True progressive harmony exists

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Abstract

We argue that true progressive directionality in harmony is representable in the phonology. We analyze data from Tz'utujil and Sakapultek (Mayan) that exhibit a pattern of surface-progressive sibilant harmony that cannot be reduced to prominence-control of any kind, filling thus a hitherto assumed typological gap. We provide an analysis couched in Optimality Theory, argue against putative alternatives, and discuss how a previously discussed link between typological asymmetries in directional-control in harmony processes and asymmetries in the relative frequency of regressive vs. progressive speech errors has little bearing on our synchronic analysis of the pattern. We propose a diachronic pathway for this improbable, but not impossible phenomenon, arguing that the phonologization of progressive harmony occurred in this instance from a misanalysis stemming from a combination of idiosyncratic properties of the languages at hand: (i) a sibilant co-occurrence restriction on roots and (ii) an asymmetric distribution of sibilant types across affixal fields.

Keywords: phonology; harmony; sibilant harmony; directionality; progressive harmony; phonological change; Mayan; Tz'utujil; Santiago Tz'utujil

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1 Introduction

This paper assesses whether limitations should be imposed on the phonological component of the grammar if typological gaps are taken to be indicative of impossible languages, as opposed to improbable ones (see Newmeyer 2005 in the context of syntactic variation). We use harmony processes as a window into this question, narrowing down on one specific aspect of the phenomenon that has received attention in the literature and has direct bearing on (potential) representations in the phonology. Concretely, we seek to answer whether linear directionality (i.e., left-to-right and right-to-left) is indeed represented in harmony processes (see for example proposals like Archangeli and Pulleyblank 1989, Kirchner 1993, Mahanta 2007, a.o.) or whether all phenomena where directionality could be invoked are actually reducible to independently needed considerations like stem-control, dominance-control (Baković, 2000) or prosodic-prominence-control (Kaplan, 2015; McCollum and Essegbey, 2020). If the latter viewpoint proved to be correct, then directionality might not need to be representable in the grammar, at least when it comes to harmony phenomena.

We will conclude that sibilant harmony in the Santiago Atitlán dialect of Tz'utujil (Mayan; henceforth STz') fills a typological gap and demonstrates that true *progressive* harmony exists, as illustrated in (1):[1] [2]

(1)	/ʃ-	in-	**s**in	-ɓaa	-Vʃ	-a/	→ [ʃin**s**inɓaasa]
	COM-	ABS1SG-	√naked	-CAUS	-PASS	-INTR	
	'I was undressed.'						

We will argue on the basis of data like the above that directionality must be representable—that is, while harmony of the STz' type appears to be *rare* cross-linguistically, it must nevertheless be *acquirable* (contra Hansson 2010 for consonantal harmony; see also McCollum and Essegbey 2020 for vowel harmony)[3]. Our conclusion removes the stipulation that only one "type" of direction (regressive), but not the other (progressive), is representable in the grammar. We consider this as an advancement of our understanding of the representation of long-distance processes. Besides leveraging the STz' data as empirical support for our conclusion, we will also reject prior arguments pertaining to biases in the directionality of coarticulation processes Hyman (2002) and speech errors Hansson (2010) that have been invoked to corroborate the exclusion of true progressive harmony from the phonology.

Before delving into the data description, let us take a step back and assess how typological observations related to harmony have been taken to inform possible representations in the grammar. Consider the results of Hansson 2010's investigation into the properties of consonantal harmony cross-linguistically. That work concludes that all consonantal harmony that appears to be progressive is in fact epiphenomenally so, and should be reduced to stem-control: in brief, while the trigger of harmony precedes the target in many languages, one can capture the data by proposing that the harmony emanates stem-outwards. In contrast, Hansson concludes that *regressive* directionality cannot be reduced to stem-control in all cases.

Notice that this conclusion necessitates going beyond mere surface considerations about the linear placement of the target of harmony with respect to the trigger. If this assessment of the typology is correct, though, how should we interpret the asymmetry? One strong conclusion that could be drawn is that the emerging picture is the result of a representational impossibility. In other words, we do not observe genuine cases of progressive harmony because such a process is not learnable; i.e., even if a learner were exposed to data that were consistent with a hypothesis encoding this type of directionality, she could not represent it.

Hansson (2010) arrives at this sort of interpretation of the typological landscape and proposes to limit the formulation of a CORR-[F_1,...,F_n] constraint in (2) that plays a role in driving harmony processes. This constraint is satisfied if a correspondence relation is established between consonants (more on this later). In this formulation, the constraint is inherently specified for a regressive direction when it comes to the relation between the trigger consonant and the target consonant (here, a correspondent):

(2) CORR-[F_1,..., F_n]
Given an output string S and two consonants C_i, $C_j \in S$, where
a. $C_i < C_j$ (C_i precedes C_j), and
b. C_i and C_j differ at most in the set of features [F_1,...,F_n],
then a correspondence mapping must be present *from* C_j *to* C_i ($C_i \leftarrow C_j$) such that C_i *is a correspondent of* C_j.

[1] This type of harmony has also been called *left-to-right*, *perseveratory*, or *carry-over*, terms that we use on occasion.

[2] We use the following abbreviations throughout the paper: ABS - absolutive, AF - agent focus, AP - antipassive, CAUS - causative, COM - completive, CTFG - centrifugal direction, DIR - directional, ERG - ergative, FEM - feminine, IMPERF - imperfective, INC - incompletive, INTR - intransitive, JUS - jussive, MASC - masculine, NEG - negation, NMLZ - nominalizer, PASS - passive, PL - plural, POT - potential, PROG - progressive, PST - past, SG - singular, SS - status suffix, SUBJ - subject, TR - transitive/transitivizer, TWRD.SP - towards the speaker, VS - versive. Whenever possible, we present the examples in IPA, based on the transcription conventions used in the original sources. We maintain a convention where we bold the **trigger** of harmony, double-underline the (successful) target(s) of the harmony process, and we occasionally single-underline an unsuccessful target—i.e., a segment that did not undergo harmony due to not meeting all the relevant requirements.

[3] Consider from Hansson (2010: p.137): "With respect to directionality, it is demonstrated that anticipatory (regressive, right-to-left) assimilation is the norm in consonant harmony, and can be regarded as a default. Though perseveratory (progressive, left-to-right) harmony is also attested, it can always be attributed to other motivated factors, such as sensitivity to morphological constituent structure."; from McCollum and Essegbey (2020: p.1): "We generalize to suggest that progressive harmony should always be reducible to independent factors, and as a result, formalized indirectly through prominence." A weaker statement can be found in Hyman (2002: p.17): "My impression is that anticipatory postlexical [Vowel Harmony] of this sort occurs more frequently than its perseverative counterpart."

The proposal to specify only one direction of correspondence is argued to be supported as well by work in the speech production literature, which has found a bias regarding the relative frequency of regressive versus progressive speech errors. We will return to the details of the above constraint in §4.

Naturally, the conclusion in Hansson (2010) is but one possible interpretation of the typology. Instead of accounting for the observed gap by limiting the space of possible representations, one could instead hypothesize that the gap is the result of considerations that are external to the grammar. To start with, the gap could be accidental and no conclusions should be drawn—the relevant phenomenon might simply be undocumented. Another interpretation would implicate diachrony in the higher frequency of one type of phenomenon versus the other, instead of recurring to limitations on the synchronic grammar (see Hansson 2007). This type of interpretation becomes particularly attractive if one were to find that some process is exceedingly rare, but not unattested.

We will show in what follows that true progressive harmony is one such instance of a rare, but not unattested process. As a result, there cannot be any limitation on the grammar regarding progressive directionality. For the specific case of the STz' phenomenon, we will propose in §5 a hypothesis on the diachronic pathway taken by the language to arrive at the pattern as it exists today, a hypothesis that capitalizes on particular facts about the language's lexicon and what learners bring to the acquisition process (see Hale et al. 2015). In a nutshell, a co-occurrence restriction on root-internal sibilants—something attested more broadly across the Mayan family—was reanalyzed as a productive phonological process, a move that was facilitated by the asymmetrical distribution of sibilant types in prefixes versus suffixes in the language. Our proposal thus uses STz' as a case study that explicitly fleshes out a suggestion in Rose and Walker (2004) that harmony processes result from this kind of extension of a co-occurrence restriction. Finally, we will show that Sakapultek, another Mayan language, possesses the same progressive harmony process as STz' (see DuBois 1981).

This article is structured as follows. We begin in §2 by discussing the taxonomy of harmony phenomena and possible analyses for them, which will become relevant later. Specifically, we make a broad distinction between examples of prominence-based systems and direction-based ones. Section §3 introduces basic facts about Santiago Tz'utujil's grammar and its sibilant harmony. In §4, we propose an analysis of the facts that revises Hansson (2010)'s constraint-based approach to harmony processes, arguing that the grammar must represent progressive directionality in order to best capture the pattern. We turn to diachrony in §5, proposing a pathway for the emergence of progressive harmony in Santiago Tz'utujil and closely-related Sakapultek. Finally, §6 concludes by summarizing the results and taking a step back, putting our results within the broader context of doing typology with the goal of informing our theory of linguistic competence. Throughout our discussion, note that we zoom in and out between different levels of what we descriptively refer to as harmony processes—most narrowly, we focus on sibilant harmony, but whenever relevant and/or necessary, we abstract over all consonantal harmony systems, or all segmental harmony systems including vowel and vowel-consonantal harmony. We flag these levels as appropriate.

2 Taxonomy and theory of harmony relations

On the basis of a consensus in the literature, one can posit that two broad types of harmony systems exist. These two types are differentiated by the relation between the trigger (the controller of harmony) and the target (the alternating element). The sub-division of prominence based systems as in (3)a is based on McCollum and Essegbey (2020)'s discussion, which considers the location of the trigger as primordial:

(3) Types of harmony systems based on the trigger-target relation
- a. prominence-based systems: trigger is in some prominent position[4]
  - (i) stem-control (cyclic or morphological systems):
    stem is prominent; trigger is in a stem (possibly complex), target is in an affix that attaches to the stem
  - (ii) dominance-control (dominant-recessive systems):
    a particular feature value is prominent; trigger has that feature value, target harmonizes to that feature value (regardless of the location of these elements in the word)
  - (iii) prosodic-prominence-control:
    some prosodic trait (e.g., word-edge, stressed syllable) is prominent; trigger is in that prosodically prominent position, target is in a non-prominent position
- b. directionality-based system:
  trigger linearly precedes or follows the target

The classification above is meant to go beyond descriptive adequacy, serving to inform our theoretical modelling of harmony. Put differently, identifying what harmony patterns are attested and unattested cross-linguistically may clue us into what the possible and impossible systems are.

In the following subsections, we provide examples of harmony patterns argued to represent each of the types in (3) and describe in more detail the basis on which this classification is made. We will observe that the array of available analytical options leads some data to be inconclusive regarding their exact classification. A remedy for a less ambiguous classification would be to narrow down the applicability of some types in (3) to only vowel harmony systems and other types to consonant harmony systems (or their subtypes like nasal, sibilant, etc.). Such approaches are represented in the literature and we will refer to them in our

[4]Occasionally, this system is proposed to extend to situations where the *target*, rather than the trigger, is in a prominent position (Walker 2005 on metaphony in Italian dialects, Kaplan 2015 for an overview and the theory of triggers vs. targets in a prominent position). We return to this possibility in §4.3.

discussion. These considerations are necessary in order to accurately interpret and situate the scope of our ultimate claim, namely that directionality is representable in harmony systems (whether they be consonantal or vowel harmony).

