar]					
Laryngeal tier:		[Sprd.Glt]			[*Sprd.Glt]		

The occurrence of laryngeally complex sounds, such as breathy voiced obstruents, demonstrates that such a constraint could not ever be universal, but at the same time, complexity in the laryngeal domain is typologically quite rare.[21]

A final problem with the coda-epenthesis approach is that it requires [h] in pre-consonantal position to be both moraic, and non-moraic. As we have seen in the previous section, Ecuadorian Siona employs certain operations in order to fulfil the bimoraic stem constraint. The relevant examples are repeated below in (25).

(25) a. [jeʔ.ja.je]
/jeʔje-a-je/
learn-TRS-CLF:GEN
‘to teach’
(Bruil 2014: 112)

b. [õh.kʷa.je]
/ũku-a-je/
drink-TRS-CLF:GEN
‘to give someone something to drink’
(Bruil 2014: 120)

Both vowel deletion and glide formation act to restrict the size of the stem to two moras, but neither the glottal stop in (25a) (here rendered as underlying), nor the application of pre-aspiration in (25b) is affected. In other words, neither

[21]Combining voiced-aspirated and breathy voiced plosives into one category, for example, a quick search in Phoible Moran & McCloy (2019) reveals that less than 3% of languages have such sounds at the Labial place of articulation, and for the Coronal and Dorsal PoAs the occurrence is less than two percent in each case.

appears to count as moraic. At the same time, if the absence of pre-consonantal [h] in the case of long vowels is explained in terms of a ban on super-heavy rhymes, we must assume that pre-consonantal [h] is, indeed, moraic.

The onset pre-aspiration account does not suffer from these issues. A problem that does present itself, however, is that the onset pre-aspiration analysis appears to predict words of the shape [CVʔ.ʰCV] – and no such words are attested.[22] Crucially, this account rests on a coda-analysis of the glottal stop, but we are not convinced that such analysis accounts optimally for the data (see Section 1.3.2). For now, we argue that the onset pre-aspiration option fares better than the coda-epenthesis option, but we acknowledge that a final choice can only be made after the status of the glottal stop in Ecuadorian Siona has been properly explored. Regardless of the precise mechanism by which pre-aspiration is implemented, however, the main argument that we make here is that pre-aspiration in Ecuadorian Siona is the result of a foot-based fortition process.

5.4 The mysterious case of [ɲ]

In Section 4, we noted that outside the root, pre-aspiration occurs on a smaller and different set of consonants than in root-internal position. These root-external consonants are:

(26) [k, s, t, ɲ]

The first thing that we see is that, once more, no laryngealized obstruents are eligible for pre-aspiration, while the first two of the three consonants listed do in fact have laryngealized counterparts. Second, the set of eligible consonants is smaller than the root-internal set, but also contains a non-obstruent: [ɲ][23].

The first of these two observations (the absence of some root-internal candidates for pre-aspiration in the root-external condition) can be explained fairly straightforwardly. Suffixes have a far more restricted distributional freedom when it comes to consonants. In our data we do not see any other suffixes with non-laryngealized obstruent onsets that occur in foot-head positions. This leaves the apparently aberrant [ɲ] (or /j/) as the only non-obstruent to receive pre-aspiration, and only in root-external positions.

The solution to this problem lies directly in the phonological contexts in which we find [-ʰɲ-]. This sound only occurs (a) in the /-jã/ plural suffix, and, crucially,

[22]Once more, we thank the anonymous reviewer for pointing this unattested prediction out to us.

[23]To reiterate, this is an allophone of /j/ derived under nasal harmony.

(b) *only* if the preceding root has undergone truncation (as described in Bruil 2014: 105):

(27) a. [to.ʰto]
tohto
board
‘board’

b. [to.ʰɲã]
toh-jã
board-PL
‘boards’

In non-truncating situations, [ɲ] is not preceded by aspiration, even if it is the onset of the second syllable (and thus in an eligible position), as illustrated in (28) below.

(28) [wãɲumi]
wãñumi
‘anaconda’

This illustrates that [ɲ] (underlyingly /j/) is not, by itself, a candidate for pre-aspiration.

We propose, then, that the apparent pre-aspiration of [ɲ] (/j/) occurs *not* because this sound is eligible for pre-aspiration, but rather because of an ordering of pre-aspiration and truncation in the phonological derivation, as illustrated below:

(29) Counterbleeding rule ordering yields correct outcome:

UR	/toto/	/toto-jã/
Pre-aspiration	to.ʰto	to.ʰto.jã
Truncation	–	to.ʰjã
Nasal Harmony	–	to.ʰɲã
SR	[to.ʰto]	[to.ʰɲã]

Should the rules for pre-aspiration and truncation apply in another order, the derivation fails to produce the correct surface representation:

(30) Alternative rule ordering fails:

UR	/toto/	/toto-jã/
Truncation	–	to.jã
Pre-aspiration	to.ʰto	–
Nasal Harmony	–	to.ɲã
SR	[to.ʰto]	*[to.ɲã]

Note that nasal harmony is not crucially ranked with either of the other two processes, as it interacts with neither.[24] In other words, the situation is one of phonological *opacity*, whereby pre-aspiration must precede (in formal terms, "counterbleeds"; Kiparsky 1973) truncation.