In what follows, keep in mind that while there is no definite consensus as to the qualitative distinction between vowel and consonantal harmony systems, the two differ in some ways that might point to the existence of a fundamental difference (see Hansson 2010: p.7 for empirical differences like neutralization and opacity effects, as well as Hansson 2008 on learnability factors; see also Levelt 2011). Furthermore, more work has discussed vowel harmony, partly because it seems to be more common cross-linguistically. For that reason, we are not a priori setting aside the relevance of vowel harmony in our consideration of directionality.

2.1 Prominence-based systems

2.1.1 Stem-control harmony

The stem-control system (also known as cyclic or morphological system) is a type of harmony where a trigger is in a stem (which may be complex), and a target is in an affix that attaches to the stem (Baković, 2000, 2001). Given the right context and without any further stipulations, this harmony is bidirectional and neither the target nor the trigger is limited to any prosodic position. The trigger can be limited to one value of a feature like [+F] or [–F], (henceforth an asymmetrical trigger), or either value of a feature can be a trigger (henceforth a symmetrical trigger).[5]

The inventory in (4) lists the languages considered by Hansson (2010) to possess consonantal harmony that appears to be progressive on the surface, but can be reduced to stem-control:[6]

(4) Stem-control systems (apparent progressive harmony)

a. **Sibilant harmony** OMOTIC: Aari, Koyra, Benchnon, Zayse, Dime | COSTANOAN: Rumsen | BANTU: Izere | QUECHUAN: Wanka Quechua | CUSHITIC: Sidaama | ATHAPASKAN: Diné (Navajo)
b. **Coronal (nonsibilant) harmony** NILOTIC: Mayak, ?Päri
c. **Liquid harmony** AUSTRONESIAN: Sundanese | BANTU: Basaa, Pare, ?Mwiini, Bukusu
d. **Nasal consonant harmony** BANTU: Bemba, Lamba, Luba, Ndonga, Tonga, Herero, Ila, Kwanyama, Suku, Kongo, Yaka, Mbundu, Teke (language cluster), Tiene[7]
e. **Laryngeal harmony** CHADIC: Kera
f. **Stricture harmony** BANTU: ?Pare

Consider sibilant harmony in Koyra (Koorete) as an illustration (Hayward, 1982). Examples (5)–(6) show that in this language, a non-anterior sibilant like [ʃ] in the stem triggers a /s/→[ʃ] alternation in (adjacent) affixes:

(5) /goːʧ -(u)s̳/ → [goːʧuʧ̳]
√pull -CAUS
'cause to pull'

(6) /ʤaʃ -(u)s̳ -es̳ːe/ → [ʤaʃuʃ̳eʃ̳ːe]
√scare -CAUS -3SG.MASC.JUS
'let him/them be frightened'

The Koyra lexicon does not seem to include sibilant-containing prefixes that would straightforwardly adjudicate between a stem-control analysis (i.e., potentially bidirectional harmony) and a progressive-control one.[8] However, Hayward (1988) finds evidence for bidirectional harmony in loanword adaptation from Amharic. Unless there is a non-anterior sibilant later in a word, Amharic [t'] is usually rendered as [ts'] in closely-related Zayse, which displays a similar sibilant harmony pattern. However, Amharic [t'äʤː] 'mead' maps to [ʧ'aʤːe] in Zayse, rather than *[ts'aʤːe]. Although the loanwords do not have a clear morphological

[5]The typology of symmetrical or asymmetrical triggers in sibilant harmony (the phenomenon that will become our focus when we discuss in STz') will not be discussed in depth in this paper. However, it is worth pointing out that Lyskawa and Ranero (2021a) show that sibilant harmony in STz' is a typological outlier in this respect— perhaps the only one alongside Tlachichilco Tepehua and Sakapultek; see §5.4)—in that it exemplifies a system with an asymmetrical trigger that is [+ANT].

[6]The list is primarily based on Hansson 2010: p.145; a question mark symbol indicates cases that are deemed inconclusive. We have added a handful of additional languages based on (i) our study of the literature (Sidaama, which displays assimilation of /s/ to palatal consonants in the stem; Kawachi 2007: 39), as well as (ii) the discussion throughout Hansson (2010) of languages that seem to meet the relevant criteria but for reasons unknown to us are not listed explicitly: Dime (p. 50) and Diné (p. 149-151).

[7]Hansson acknowledges that the Tiene case is a challenge to his conclusions (see our fn.3). The relevant data involve a segment in an infix that appears to control an alternation on a subsequent, root-internal target. One possibility (not entertained by Hansson) that would make the Tiene case irrelevant to the debate on the existence of progressive harmony is that the infix at hand is a suffix at one level of representation (see Kalin 2022 for one recent proposal that all infixes are underlyingly prefixes or suffixes). Hansson: p.145 notes that Tiene affixes alternate between infixes and suffixes based on templatic considerations, lending some evidence that even this infix is underlyingly a suffix. Thus, the Tiene pattern may involve regressive harmony that appears progressive on the surface given the ordering particularities of the affix in question. This analysis would be a departure from the overarching stem-control analysis argued by Hansson for all apparently progressive harmony, but crucially Tiene would still not constitute an example of true progressive harmony. Naturally, if the Tiene data must involve progressive directionality, then data from this language would lend further support to our argument that progressive harmony does exist. We leave further analysis of Tiene for the future.

[8]Furthermore, Hayward (1982: p.252) also notes that the harmony process is further constrained such that triggers are always in a root, never in a suffix. This might not be a 'deep' synchronic property of Koyra but rather a lexical accident. Nevertheless, it means that we are not able to determine whether a non-anterior sibilant in a suffix would trigger harmony on a following suffix—predicted by a stem-control analysis—or the preceding stem—predicted to be impossible under a stem-control analysis, but consistent with a progressive directionality analysis. Thus, we cannot use direct synchronic evidence to rule out analyses other than stem-control for Koyra.

breakdown into stem and prefixes, Hansson (2010) interprets the co-occurrence of non-anterior sibilants as evidence for synchronic stem-control in Zayse and Koyra.

This kind of indirect argumentation for classifying sibilant harmony as one type or another is common given the limitations imposed by the lexicons of the languages under investigation. In fact, in our review of sibilant harmony patterns argued to instantiate stem-control, we found no example where the data provided could adjudicate between all the types of harmony in (3). Since the goal of this paper is not to argue *against* the existence of any single type of harmony, but rather in favor of one particular type (true progressive harmony), we leave this issue of multiple possible analyses aside for the time being (though see our discussion in §4.3.2).

Vowel harmony provides clearer cases of stem-control. Consider the data in (7)–(10) below from Degema (Kari, 2007: p.90), which show that [ATR] harmony emanates outwards from the stem into both the pre-stem and post-stem portions of a circumfix:[9]

(7) u- ɓ**ó**ꜜl -ə́m → [uɓ**ó**ꜜlə́m]
NLMZ- √hold -NLMZ
'holding'

(8) u- g**ɛ́**ꜜn -ə́m → [ʊg**ɛ́**ꜜnám]
NLMZ- √look -NLMZ
'looking'

(9) o- ɗ**ú**ꜜm -ə́m → [oɗ**ú**ꜜmə́m]
NLMZ- √create -NLMZ
'creator'

(10) o- h**ɔ́**ꜜr -ə́m → [ɔh**ɔ́**ꜜrám]
NLMZ- √sharpen -NLMZ
'sharpener'

Examples (7) and (8) show that the same underlying circumfix differs on the surface regarding the [αATR] value of its vowels because it must match the value of the stem vowel. Examples (9) and (10) display another circumfix. We see the same surface contrast where the [αATR] value of vowels in the circumfix must match the [αATR] value of the stem vowel.

In sum, we observe patterns where stem-control is implicated in harmony, most clearly in vowel harmony, but arguably in consonantal harmony as well.

2.1.2 Dominance-control harmony

In a dominant-feature system (also known as a dominant-recessive system), a particular feature (or its value) is dominant and triggers harmony on other segments regardless of their morphological position or prosodic traits. Similarly to stem-control, harmony is bidirectional given the right context.

Hansson (2010: p.142) remarks that such systems are generally rare cross-linguistically and unattested for consonantal harmony. Given this (possibly accidental) gap, we illustrate this pattern using vowel harmony, specifically [ATR] harmony in Diola-Fogny (Sapir, 1965: p.12). [+ATR] vowels like [u] in the TWRD.SP suffix [-ul] trigger an alternation on underlyingly [–ATR] vowels like /a/→[ə]. This type of alternation is observed even in roots like /baj/→[bəj] 'have' in (11), which differs from cases where stem-control is implicated:

(11) /baj -**u**l/ → [bəj**u**l]
√have -TWRD.SP
'to have from'

Example (12) illustrates a trigger in a root acting on a target in a suffix. This illustrates the bidirectional nature of harmony here.

(12) /jit**u**m -ɛn/ → [jit**u**men]
√lead.away -CAUS
'to cause to lead away'

[–ATR] vowels may surface if there are no [+ATR] vowels in the domain of harmony, like in (13):

(13) /baj -ɛn/ → [bajɛn]
√have -CAUS
'to cause to have'

Baković (2000, 2001)'s seminal formulation of stem- (3-a-i) and dominance-control (3-a-ii) harmony systems led to attempts to reduce all cases of harmony to either of these subtypes of prominence-control, an approach dubbed the strong prominence hypothesis by McCollum and Essegbey (2020). However, it has become apparent that these two systems are not sufficient to capture all types of harmony patterns. Specifically, we find at least one other prominence-based system, where the prominent position is described in prosodic

[9] Kari (2007) does not provide the underlying form of the nominalizing circumfix, i.e., we cannot determine whether the underlying vowel is [+ATR] or [–ATR] (or even front or back), but we arbitrarily choose to present it as underlyingly [+ATR] (tense) in order to capture the identity of the underlying representation vs. the alternation of the surface forms. We are also not making commitments as to whether the [ATR] feature is privative or binary, but rather choose to illustrate it using binary values [+ATR] and [–ATR] for expositional purposes.

terms, as well as a strikingly different type based on directionality rather than prominence. We describe these accordingly in the following sections.

2.1.3 Prosodic-prominence-control harmony

Prosody has been argued to be the determinant for a third type of prominence-control: a segment may be a trigger for harmony if it is in a prosodically prominent position like the edge of a word or a stressed syllable. In contrast to stem-control, the trigger's relation to a word's *morphological* structure does not govern the process in such a system.

This type of harmony is in principle bi-directional, with the exception, naturally, of cases where the trigger is at the edge of a word. Hansson (2010: §3.2, p.326) notes that prosody does not seem to play a role in consonantal harmony, although it is not clear why—it might be an accidental gap or a reflection of some deeper property of said harmony (we return to discuss some of these considerations in §4.3.2). As a result, we illustrate prosodic-prominence-control using vowel harmony.

McCollum and Essegbey (2020: p.2) present the data in (14)–(15) regarding labial (rounding) harmony in Tutrugbu, where the labial features of a vowel in an agreement prefix (the trigger) determines the labial feature of a vowel in the FUT prefix that follows it (the target). Note that vowels in roots do not undergo harmony:

(14) /ɔ- ba̳- bá/ → [ɔbɔ̳bá]
2S- FUT- √come
'You'll come.'

(15) /ɛ^{H}- ba̲- bá/ → [ɛ^{H}ba̲bá]
1S- FUT- √come
'I'll come.'

Notice that one could describe the pattern in Tutrugbu as progressive harmony. However, the prominence-based analysis circumvents the need to posit a process based on directionality. McCollum and Essegbey argue that the key data that could adjudicate between the two analyses on the table would involve examples where a prefix with a non-round vowel were added outside of the agreement prefix that triggers the process. In this scenario, if the labial harmony was observed despite the trigger not being at the word-edge, the prosodic-prominence analysis would be falsified for this particular case. Unfortunately, the grammar of Tutrugbu does not provide such a configuration and thus McCollum and Essegbey decide between these two logically-possible analyses on the basis of indirect evidence (in a similar vein to what we observed in §2.1.1 that Hansson 2010 did for Koyra). First, root vowels do not undergo harmony, only prefix vowels do. The authors take this to be a manifestation of morphological prominence. Extending this proposal, they argue that prominence in general, be it morphological or prosodic, plays a role in Tutrugbu. Second, independently of the rounding harmony, the word-initial syllable exhibits a privileged status in Tutrugbu. For example (and setting roots aside), initial syllables display a wider inventory of underlying and surface vowels compared to medial or final syllables. Furthermore, vowel hiatus resolution fully retains V_1 in a V_1V_2 sequence only if V_1 happens to be in an initial syllable; otherwise V_1 either deletes or reduces to a glide. McCollum and Essegbey conjecture that prominence, both structural and prosodic, is independently active in Tutrugbu, thus an analysis of labial harmony is more elegant when referring to this primitive rather than a different consideration such as directionality.

Taking a broader viewpoint on the relevance of the Tutrugbu data and McCollum and Essegbey's interpretation, if we have independent evidence for the relevance of word-edge prominence, and crucially word-edge is a possible location for a trigger of harmony, there is no need to extend the taxonomy of harmony systems beyond this. On the other hand, if progressive harmony was an equally viable analysis for a phenomenon, then the empirical arguments in favor of prosodic-prominence would be weakened.

While word-edge is one of the types of prosodically prominent positions, it is not the only one—word-stress is another type Kaplan (2015). In such a case, the trigger of harmony is in a stressed syllable, while the target is in an unstressed syllable. Claro (Delucchi, 2011) and Brazilian Portuguese (Bisol, 1989) are examples or languages displaying this type of system. In the interest of continuing to the key part of the paper, we move on to the next section now, where we end our discussion of harmony systems by presenting a fourth type which must be accounted for. This system requires as its basis the linear relation between the trigger and target.

2.2 Directionality-based system(s): True regressive harmony

As mentioned at the outset, an attempt has been made to render as epiphenomenal all directionality in harmony (Baković, 2000; Kaplan, 2015). However, there is a growing consensus that *regressive* directionality has to be representable, since the analysis of harmony in several languages must be grounded on the linear relation between the trigger and target. To illustrate, the languages in (16) require a statement of directionality in the grammar. We amend Hansson (2010)'s typology of languages with true regressive harmony by adding Tseltal to this category based on Lyskawa and Ranero (2021a)'s analysis of data from Polian (2013) and Kaufman (1971).

(16) Consonantal harmony systems displaying true regressive harmony (modified from Hansson 2010: p.146-148)

a. **Sibilant harmony** CHUMASHAN: Samala (Ineseño), Barbareño, Ventureño | BANTU: Rundi, Rwanda | MAYAN: Tseltal

b. **Nasal harmony** BANTU: Pangwa

c. **Indeterminate cases** TOTONACAN: Misantla Totonac, Tlachichilco Tepehuaic: Kera | MAYAN: Tsotsil | AUSTRONESIAN: Yabem | ATHAPASKAN: Sarcee (Tsuut'tina), Chiricahua Apache, Plains Apache (Kiowa Apache), Tsilhqot'in (Chilcotin), Tahltan, Dane-zaa (Beaver), Dene-tha (Slave), Tanana, Diné (Navajo); all examples involve alternating prefixes

Furthermore, regressive directionality is needed to analyze some vowel harmony systems as well:

(17) Vowel harmony systems displaying true regressive harmony
KARAJÁ: Iny rybè (Ribeiro, 2002) | INDO-ARYAN: Assamese, Bengali (Mahanta, 2007) | GUANG: Gua (Obiri-Yeboah and Rose, 2017)

To show that we are dealing with true directionality in these cases (as opposed to systems that are reducible to prominence-control), consider data from Samala (Applegate, 1972). Samala exhibits a symmetrical trigger system; i.e., both anterior (e.g., [s]) and non-anterior (e.g., [ʃ]) sibilants are triggers. Example (18) shows that an anterior sibilant that follows a non-anterior sibilant triggers harmony (our glossing is based on source data cited by Hansson 2010):

(18) /s- api ʧʰo -u**s**/ → [sapitsʰolu**s**]
he- √quick √good -him
'he has a stroke of good luck'

In (19), when another suffix is added, such that a non-anterior sibilant follows two anterior sibilants, these two harmonize:

(19) /s- api ʧʰo -us -wa**ʃ**/ → [ʃapiʧʰoluʃwa**ʃ**]
he- √quick √good -him -PST
'he had a stroke of good luck'

It is unclear how a prominence based analysis could account for the Samala data, and directionality is needed to capture the process (see Mithun 1999: p.29 for similar examples in Barbareño Chumash).

The regressive nature of a harmony system is observed even more clearly when the trigger is asymmetrical; i.e., when only one value of a feature triggers an alternation, rather than either value doing so (as we observed for Samala). Consider [ATR] harmony in Iny rybè (Ribeiro, 2002: 482). In Iny rybè, only [+ATR] vowels (e.g., [u, e]) trigger an alternation on underlyingly [–ATR] vowels (e.g., /ɔ/→[o]), but not vice-versa. In the underlying representation in (20) the bolded [+ATR] trigger [u] is both preceded and followed by the [–ATR] vowel /ɔ/, a potential target. In the surface form, however, only the vowel that precedes the trigger alternates and surfaces as [o] (double underline); the vowel that follows the trigger does not alternate (single underline).

(20) /Ø- r- ɔ- ɗ**u**hɔ =rɛrɪ/ → [roʧ**u**ˈhɔrɛrɪ]
3- CTFG- ANTI- √curse =CTFG.PROG
'He is cursing.'

Observe further that in a minimally different example (21) with a different suffix, IMPERF [-e], the [–ATR] vowel that did not alternate in (20) does alternate now, given that it is followed by a trigger:

(21) /Ø- r- ɔ- ɗuhɔ =r -**e**/ → [roʧuˈhor**e**]
3- CTFG- ANTI- √curse =CTFG -IMPERF
'He cursed.'

The Samala and Iny rybè harmony data thus demonstrate that there are cases where the target precedes the trigger that cannot be reduced to independent considerations like prominence-control. As a result, regressive directionality must be representable in the grammar. Put simply, harmony of this type is learnable, whether it involve consonants or vowels.

2.3 Interim summary

Let us summarize the attested types of harmony systems based on the trigger-target relation:

(22) Types of harmony systems based on the trigger-target relation (expanded from (3))

a. stem-control (cyclic or morphological systems): trigger is in a stem (possibly complex), target is in an affix that attaches to the stem
 (i) sibilant harmony: Koyra in (5)–(6)
 (ii) vowel harmony in Degema in (7)–(10)

b. dominance-control (dominant-recessive systems): trigger has a particular feature value, target harmonizes to that feature value (regardless of the morphological location of these elements)
 (i) vowel harmony: Diola-Fogny in (11)–(13)

c. prosodic-prominence-control: trigger is in some prominent position like stressed syllable or edge of the word
 (i) vowel harmony: Tutrugbu in (14)–(15)

d. directionality-based system: trigger linearly precedes or follows the target
   (i) regressive sibilant harmony: Samala (Ineseño) in (18)–(19)
   (ii) regressive vowel harmony: Iny rybè in (20)–(21)

Henceforth, the most relevant type for our purposes is systems based on directionality, given the claim that only one of the directions (regressive) is attested and representable in the grammar (Hansson 2010: p.137 for consonantal harmony and McCollum and Essegbey 2020: p.1 for vowel harmony; see fn.3). In the following section, we outline some approaches to formalizing directionality in harmony processes, in order to ground our subsequent analysis of sibilant harmony in STz' that, we argue, must encode progressive directionality.

2.4 Encoding directionality

The possibility of representing directionality in the grammar is not tied to any single phonological framework. Nevertheless, we use Optimality Theory (OT) to illustrate how this can be achieved, given that the proposals we address largely employ this approach. Note, however, that our ultimate claim about the representability of progressive harmony generalizes to other approaches.

A handful of constraints have been proposed to encode directional control in harmony. For example, the agreement-by-correspondence (ABC) approach (Walker, 2000b; Rose and Walker, 2004) is used by Hansson (2010: p.241) for consonantal harmony. Hansson proposes the following formulation of a correspondence constraint in (23), which is satisfied by establishing a (possibly long-distance) relation between a pair of consonants (see also Rose and Walker 2004). Notice that this relation is inherently specified as regressive.

(23) CORR-[F_1,..., F_n]
Given an output string S and two consonants C_i, $C_j \in S$, where
   a. $C_i < C_j$ (C_i precedes C_j), and
   b. C_i and C_j differ at most in the set of features [F_1,...,F_n],
then a correspondence mapping must be present *from C_i to C_j* ($C_i \rightarrow C_j$) such that *C_i is a correspondent of C_j*.

The constraint in (23) is violated if the asymmetrical correspondence relation between a trigger and target consonant is not established.

This constraint alone is not enough to drive harmony and a second type of constraint is needed. An identity constraint like the one in (24) is satisfied if there exists featural identity between a trigger and target that stand in a correspondence relation. In Walker (2000b), such a constraint for e.g., the [VOICE] feature is stated as follows:

(24) IDENT-*CC*
Let C_1 be a consonant in the output and C_2 be any correspondent of C_1 in the output. If C_1 is [αVOICE], then C_2 is [αVOICE].

A parallel constraint in Hansson (2010: p.243) can be specified for any feature [F].

In sum, the ABC approach within OT requires two constraints in order to arrive at harmony: CORR-[F_1,..., F_n] for establishing a correspondence relation, and IDENT-*CC* (relativized to whatever feature) for driving identity between two consonants that stand in a correspondence relation.

A different OT approach captures directional control through a sequential markedness constraint. Consider the proposal by Mahanta (2012: ex.(11)):

(25) a. *[+F][−F]
Assign a violation mark to a [−F] segment preceded by a [+F] segment.
   b. *[−F][+F]
Assign a violation mark to a [+F] segment preceded by a [-F] segment.