5.5 Summary

In Section 5, we have outlined a synchronic account of pre-consonantal [h] in Ecuadorian Siona, which we argue is fully prosodically motivated. More specifically, pre-aspiration in Ecuadorian Siona is a case of enhancement of the onset consonant of the foot-head syllable. This is analogous to how the onset of the foot-head syllable in modern English is enhanced by post-aspiration. The crucial difference lies in the foot structure: whereas English is predominantly trochaic, Ecuadorian Siona feet are iambic. Even if no other phonetic correlates for iterative stress survive in modern language, the prevalence of iambs in surrounding languages (Wheeler 1987a, Johnson & Levinsohn 1990) strengthens this claim from a phylogenetic perspective, not to mention the iterative nature of pre-aspiration in Ecuadorian Siona itself. As for the precise mechanisms of pre-aspiration in Ecuadorian Siona, we propose that the onset enhancement approach is slightly preferable over the coda epenthesis alternative, but we must concede that a definitive resolution is not yet possible.

The seemingly aberrant behaviour of [ɲ] (/j/), the only non-obstruent that receives pre-aspiration, remains the proverbial elephant in the room. However, we argue that this is only an apparent conundrum. Upon closer inspection, pre-aspirated [ɲ] only regularly occurs directly following a limited set of truncated roots. By referring to a counterbleeding rule ordering we have shown that pre-aspiration in such cases still only targets non-laryngealized obstruents.

This is not to say that all issues have been solved, unfortunately, as there is a small group of words that escape the current analysis. These cases must, for the time being, remain classified as unresolved. However, in the case of [iʰɲõ] 'here'

[24]This "survival" of pre-aspiration after its original host consonant has been lost due to truncation is very reminiscent of Stenzel (2007)'s proposal for a suprasegmental analysis for the glottal stop in Kotiria.

for example, there are good reasons to assume a morphologically complex history. Likewise, for [-gʷaʰɲo-] 'causative', we suspect that an alternative analysis in terms of serial verbs might be appropriate, in which case, again, the etymology must be further scrutinized. For now, we leave these cases as topics for further research.

6 Conclusion

In this study, we have looked at the status of pre-consonantal [h] in Ecuadorian Siona. In comparison to other Tukanoan languages, the situation in this language appears to be more complex, primarily due to the occurrence of an apparently pre-aspirated non-obstruent and the wider occurrence of pre-aspiration. We have considered three potential statuses of pre-consonantal [h] in this language: as an independent phoneme, as the result of coda-epenthesis, or as the result of prosodically driven pre-aspiration. Having considered all the evidence, we concluded that the latter analysis provides the closest match to the observed facts and the greatest amount of insight in the phonology of Ecuadorian Siona. Even the superficially spurious occurence of pre-aspirated [ɲ] turned out to be no more than a surface result of a counterbleeding rule ordering.

All in all, then, we conclude that Ecuadorian Siona does indeed have prosodically motivated pre-aspiration, presumably as the last vestiges of an otherwise lost stress system.

Abbreviations

2	Second person	fut	future
3	Third person	gen	general
anim	animate	impf	imperfective
ass	assertive	Lab.	labialized
C-place	consonantal place of articulation	Lar.	laryngeal/laryngealized
		m	masculine
caus	causative	n	non
cmpl	completive	obj	object
clf	classifier	OC	oral constriction
Cont	continuant	pl	plural
cop	copula	prs	present
dim	diminutive	pst	past
f	feminine	rep	reportative

S	singular	TRS	transitivizer
SBJ	subject	UR	underlying representation
sp.	species	μ	mora
SPRD.GLT	spread glottis	σ	syllable
SR	surface representation		

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Name index

Rarities in phonetics and phonology

Rare phenomena play a key role in forming and challenging linguistic theory. This volume presents multi-faceted analyses of rarities in phonetics and phonology, from a wide variety of theoretical standpoints. Some contributions to the volume analyse language-specific rare features, placing them in a broader cross-linguistic context and looking at a sum of their phonological, phonetic, and evolutionary properties, at times also making connections to sociolinguistic factors. Others consider the same (or similar) phenomena from different analytical angles, with extensive cross-referencing, or take a broad analytical or typological stance towards rare phenomena and discuss what it means to be rare.

The volume provides a nuanced picture of phonetic and phonological rarities in genealogically diverse languages, mostly lesser-studied, from around the globe. Authors were encouraged to attempt to strike a middle ground between radical exoticisation of the rarities at hand (describing them in idiosyncratic terms) and radical normalisation (underplaying the rarity of the phenomena at hand). Highly theory-specific or technical terminology is avoided or explained carefully, in order to make the book maximally accessible for a wide typologically-minded audience.