Although this constraint seems more straightforward in deriving harmony than the two-step combination used in ABC through correspondence (23) and identity (24), it has been argued that such apparent simplicity is not necessarily advantageous (Rose and Walker, 2004).

A third type of a constraint can encode directionality, namely an alignment constraint such as the one below from Gafos (1999: p.268):[10]

(26) ALIGN*(Spreading parameter, Domain of extension, Direction)*
Spreading parameter = {Tongue Tip Orientation, Cross-Sectional Channel}
Domain of extension = {Morphological-Category, Prosodic-Category}
Direction = {Left, Right}

The Spreading parameter encodes the feature that spreads within the theory of Articulatory Phonology (Browman and Goldstein, 1986); Domain of extension encodes how far harmony propagates (e.g., within an entire prosodic word); finally, Direction encodes the directionality of spread. Note that Direction = {Right} derives progressive directionality under this final approach.

For the purposes of our main argument—that the directionality of both regressive and progressive types is encodable in the grammar—it is ultimately orthogonal whether such encoding is mediated via the ABC

[10] Hansson (2010: p.215–216) shows how this constraint alone does not actually derive a desired directionality effect in languages with an asymmetric trigger (i.e., both /s/ and /ʃ/ would need to be triggers to achieve directional control). Instead, further constraints are required, which we set aside here.

approach or the other proposals presented here. In our analysis in §4, we choose to use the ABC approach, but the issue of directionality arises in any theory that seeks to account for asymmetrical relations between features/segments.

In sum, we surveyed three approaches grounded in OT that encode directionality in harmony: (i) the ABC approach in (23)-(24) that was argued by Hansson (2010) to be inherently specified for regressive directionality, (ii) a sequential markedness constraint in (25) that was proposed to come in both regressive and progressive types, and (iii) an alignment constraint in (26) that was equally suitable for progressive and regressive directionality. Overall, then, different approaches can encode directionality. However, while each approach could stipulate a restriction on one of the directions, only the correspondence constraint in Hansson (2010) does so as a result of the author's conclusions about the typology of harmony (see also McCollum and Essegbey 2020). We will thus engage directly with this specific proposal.

At this juncture, it is important to note again that we have only seen clear empirical evidence for true regressive harmony—all cases of surface progressive harmony like Koyra in (5)–(6) have been argued to be reducible to other non-directional systems. We will postpone our discussion of what has been taken to be corroborating evidence for the special status of regressive versus progressive harmony until §4.4. In the meantime, we proceed to discuss empirical data that was not considered by Hansson (2010) at the time of claiming that all progressive harmony is epiphenomenal.

3 Santiago Tz'utujil

In this section, we discuss data that demonstrate that progressive directionality must be represented in our accounts of consonantal harmony (contra Hansson 2010; see also McCollum and Essegbey 2020 for an analogous limitation in vowel harmony, as well as Baković 2001, Hyman 2002, i.a.).

Tz'utujil (ISO 639-3) is a Mayan language from the K'ichean branch spoken primarily in several towns on the southern shores of Lake Atitlán in Guatemala. We will discuss the Tz'utujil dialect spoken in Santiago Atitlán, which, as a reminder, we have been referring to throughout the paper as STz'. There are two grammars of Tz'utujil: the first, primarily focusing on the San Juan la Laguna dialect by Dayley (1985), and a later one on the San Pedro la Laguna dialect by García Ixmatá (1997). Other work includes a dictionary by Pérez Mendoza and Hernández Mendoza (2001) which focuses on San Pedro, as well as a study on derivational morphology (García Ixmatá, 1998), and papers on a variety of topics in syntax and phonology (e.g. Aissen, 1999; Levin et al., 2020; Lyskawa and Ranero, 2022, 2021a; Wax Cavallaro, 2021).

There exists significant dialectal variation between Tz'utujil varieties. The phonological characteristics of STz' that make it contrast significantly with the San Juan and San Pedro dialects are briefly mentioned in Dayley (1985). One of these is the sibilant harmony process that we focus on moving forward.

3.1 STz' sibilant harmony: preliminaries

Dayley (1985: 36) notes a process unique to STz' among Tz'utujil dialects, where an underlying phone /ʃ/ optionally surfaces as [s] when it (possibly non-immediately) follows /s/. The following rule in (27) is provided to illustrate the process, alongside three examples (28)–(30) (bolding and underlining is ours):[11]

(27) ʃ→ s / ... s ... _ (optional)

(28) /ʃ̲kam**s**aʃ̳a/ → [ʃ̲kam**s**as̳a] 'it was killed'

(29) /ʃ̲χo**s**q'iʃ̳a/ → [ʃ̲χ**s**q'is̳a] 'it was cleaned'

(30) /ʃ̲mi**s**taʃ̳a/ → [ʃ̲m**s**tas̳a] 'it was swept/forgotten'

Notice the single- and double-underlined sibilants on both sides of the bolded triggers in (28)-(30): only the sibilant *following* the trigger (double-underline) undergoes an alternation involving anteriority. In contrast, the sibilant preceding the trigger (single-underline) does not alternate. At first glance, then, this seems like an instance of progressive harmony. In order to show that this conclusion holds beyond mere surface appearances, let us now delve deeper into the phenomenon.

More recently, Lyskawa and Ranero (2021a) confirmed and expanded on Dayley's description. A first extension that is crucial for establishing that STz' sibilant harmony can shed light on the issue of directionality in the phonology concerns whether the phenomenon is purely phonological in nature as opposed to morphological (i.e., an instance of a phonologically-conditioned morphological alternation).[12] Here, the evidence comes from the applicability of harmony at a long-distance. Morphological alternations necessarily apply locally, between structurally adjacent morphemes (Bobaljik 2012; Moskal and Smith 2016, but cf. Gouskova and Bobaljik 2020: §4.2) and, depending on one's assumptions, linearly adjacent ones (Embick 2010; see Baker 1985 for the Mirror Principle, which ensures that linear order reflect hierarchical relations). If an alternation in a harmony process were always local (i.e., the trigger and target were always in immediately adjacent elements), one could conceive of situating the analysis outside of the phonology proper and thus render it irrelevant for our discussion.

[11] Lyskawa and Ranero 2021a point out that the translation provided by Dayley for (30) is likely a mistake and the example means 'it was forgotten'.

[12] This analytical option, that a harmony process be morphological in nature, is rarely entertained in the literature (notably, it is not considered in Hansson 2010). We fail to see why this alternative would be off the table a priori, especially since it could explain away some patterns without revising phonological accounts, while fitting squarely with morphological theories. See fn. 7 for an example of how an unusual phonological pattern can be simplified by means of a morphological approach.

Regarding this point, consider that the STz' process applies to a target in a morpheme that is non-adjacent to the trigger (32):[13]

(31) /nk- at- kon -Vʃ -a/ → [nkatkonoʃa]
INC- ABS2SG- √look.for -PASS -INTR
'You are being looked for.'

(32) /ʃ- in- **s**in -ɓaa -Vʃ -a/ → [ʃinsinɓaasa]
COM- ABS1SG- √naked -CAUS -PASS -INTR
'I was undressed.'

In (32) above, there is a linearly intervening morpheme (the causative suffix [-ɓaa]) between the trigger in the root and the target in the passive suffix. The fact that harmony still applies rules out an analysis where the alternation is not the product of a purely phonological process but of a phonologically-conditioned morphological alternation that is specific to the suffix bearing the target (in the example above, the passive suffix); see Paster (2006) for a subcategorization approach that could be employed if the locality problem did not exist.

Notice further that we can reject an analysis where the root (containing the trigger) and the passive (containing the target) are in fact structurally adjacent and the example simply does not obey the Mirror Principle. The reason is straightforward: the root here belongs to the Mayan-specific class of roots traditionally called positionals, which can never surface bare and require root-particular morphemes to be usable as stems (Haviland, 1994; Tummons, 2010; Coon, 2019; Henderson, 2019; Lyskawa and Ranero, 2022). In this example, then, the causativizer morpheme is closest to the root, setting the valency at two and allowing for the root to be usable. The passive morpheme then lowers the valency and is hierarchically outside the causative. In short, the locality issue appears to be insurmountable, so a morphological analysis is untenable.

Moving on, a second extension of Dayley's initial observations made by Lyskawa and Ranero (2021a) is that the sibilant alternation applies more broadly than to the target in the passive morpheme (which appears in all the examples provided originally in 1985). This casts further doubt on an analysis invoking a phonologically-conditioned morphological alternation. Specifically, Lyskawa and Ranero (2021a) show that a sibilant in one of the language's nominalizing suffixes /-ʃik/ also undergoes harmony:[14]

(33) /ruu- **s**ik' -ʃik/ → [r**s**ik'sik]
ERG3SG- √call -NMLZ
'his calling'

Given these two extensions of Dayley (1985)'s description, we must conclude that the phenomenon is stated in the phonological component of the grammar and thus can bear on the theory of harmony and the issue of directionality.

Having established this conclusion, we can further refine our description of the phenomenon. First, notice that the entire natural class of anterior sibilants in STz' /s, ts, ts'/ are triggers:

(34) /ʃ- Ø- qa**s** -Vʃ -a/ → [ʃqa**s**asa]
COM- ABS3SG- √cut -PASS -INTR
'It was cut.'

(35) /ʃ- ee- **ts**iχ -Vʃ -a/ → [ʃi**ts**iχosa]
COM- ABS3PL- √speak.ill -PASS -INTR
'They were spoken ill of.'

(36) /ʃ- Ø- **ts'**aχ -Vʃ -a/ → [ʃ**ts'**aχeesa]
COM- ABS3SG- √smash -PASS -INTR
'It was smashed.'

Second, sibilant harmony in STz' is asymmetric in that only [+ANT(ERIOR)] sibilants are triggers. This means that [–ANT] segments can only be targets, not triggers of harmony (in contrast, for example, to Samala in (18)–(19)). In (37) below, we observe that [ʃ] in the root does not trigger harmony on a sibilant in a suffix (i.e., there is no /s/→[ʃ]):

(37) /ʃ- in- a- ʃχow -saa -Vχ/ →[ʃnaʃχowsaaχ]
COM- ABS1SG- ERG2SG- √dance -CAUS -TR
'You made me dance.'

Third, the trigger may be in a root (as seen in all examples thus far) or in an affix, like in (38):

[13] All the STz' data come from our work in Guatemala with four consultants whose first language is STz'. For simplicity of exposition, we do not explicitly provide the non-harmonizing version(s) for each relevant example, but note that those versions are indeed deemed unacceptable by our consultants. We interpret this state of affairs as meaning that the non-harmonizing versions are ungrammatical.

[14] The analytical possibility exists of decomposing this suffix into two morphemes: passive /-Vʃ/ and a nominalizer /-ik/. This would thus make moot the observation that the alternation occurs in more than one morpheme. However, this putative alternative faces a challenge, since some root transitives in STz' of the form CVC are nominalized via /-ʃik/ and others via /-ik/ only (see Lyskawa and Ranero 2022 for detailed discussion). This suggests that valency reduction via passivization is not a prerequisite for nominalization. On a related note, Dayley (1985: p.179) reports that in San Juan Tz'utujil, CVC roots are passivized via the infix /-χ-/ and then undergo nominalization. One could imagine that the same holds in STz', but we do not observe such a requirement in this dialect, since the nominalizer can attach directly to what appear to be underived CVC roots and only a subset of these take an infix, which surfaces as [-ʔ-] in STz' (see e.g., (50)).

(38) /ʃ- in- ʃχow -saa -Vʃ̠ -a/ → [ʃinʃχowsaas̠a]
COM- ABS1SG- √dance -CAUS -PASS -INTR
'I was made to dance.'

Finally, the process is obligatory for contemporary speakers, who reject the non-harmonizing forms and consider them unacceptable. Nevertheless, they recognize them as pronunciations that a speaker of a different Tz'utujil dialect might produce—recall that the harmony process is unique to STz' among described Tz'utujil dialects. This state of affairs contrasts with the brief description in Dayley (1985), where optionality is reported (though it is hard to determine exactly whether the author meant e.g., intra- or inter-speaker optionality).

Summing up, we may represent (for expository purposes) sibilant harmony in STz' via the following SPE-style rule:

(39) Sibilant harmony in contemporary STz'
ʃ→ [+ANTERIOR] / [+ANTERIOR, +STRIDENT] ... _ (obligatory)

We will now delve into the data more closely and argue against analyses that would take the process to involve something other than a statement that encodes the progressive nature of the harmony. As a result, we will argue that STz' sibilant harmony fills in most clearly what had been taken to be a typological gap. This will have consequences for the limitations (or lack thereof) imposed on the representation of harmony processes in the grammar, as discussed in §4.

3.2 STz' sibilant harmony is truly progressive

The data analyzed in this section pertain directly to the question that interests us: does sibilant harmony in STz' require the encoding of progressive directionality in the phonological component of the grammar? In all the STz' examples we have assessed so far, only the sibilant following the trigger undergoes harmony; the sibilant preceding the trigger never does. Thus, at least on the surface, we appear to be dealing with progressive harmony. In what follows, we rule out several putative alternative analyses that would not encode directionality in the analysis of the process.

3.2.1 Ruling out stem-control

Zooming in closer on non-harmonizing sibilants that precede a trigger, we have seen examples where the sibilant in the completive aspect prefix /ʃ-/ does not alternate (i.e., there is no /ʃ/→[s]). This is not the idiosyncratic behavior of a single morpheme resisting harmony. The same absence of an alternation is observed for sibilants in two other prefixes: the potential aspect /ʃt-/ (*/ʃt-/→[st]), as in (40), and the 2nd plural absolutive agreement prefix /iʃ-/ (*/iʃ-/→[is]), as in (41):

(40) /ʃ̠t- Ø- a- **s**ik' -Vχ teχlal/ → [ʃ̠ta**s**ik'iiχ teχlal]
POT- ABS3SG- ERG2SG- √call -TR hopefully
'Hopefully you call him.'
Spanish: 'Ojalá lo llamés.'

(41) /k- iʃ̠- in- **s**ik' -Vχ/ → [kiʃ̠in**s**ik'iiχ]
INC- ABS2PL- ERG1SG- √call -TR
'I am calling you all.'

We see, then, that sibilants in several morphemes preceding the trigger do not undergo the type of alternation under consideration. Furthermore, these non-alternating segments do not fall in the exact same morphological slot: on a surface left-to-right breakdown of the verbal stem in STz', the aspect morphemes occupy the first slot, while the absolutive agreement morpheme occupies the second slot:

(42) *V*erbal stem in STz'
TAM- ABS- ERG-√ROOT -DERIVATION -SS =OTHER

Let us appreciate why these examples are important. The reduction of harmony processes to sources that do not invoke directionality was driven most prominently by the observation that stem-control can frequently account for surface regressive or progressive patterns (Baković, 2000). Recall, for example, data from the Omotic languages (see (5)-(6)). Since these languages are exclusively suffixing, stem-control can thus account straightforwardly for the surface-progressive nature of the harmony observed without needing to posit progressive directionality in the phonology. Recall as well that the clearest cases of stem-control are languages that are both prefixing and suffixing, since the harmony process can be observed to apply outwardly from the trigger's location; i.e, from the root into the prefixal and suffixal fields like in Degema illustrated in (7)–(10).

STz' is clearly unlike the Omotic languages and like Degema in being a prefixing and suffixing language. Thus, all else being equal, it would be expected under a stem-control analysis that targets in the prefixal field would undergo the same alternation that we observe in the suffixal field. However, we do not observe this. Thus, a stem-control analysis cannot account for the data. We will return to a stem-control analysis once more, with one additional stipulation regarding the role of prefixes, in §4.3.1 and show why such a proposal—in its attempt to salvage a ban on progressive directionality in the grammar—cannot be maintained.

3.2.2 Ruling out dominance-control

Moving on, observe that sibilants in a root also do not alternate when they precede a trigger (in this case, the trigger is a sibilant in the causative suffix /-saa/):

(43) /ʃ̲- in- a- ʃ̲χow -**s**aa -Vχ/ → [ʃ̲naʃ̲χow**s**aaχ]
COM- ABS1SG- ERG2SG- √dance -CAUS -TR
'You made me dance.'

If STz´ harmony was a straightforward case of [+ANT]-dominance, we would expect all sibilants, regardless of their morphological status (root or affix) to match this feature. In (43) we see that this is not the case. This data point is enough to rule out an analysis that would resort to a dominant-recessive system relativized to [+ANT].

3.2.3 Ruling out prosodic-prominence control

Let us illustrate how a prominence-based analysis could not account for the STz' data. First, ruling out edge-prominence is straightforward, since the trigger has not been in the first or last syllable of the word in any of the examples we have discussed.

Example (44) shows that a stress-based analysis, where the trigger occurs in the special prominent position of stressed syllable (marked with ˈσ in the surface form), could not make sense of the pattern either:

(44) /ʃ- in- ʃχow -**s**aa -Vʃ̳ -a/ → [ʃin.ʃχow.**s**aa.ˈs̳a]
COM- ABS1SG- √dance -CAUS -PASS -INTR
'I was made to dance.'

Stress in STz' falls predictably on the final syllable. In (38) and all previous examples, the trigger is in an unstressed syllable. We can thus rule out any analysis that would take the process to involve stress-control, since harmony does not emanate from a stressed syllable. In §4.3.2, we will return to the issue of stress-placement and reject an alternative analysis invoking featural attraction *to* the stressed syllable (see Walker 2005 for vowel harmony).

To wrap up our discussion here, we present a set of examples that taken together with (38) above encapsulate why prosodic prominence could not be at play. In brief, it is impossible to formulate a natural class for a trigger's position based on prominence. The examples below show that the trigger can be the first segment of a root as in (45), the last segment of a root as in (46), or root-internal (47). Considering that the trigger can also be in an affix as in (44), we fail to see how any prosodic generalization could be posited.

(45) /ʃ- ∅- **ts'**aχ -Vʃ̳ -a/ → [ʃ**ts'**a.χee.s̳a]
COM- ABS3SG- √smash -PASS -INTR
'It was smashed.'

(46) /ʃ- ∅- qa**s** -Vʃ̳- a/ → [ʃqa.**s**a.s̳a]
COM- ABS3SG- √cut -PASS -INTR
'It was cut.'

(47) /ʃ- ∅- χo**s**q'- Vʃ̳- a/ → [ʃχ**s**ɢ̆i.s̳a]
COM- ABS3SG- √clean -PASS -INTR
'It was cleaned.'

We conclude that the four examples in this subsection show that a prosodic-prominence-control approach such as McCollum and Essegbey (2020)'s for Tutrugbu vowel harmony fails to account for sibilant harmony in STz'.

3.2.4 Interim summary

To summarize, we have shown that it is not feasible to reduce sibilant harmony in STz' to a process that does not encode progressive directionality. This argument is the first and primary contribution of the paper. We have ruled out stem-control, since prefixes do not participate in harmony; we have ruled out dominance-control, since the [+ANT] feature does not trigger alternations across the board; we have ruled out prosodic-prominence control, since word-edge and stress play no role in establishing the harmony trigger. One could conceive of further data to test our proposal, which we turn to below in §3.3 (where we report on some data limitations), and in §4.3, where we refute additional counter-analyses. After wrapping up this section, we will elaborate on our contribution in two ways: by providing a formalization of progressive harmony in STz' in §4 and by arguing for a concrete diachronic pathway for the emergence of the phenomenon in §5.

3.3 Limitations in the STz' data

Given certain limitations of the lexicon in STz', we are not able to detect whether certain properties of sibilant harmony in the language hold beyond the domains analyzed here.

For example, we cannot test whether an anterior sibilant in a prefix can be a trigger (leading thus to an alternation on a root segment), since the language provides no prefixes bearing such a sibilant. It is conceivable that a wug test could be devised to address this lexical gap, but designing stimuli where the relevant segment in a nonce word is a functional prefix (such as TAM or agreement) seems challenging from a methodological standpoint. Furthermore, whatever results are obtained would be difficult to evaluate—in fact, only a positive result would be interpretable, since a negative result might indicate that the experiment was not well-designed or the participants did not perform the intended task (for related observations regarding the use of this kind of experiments, see §6). We thus leave this for future consideration.

Lyskawa and Ranero (2021a) also note that compounds do not provide empirical evidence for or against the interpretation we gave for the data, given that compounds do not constitute a domain for sibilant harmony in STz'. Consider the example below:

(48) /nuu- smal+tʃii/ → [nsmatʃii] / *[nsmatsii]
GEN1SG- hair+mouth
'my beard'

There are two sibilants in (48): /s/ and the following /tʃ/. Thus, according to the description we provided for sibilant harmony in STz' (see (39)), /tʃ/ should harmonize and surface as [ts]. However, the unacceptability of the harmonizing variant implies that the domain for sibilant harmony excludes compounds. Note that this state of affairs, where compounds do not constitute a domain for harmony, has been observed in other languages (see Hansson 2010: p.379 for Diné and Turkish). We leave for future work determining whether all STz' compounds are equal in this regard.

Furthermore, Lyskawa and Ranero report one root in STz' that is unexpected given the harmony process that is otherwise active in the language:

(49) /ʃ- ∅- a- **s**atʃ a- jaw/ → [ʃa**s**atʃ ajaw]
COM- ABS3SG- ERG2SG- √lose ERG2SG- key
'Did you lose your key?'

In (49), [tʃ] disagrees in anteriority with the preceding [s]. This example is doubly notable since it does not conform to the sibilant co-occurrence restriction that we will describe in §5.1.

For orthogonal reasons, it is not possible to observe whether this root triggers harmony on the sibilant in the passive or nominalizing suffixes that we discussed. First, the passive morpheme that this root takes is an infix that surfaces as [-ʔ-] rather than the passive suffix containing a sibilant:

(50) /ʃ- in- sa<-ʔ->atʃ -a/ → [ʃinsaʔatʃa]
COM- ABS1SG- √lose<PASS> -INTR
'I got lost'

Second, the allomorph of the nominalizing suffix that attaches to this root also does not contain a sibilant:

(51) /ruu- satʃ -ik/ → [rsatʃik]
ERG3SG- √lose -NMLZ
'its losing'

While the existence of this root might appear to be a challenge to the analysis of STz' as having a sibilant co-occurrence restriction and progressive harmony, it seems reasonable that a small number of lexical items could be learned and stored as exceptions to otherwise productive patterns, as long as there are enough examples that follow the productive process (Yang, 2016).

At this juncture, it is worth bringing up that the existence of certain empirical limitations in STz' is hardly unique to the language. We have remarked already in §2 on parallel limitations that are detectable in even the most widely cited examples of harmony patterns in the literature. As a result of these limitations, indirect evidence is occasionally used to complement the proposed analyses; e.g., given the absence of prefixes in Koyra, how the behavior of loanword adaptation in a closely related language argues for a stem-control analysis (see §2.1.1). Taking a bird's eye view, then, we will see that once we conclude that progressive harmony is representable in the grammar, and that languages hardly ever provide every single piece of empirical evidence that could adjudicate between two or more competing analyses, proposals that have taken progressive harmony to be reducible to other types may need to be revisited. In other words, languages like Koyra should not be considered unequivocal instances of stem-control. This reconsideration of consonantal harmony systems might lead us in turn to question (i) whether progressive harmony is indeed as cross-linguistically rare as assumed and (ii) whether stem-control is comparatively more abundant.

4 Analysis

In this section, we provide an analysis of progressive sibilant harmony in STz' couched in Optimality Theory (OT). More specifically, we use the Agreement-by-Correspondence approach (ABC; Rose and Walker 2004; Walker 2000a,c) introduced in §2.4. Our implementation modifies Hansson (2010)'s account of regressive consonantal harmony. In brief, we will show that removing a limitation on the permitted directionality of correspondence between consonants enforced by Hansson's version of CORR[F]-CC constraints allows us to account for the truly progressive nature of the STz' phenomenon.

In principle, our proposal should be possible to state in other OT-based approaches (recall the alternatives discussed previously in (25) from Mahanta 2007, and (26) from Gafos 1999), or in rule-based frameworks. However, we choose to use ABC in order to respond to and be in conversation with a literature that has played a prominent role in accounting for typological generalizations regarding harmony phenomena.

4.1 Introducing the relevant OT constraints

4.1.1 Correspondence constraints

The ABC approach relies on the interaction between two types of constraints in order to derive harmony. The first type are correspondence constraints which are satisfied if a correspondence relation is established between consonants in output candidates (Rose and Walker, 2004: p.491) (italicization for the sake of emphasis is ours):

(52) CORR-C↔C
Let S be an output string of segments and let C_i, C_j be segments that share a specified set of features F. If $C_i, C_j \in S$ then C_i is in a relation with C_j, that is, *C_i and C_j are correspondents of one another*.

Note that correspondence as stated in (52) does not encode directionality yet; i.e., the relation established between two consonants is mutual and symmetrical. Hansson (2010: p.241) argues that, if linear directionality is necessary to account for a harmony process (rather than appealing to e.g, a morphology-based notion such as stem-control), this directionality is always regressive and encoded as follows in the definition of the constraint (repeated from (23)):

(53) CORR-[F_1,..., F_n]
Given an output string S and two consonants $C_i, C_j \in S$, where
a. $C_i < C_j$ (C_i precedes C_j), and
b. C_i and C_j differ at most in the set of features [F_1,...,F_n],

then a correspondence mapping must be present *from C_j to C_i* ($C_i \leftarrow C_j$) such that *C_i is a correspondent of C_j*.

In such unbalanced correspondence relations as in (53), we will refer to the source/agent of the relation as a *corresponder* and the receiver of the relation as a *correspondent*. For clarity, we will label this type of unbalanced correspondence relation as a *corresponder-correspondent* relation.

Besides the difference in the absence vs. presence of encoded directionality between the correspondence constraint in (52) and (53), note also that the correspondence in the former is stated between consonants that *share* a set of features, while in the latter, it is stated as being established between consonants that *differ at most* in a set of features. For the sake of presenting a direct modification of one proposal, we will follow Hansson's formulation. For typesetting purposes, however, we follow Rose and Walker (2004)'s labeling convention of CORR-C↔C rather than Hansson's CORR-[F_1,..., F_n].

As foreshadowed before, our proposal is that this constraint should not be limited as argued by Hansson in order to account for the typological landscape (as understood at the time); see also §4.3 below. Instead, the constraint should come in two flavors: (i) regressive as stated in (53) by Hansson (which we will label with an arrow $^{\leftarrow}$CORR-C↔C henceforth), and (ii) progressive, defined as follows:

(54) $^{\rightarrow}$CORR-C↔C
Given an output string S and two consonants $C_i, C_j \in S$, where
a. $C_i < C_j$ (C_i precedes C_j), and
b. C_i and C_j differ at most in the set of features [F_1,...,F_n],

then a correspondence mapping must be present *from C_i to C_j* ($C_i \rightarrow C_j$) such that *C_j is a correspondent of C_i*.

For the specific case of STz', we will enforce correspondence between consonants that differ at most in the feature set [αANT(ERIOR), αDEL(AYED) REL(EASE), αCONSTR(ICTED GLOTTIS], i.e., all other features are shared by the two consonants. We will represent this constraint as →CORR-[ts'↔ʃ]. Establishing this correspondence will capture the fact that the entire natural class of sibilants participate in the harmony process:[15]

(55) $^{\rightarrow}$CORR-[ts'↔ʃ]
Given an output string S and two consonants $C_i, C_j \in S$, where
a. $C_i < C_j$ (C_i precedes C_j), and
b. C_i and C_j differ at most in the set of features [αANT, αDEL REL, αCONSTR],

then a correspondence mapping must be present *from C_i to C_j* ($C_i \rightarrow C_j$) such that *C_j is a correspondent of C_i*.

Note that the correspondence must be limited to sibilants in STz' and exclude other consonants that do not participate in harmony. For example, while the coronal fricative [s] is a trigger, the coronal stop [t] must not be. Such a limitation is necessary for harmony processes elsewhere, like in Samala in (18)–(19)—a language for which Hansson provides an analysis of regressive harmony within the ABC framework. We will assume that the features [αANT] and [αDEL REL] are limited to sibilants in STz', such that non-sibilants do not meet the condition (55-b) for the applicability of the correspondence constraint.

[15] Cross-linguistically, it is common for harmony systems to be limited by locality/proximity; e.g., a harmonizing element could be separated from the trigger by at most a vowel. Hansson (2010: p.232 onwards) discusses how correspondence constraints can be specified for the distance that can exist between the relevant consonants. Since STz' sibilant harmony is long-distance—which we showed via examples like (32) where two vowels and a morpheme intervene between trigger and target—we could use the explicit notation C-∞-C to indicate that the constraint is violated if a correspondence relation is not established between two sibilants in an output candidate, regardless of the distance between them. For simplicity of presentation, we are omitting this additional symbol.

Two expositional notes are in order. First, we will notate that two consonants in an output candidate stand in a correspondence relation by supplying them with identical subscript letters. For instance, in a string C_x ... C_x, a correspondence relation is established, whereas in C_x ... C, a correspondence relation is not established and one violation of the constraint is assigned. Second, we assume that each corresponder (i.e., in progressive harmony the first C_x in a C_x ... C_x sequence) can establish its own correspondence relation with all applicable correspondents. Thus, in a scenario where a word contains two corresponders, they will each independently establish correspondence (subscripts $_x$ and $_y$) with (possibly overlapping) correspondents:

(56) C_x ... $C_{x,y}$ ... $C_{x,y}$
corresponder$_x$ ... correspondent$_x$/corresponder$_y$ ... correspondent$_x$/correspondent$_y$

4.1.2 Identity constraints

At this point, it is crucial to emphasize once more that a correspondence relation does not, by itself, drive harmony. Rather, the interplay of correspondence constraints with a second type—featural identity constraints—is used in the ABC approach to deliver harmony. These latter constraints are satisfied if consonants that stand in a corresponder-correspondent relation agree for a specific featural value:

(57) IDENT-CC
Let C_1 be a corresponder in the output and C_2 be any correspondent of C_1 in the output. If C_1 is [αF], then C_2 is [αF].

Recall from the data presentation that STz' sibilant harmony is asymmetric when it comes to the trigger; i.e., it is a system where only [+ANT] sibilants are triggers, whereas [−ANT] sibilants are not. Given this characteristic of the system, we will rely on a constraint that is violated if sibilants in an output candidate that stand in a corresponder-correspondent relation do not agree in [+ANT]:[16]

(58) IDENT[+ANT]-CC
Let C_1 be a corresponder in the output and C_2 be any correspondent of C_1 in the output. If C_1 is [+ANT], then C_2 is [+ANT].

We assume that the counterpart of the constraint in (58) (IDENT[−ANT]-CC) is ranked low in STz'. We will not consider it further in our analysis.

Finally, we will also employ input-output constraints relativized to specific features in order to derive the pattern. Specifically, consider the constraint below, which is violated once by each segment in an output candidate whose value for [αANT] is different from its input value.

(59) IDENT[αANT]-IO (adapted from Walker, 1998: p.15)[17]
Let C_i be a segment in S_1 (the input) and C_j be any associate of C_i in S_2 (the output). If C_i is [αF], then C_j is [αF]. (Associated segments are identical in feature F.)

Pairs of input-output segments that are evaluated according to the constraint in (59) will be labeled with a numerical subscript (e.g., C_1) to differentiate them from the letter subscript we use for the evaluation of consonant pairs with respect to the correspondence relation in the output string. Thus, the sibilants under consideration will be labeled with two subscripts that are orthogonal to each other, such as C_{1x}, C_{2x}, and so on.

Given that we observe alternations from [−ANT] to [+ANT] in STz', we propose that IDENT[−ANT]-IO is ranked low in the language. Conversely, we do not observe alternations in the opposite direction. As such, we propose that IDENT[+ANT]-IO is ranked higher.

We now turn to the ranking of these input-output constraints, in conjunction with the correspondence and agreement constraints introduced earlier, to show how the pattern in STz' is derived.

4.2 Constraint rankings in STz´

We can now illustrate how the constraint set regulates the choice of an optimal candidate in STz'. In our presentation, we focus on the behavior of sibilants, setting aside all other segments for which the constraints are not applicable. Thus, when deriving an STz' example like (46) (repeated as (60) below), we represent the input /ʃqasVʃa/ as /$ʃ_1$...s_2...$ʃ_3$/ in the tableau in (61).

[16] Note that we are not using a *targeted* IDENT[αANT]-CC as in Hansson (2010: p.263):

(i) IDENT[αant]-CC
P ⇒ Q, where
P: ($C_1 \leftarrow C_2$ and C_2=[αant]); Q: C_1=[αant].

This special flavor of constraint is necessary to account for languages with symmetrical trigger systems; i.e., systems where both [+ANT] and [−ANT] sibilants trigger harmony, such as the Samala case exemplified in (18)–(19). We could use such targeted constraints here as well, but for ease of exposition, we can resort to a simpler formulation of IDENT-CC closer to the original one formulated in Rose and Walker (2004: p.492).

[17] We depart from Walker and choose to use the term *associate* instead of *correspondent* to describe two segments whose input-output relation is evaluated, in order to avoid proliferating the use of the term *correspondent*; we use the latter only when it pertains to segments in a surface string that stand in a correspondence relation (e.g., in (58)).

(60) /ʃ- ∅- qas -Vʃ -a/ → [ʃqa.sa.sa]
COM- ABS3SG- √cut -PASS -INTR
'It was cut.'

(61) Santiago Tz'utujil: progressive [+ANT] harmony among sibilants

/$ʃ_1$...s_2...$ʃ_3$/	ID[+ANT]-IO	$^{\rightarrow}$CORR-[ts'↔ʃ]	ID[+ANT]-CC	ID[−ANT]-IO
a. $ʃ_{1x}$...s_{2y}...$ʃ_3$		*!**		
b. $ʃ_{1x}$...$s_{2x,y}$...$ʃ_{3x,y}$			*!	
c. $ʃ_{1x}$...$ʃ_{2x,y}$...$ʃ_{3x,y}$	*!			
d. s_{1x}...$s_{2x,y}$...$s_{3x,y}$				**!
e. s_{1x}...$s_{2x,y}$...$ʃ_{3x,y}$			*!*	*
☞ f. $ʃ_{1x}$...s_{2x}...s_{3x}				*

Let us go over the violations incurred by the sub-optimal candidates, starting with the fully faithful candidates (a) and (b).

First, observe for (a) [$ʃ_{1x}$...s_{2y}...$ʃ_3$] that this is an output candidate where no harmony is observed. Thus neither ID[+ANT]-IO nor ID[−ANT]-IO are violated. However, the candidate incurs in fatal violations of the correspondence $^{\rightarrow}$CORR-[ts'↔ʃ] constraint, since no relation *x* is established between $ʃ_{1x}$...s_{2y} or $ʃ_{1x}$...$ʃ_3$, and no relation *y* is established between s_{2y}...$ʃ_3$. Note that IDENT[+ANT]-CC is vacuously satisfied, since (i) $ʃ_{1x}$ is not [+ANT], and (ii) there is no correspondence relation between s_{2y} and $ʃ_3$.

Candidate (b) [$ʃ_{1x}$...$s_{2x,y}$...$ʃ_{3x,y}$] is also fully faithful and string-identical to (a), but the relevant correspondence relations are established, thus satisfying $^{\rightarrow}$CORR-[ts'↔ʃ]. This candidate is sub-optimal, however, because it incurs in a different set of violations. Specifically, a violation of IDENT[+ANT]-CC is fatal—while the final two sibilants stand in a correspondence relation *y* (correspondence relation *x* is less relevant here), sibilant $ʃ_{3x,y}$ does not harmonize with the preceding trigger $s_{2x,y}$ in [+ANT], therefore violating IDENT[+ANT]-CC.

Turning now to total [−ANT] harmony illustrated by (c) [$ʃ_{1x}$...$ʃ_{2x,y}$...$ʃ_{3x,y}$], such a candidate would result from either a dominance-control system or directional-control (progressive or regressive) relativized to [−ANT]. Observe that both $^{\rightarrow}$CORR-[ts'↔ʃ] and IDENT[+ANT]-CC are satisfied (the latter vacuously). However, the high-ranked IDENT[+ANT]-IO is violated due to the illicit /s_2/ to [$ʃ_2$] alternation, rendering the candidate sub-optimal.

As for candidate (d) [s_{1x}...$s_{2x,y}$...$s_{3x,y}$], which exemplifies total [+ANT] harmony, such a candidate would be expected under either a stem-control or dominance-control system relativized to [+ANT]. Given our proposed constraint ranking, the candidate exhibits a double violation of the lower-ranked IDENT[-ANT]-IO, one by the /$ʃ_1$/→[s_1] and another one by /$ʃ_3$/→[s_3]. Although no other constraints are violated, the bidirectional harmony illustrated by the candidate incurs more violations than a unidirectional one, all else being equal.

The final sub-optimal candidate we discuss here is (e) [s_{1x}...$s_{2x,y}$...$ʃ_{3x,y}$], displaying regressive rather than progressive [+ANT] harmony. This candidate fully satisfies IDENT[+ANT]-IO since it is a [+ANT] type of harmony and involves no alternation to [−ANT] between input and output forms. The candidate also fully satisfies $^{\rightarrow}$CORR-[ts'↔ʃ] because both of the relevant correspondence relations are established. However, as a result of the establishment of these relations, correspondent [$ʃ_{3x,y}$] violates the IDENT[+ANT]-CC contraint twice—once by failing to harmonize with the relation *x* corresponder [s_1] and a second time by failing to harmonize with the relation *y* corresponder [s_2]. The candidate also violates IDENT[+ANT]-IO once (though this violation is overall irrelevant given the previously described ones).

Now let us turn to the winning candidate (f) [$ʃ_{1x}$...$s_{2x,y}$...$s_{3x,y}$]. First, no violation of ID[+ANT]-IO is incurred since the [+ANT] feature is faithfully preserved on the relevant segment, i.e., /s_2/→[s_2]. There is also no violation of $^{\rightarrow}$CORR-[ts'↔ʃ] since a progressive correspondence relation is established between all applicable segments, i.e., all sibilants differing only in the features [αANT, αDEL REL, αCONSTR]—relation *x* is established between a corresponder [$ʃ_{1x}$] on one hand, and its two correspondents [$s_{2x,y}$] and [$s_{3x,y}$]; relation *y* is established between a corresponder [$s_{2x,y}$] and its correspondent [$s_{3x,y}$].[18] The third of the constraints that are ranked most highly, ID[+ANT]-CC, is also not violated by this candidate, given that among the corresponding sibilants, the corresponder (the leftmost member of a pair, the trigger) is always identical in the feature [+ANT] [s_{2x}...s_{3x}]. Note that [$ʃ_{1x}$...$s_{2x,y}$] and [$ʃ_{1x}$...$s_{3x,y}$] vacuously satisfy the constraint, since [$ʃ_{1x}$] is not [+ANT]. Candidate (f) thus only violates the lower ranked ID[−ANT]-IO once, given the alternation /$ʃ_3$/→ [s_3], but such a violation is not fatal since all other candidates violate higher ranked constraints.

We have demonstrated how sibilant harmony in STz' is straightforwardly derived by representing progressive directionality in the grammar. We now pivot once more to putative alternatives that would not encode progressive directionality in the analysis, expanding on our prior discussion. We will show again why our approach should be preferred.

4.3 Back to putative alternative analyses

In §3, we showed that STz' sibilant harmony represents a true case of progressive harmony, since none of the strategies used elsewhere to derive cases of progressive harmony without appealing to directionality could satisfactorily explain the phenomenon. We are now in a position to assess two additional alternative analyses that were briefly mentioned in that section: (i) stem-control coupled with a stipulation to exempt prefixes

[18]Note that these sibilants differ only in the feature [αANT] and not in [αDEL REL], but no violation would be incurred even if one of the corresponding segments was a glottalized affricate like [ts'], as in (45).

from the domain of harmony and (ii) *target*-oriented prominence-control. Adopting either of these analyses would potentially constitute a significant departure from a parsimonious and explanatory theory of harmony systems and the grammar more broadly. Thus, we need to asses their costs and benefits.

In assessing (and rejecting) these two putative alternatives, we will also circle back to the independent reasons which previous authors have appealed to in order to explain the apparent typological gap of true progressive harmony that cannot be reduced to other systems. Recall that Hyman (2002) and Hansson (2010) did not make their proposals solely on the basis of their understanding of the typological landscape at the time. Rather, Hyman considered relevant the existence of a tendency when it comes to coarticulation. Namely, in a VCV sequence, the realization of one V as measured by (for example) formant frequencies, influences the realization of the other V, and in many cases the second V influences the first V to a greater extent than the reverse direction. In other words, Hyman contends that there is a greater regressive tendency in coarticulation effects. In a similar vein, Hansson argues that it is relevant that there also exists a tendency for regressive speech errors to be relatively more frequent than progressive speech errors. Hyman and Hansson's observations become relevant to harmony only if one assumes that coarticulation and/or speech errors are possible sources for the emergence of harmony as a synchronically represented phonological process—i.e., facts external to the phonology could shape the way in which a phenomenon is represented upon phonologization.

Let us first discuss the two alternative analyses and then assess whether the aforementioned observations about coarticulation and speech errors are enough to reject an analysis like ours that invokes progressive directionality.

4.3.1 Ruling out stem-control plus an additional stipulation

Consider example (62), repeated from (38):

(62)	/ʃ-	in-	ʃχow	-**s**aa	-Vʃ	-a/	→ [ʃinʃχow**s**aasa]
	COM-	ABS1SG-	√dance	-CAUS	-PASS	-INTR	
	'I was made to dance.'						

Imagine that, instead of having the grammar of STz' represent progressive directionality, we were to insist that the phenomenon we observe is the product of stem-control. Naturally, this putative alternative by itself would not derive the pattern—it is clear that in (62) the [ʃ] that precedes the root does not undergo an alternation. What we would need to say, then, is that the harmony process is stem-controlled, but the prefixal field does not count for the application of harmony. In other words, even though STz' sibilant harmony does not show the pattern that is definitional of stem-control—i.e., harmony in STz' does not apply outwardly in both directions from an inner stem—we would use an additional stipulation to exclude the STz' pattern from our discussion of directionality in the grammar.

When taken at face value, this putative alternative seems like a brute force move—calling the STz' pattern stem-control is a last ditch effort to exclude progressive directionality from the phonological component. Let us consider it seriously, though, and lay out the kind of evidence that a learner would need in order to be tempted to posit the representation being entertained in this sub-section, as opposed to what we proposed in §4.

Specifically, if the prefixal field in STz' could be shown to be opaque to the application of phonological processes independently of the sibilant harmony facts, then one could imagine that a learner would have some evidence to posit that the prefixal field is indeed special. However, we have been unable to find such evidence. In fact, there exist phonological processes that clearly target elements across the entire word, in both the prefixal field and in the root. For example, STz' exhibits pervasive syncope that targets vowels across different parts of a word. According to Dayley (1985: p.46), vowel syncope can lead to consonant clusters of up to ten segments in STz':[19]

(63)	/ma	ʃtk-	at-	qa-	kam	-saaχ	ta/	→ [mʃtktqkmsaaχ ta]
	NEG	POT-	ABS2SG-	ERG1PL-	√die	-CAUS	NEG	
	'We wouldn't kill you.'							

In (63), we observe syncope of three vowels in the prefixal field, NEG /ma/→[m], ABS2SG /at-/→[t], ERG1PL /qa-/→[q], and syncope of one vowel in the root 'die' /kam/→[km].

Consider further the more contemporary examples below from our own work, where the vowel /a/ that is underlyingly part of the prefix /qa-/ ERG1PL surfaces only in some phonological contexts like (64), but not in others like (65):

(64)	/ʃ-	ee-	qa-	ts'et/	→ [ʃiqats'et]
	COM-	ABS3PL-	ERG1PL-	√see	
	'We saw them.'				

(65)	/ʃ-	ee-	qa-	raq	=piχ/	→ [ʃiqraqpiχ]
	COM-	ABS3PL-	ERG1PL-	√break	=DIR	
	'We broke them.'					

Although the surface form of roots has reflected their underlying CVC form in the STz' examples discussed so far that stem from our work, many examples from contemporary speakers pattern with the data reported by

[19]We cannot determine why the surface (and possibly underlying) form of POT in Dayley (1985: p.46) appears to be [ʃtk] rather than the expected [ʃk] (or its allomorph [ʃt] in cases of ABS3SG) (Dayley, 1985: p.80). Even if it is just a typo and the surface form of POT is [ʃk], our point regarding rampant vowel syncope across different parts of a word still stands.

Dayley in (63). For instance, notice how in the following example the vowel in the root does not surface:[20]

(66) /naq ʃ- ∅- ts'et -ow -a/ → [naq ʃts'towa]
who COM- ABS3SG- √see -AF -INTR
'Who saw him/her?'

This state of affairs differentiates STz' from some other Mayan languages like Uspantek, where prefixes are indeed excluded from the domain of vowel deletion (Bennett et al. 2021; Bennett et al. in prep).

We observe, then, that a STz' learner would not have independent evidence to posit that (i) prefixes in STz' constitute a separate phonological domain to the exclusion of roots and suffixes, and consequently (ii) sibilant harmony in their target grammar should be represented as a stem-controlled process that excludes the prefixal field. Put simply, we find no evidence that the prefixal field is special in STz'.[21] As a result, we consider that any approach that would seek to maintain a stem-control analysis for STz' sibilant harmony can be discarded and our conclusions can be maintained.

4.3.2 Ruling out a weak trigger and prominent target

Let us discuss a second putative alternative. Recall that McCollum and Essegbey (2020)'s list of prominence-based systems only include cases where one can capitalize on the *trigger* being prominent. For instance, their analysis of Tutrugbu rounding harmony relies crucially on the trigger's placement on the left-edge of the word; similarly, they cite Claro (Delucchi, 2011) and Brazilian Portuguese (Bisol, 1989) as cases of stress-control, where only stressed vowels trigger the process.

Within the typology of vowel harmony, however, there exist phenomena where prosodically the target is strong and the trigger is weak (Walker, 2005; Kaplan, 2015).[22] For example, Walker (2005) discusses cases of metaphony in Ascrea where a stressed mid-vowel (the target) raises if followed by an unstressed high vowel (the trigger):

(67) a. metésse
'reap (1SG IMPERF SUBJ)'
b. metíʃʃi
'reap (2SG IMPERF SUBJ)'

(68) a. prefónna
'profound (FEM SG)'
b. prefúnnu
'profound (MASC SG)'

To our knowledge, there is no description of consonantal harmony where a pattern is described in a parallel manner—in fact, as mentioned already in §2.1.3, Hansson (2010: §3.2, p.326) notes that prosody does not seem to play a role in consonantal harmony. Thus, even if our rejection of this putative alternative is deemed inconclusive, the existence of the STz' phenomenon as an outlier would still be in need of explanation when placed within the typology of consonantal harmony (see also our discussion of Sakapultek in §5.4).

Nevertheless, under an approach allowing prosodic-prominence-control for sibilant harmony, specifically positing a weak trigger analysis like Walker's for Ascrea raises the following question: could STz' sibilant harmony be handled in the same way in order to avoid positing progressive directionality? In other words, could the [+ANT] feature be attracted to the sibilant in the stressed syllable, which happens to always be the position where targets of harmony appear in the language? While such proposal is consistent with the data we have shown throughout the paper, we see two problems with an affirmative answer.

First, stress is a property more clearly associated with the syllable's nucleus (usually a vowel), rather than a property associated with an onset or a coda, where the sibilant target is in STz'. It should not be too surprising that phenomena like Ascrea's exist, where stress regulates *vowel* alternations in the manner described. However, it seems questionable to us to posit that sibilant harmony is equally amenable to the same analysis.

Our second issue with this putative alternative is of a broader nature. Namely, if we add the possibility of a weak trigger to systems that we call prosodic-prominence-control, and such systems falls under the umbrella of *prominence*-control more broadly, then we expand significantly the landscape of possible harmony systems. In other words, we get to the point where it becomes virtually impossible to find empirical evidence against one of these analyses as an alternative to an analysis where progressive directionality is implicated.

Imagine for instance an exclusively prefixing language where elements in the stem alternate as a result of a trigger in a prefix. In the interest of avoiding progressive harmony, and given the doors opened by the putative alternative here, we could posit a prominent target analysis for this case as well, one where the strong element to which a feature is attracted is the stem. Put differently, we have opened the door for the expectation that there exist stem-control systems where an element in the stem is the *target*, not the trigger. To our knowledge, this is not attested. If we did find such a language and allowed for the possibility of such an analytical approach, however, it would be nigh impossible to find conclusive data in favor of progressive

[20] Syncope of the sole vowel of some CVC roots leads to cases where said vowel never surfaces. Its quality, however, can be inferred from its influence on the vowel that surfaces in suffixes whose vowel is underlyingly underspecified (see Dayley 1985 and Lyskawa and Ranero 2021b).

[21] We also question the assumption that prefixes are universally different from suffixes regarding the application of harmony, though an in-depth discussion would take us too far afield (see Martin and Culbertson 2020 for a relevant study involving artificial language-learning).

[22] We thank Aaron Kaplan for encouraging us to evaluate this possibility.

harmony. Our illustration here serves to merely pinpoint the danger we incur in if we consider the putative alternative in this sub-section as superior to the progressive harmony approach we have taken, and we leave a more in-depth discussion of expanding the scope of prominence-based systems for the future.

A final comment is warranted as we transition to the next section, however. Alongside the two objections we discussed, recall that regressive harmony is clearly attested. Once we bite the bullet and establish that one side of the directionality coin is needed in the grammar, it becomes a stipulation to ban its mirror image. From the perspective of theory parsimony, then, a weak-trigger approach does not seem advantageous over the one we are proposing here, where we allow the grammar to represent true progressive harmony. We consider that the most significant reason why one would push for the weak trigger analysis in spite of our objections is if independent grounding were provided to justify excluding progressive directionality from the grammar, grounding that goes beyond the makeup of the typological landscape. In the following section, we discuss the evidence that has been taken to be such grounding, arguing that it is not as strong as it appears at first glance. This casts further doubt on the putative alternatives we have considered.

4.4 Coarticulation and speech errors pattern do not corroborate the directional asymmetry

As outlined in §2.2, Hansson (2010) argues that a handful of consonant harmony systems are truly regressive, while all apparently progressive systems can be analyzed without invoking directionality (see also McCollum and Essegbey 2020). Hyman (2002) in a typological overview of vowel harmony notices this kind of directional asymmetry as well, and both authors propose linking the asymmetry in harmony directionality to articulatory phenomena that exhibit a similar asymmetry: coarticulation and speech errors. The interpretation of these proposed links differs somewhat between Hansson and Hyman, so we will summarize their argumentation in order to (i) establish the broad nature of the phenomena and (ii) illustrate the consequences of drawing a link between them and the typology of harmony systems as it was understood in the past. Note, however, that going beyond these authors' specific claims and citations would take us too far afield. Our goal is to argue that it is overreach to use phenomena that are independent of harmony—namely, coarticulation and speech errors—to ground the exclusion of progressive directionality from the grammar.

Let us start with Hyman. On the basis of research on Turkish (Beddor and Yavuz, 1995), Shona, and Swahili (Manuel and Krakow, 1984), this author links the existence of regressive directionality in vowel harmony to the pervasive regressive directionality observed in VCV coarticulation. However, it is worth emphasizing that those cited papers report coarticulation effects in *both* regressive and progressive directions. For example, Manuel and Krakow (1984) find a progressive (carryover) coarticulation effect in F2 of vowels in both Swahili and English. The regressive effect is certainly larger than the progressive effect, and found on both F1 and F2—however, whatever the nature of the link between vowel harmony and vowel coarticulation is, it is not the case that this literature provides a grounding for complete and unequivocal ruling out the representation of progressive directionality in the grammar. In fact, Hyman's interpretation of the link is rather modest, suggesting that it can explain a bias that is reflected in the typology, instead of a limitation on the grammar.

Moreover, a closer look at this literature reveals that the picture is quite complex. In a nutshell, the strength of regressive coarticulation, and thus its apparent pervasiveness over progressive coarticulation, depends on a number of factors that must be taken into account if one was to explicitly propose how these observations link up to limitations on the grammar when it comes to harmony. Most importantly, the regressive effect on coarticulation is language-specific—it is larger in a language like Swahili than in English, presumably due to the smaller vowel inventory of the former. The dependence of the regressive effect on the language was similarly found by Beddor and Krakow (1999) who showed that Thai has a significantly less pronounced effect than English. In Manuel and Krakow (1984), a number of other factors is at play as well, e.g., (i) the exact quality of the vowel (e.g., /o/ has a particularly large effect on progressive coarticulation), and (ii) the exact quality of the intervening segment (e.g., /t/ has a larger effect than /p/). Understanding why these factors have an effect might help elucidate the nature of the hypothesized link between coarticulation and harmony. For example, if harmony were to arise from the phonologization of coarticulation, one could hypothesize a scenario in which progressive coarticulation is robust enough to be the basis for such a reanalysis. What seems to be relevant, then, is whether this flavor of phonologization relates to either of two scenarios: (i) is it the case that one of the directions must reach a certain absolute threshold (e.g., a frequency threshold) or (ii) is there direct competition between regressive and progressive directionalities such that a large enough ratio of regressive:progressive rules out the possibility of grammaticalising the latter?

Similar considerations are warranted when we assess Hansson (2010)'s proposal. Hansson links the existence of regressive directionality in harmony to the pervasive nature of regressive directionality in speech errors, which in turn may be analyzed as resulting from the architecture of the speech planning component. For example, work by Schwartz et al. (1994) and Dell et al. (1997) report the ratio of regressive to progressive errors to be as high as 3:1. However, in contrast to Hyman's degree of commitment in constructing a link between an independent phenomenon and harmony, Hansson's is somewhat stronger—the regressive:progressive ratio in speech errors is used to justify in part the reduction of every single instance of apparent progressive harmony to other analyses.[23] We would like to make clear that the absence of a categorical asymmetry in speech errors renders dubious a conclusion of this nature, in particular in the absence of a fully formed and explicit linking theory. Instead, we argue that while the presence of a regressive *bias*

[23] Admittedly, the strength of Hansson (2010)'s commitment to the link varies somewhat throughout the book. As cited in fn. 3, Hansson labels regressive directionality a 'default', thus implicitly leaving open the possibility of a marked, opposite directionality. However, the author also chooses to always reduce progressive directionality to an alternative analysis (e.g., stem-control).

in speech errors might be useful in hypothesizing about the diachronic emergence of regressive harmony, the bias does not directly bear on the possibility or impossibility of *representing* progressive harmony (see 6 for additional comments).

To summarize and ease ourselves into the next section, it is clear that regressive directionality is attested and must be representable. Given this observation, attempts have been made to explain why and how this side of the directional harmony coin arises. Any explanation for this by itself does not immediately preclude the possibility of progressive harmony—it could arise in the same way (through coarticulation and speech errors, since these manifest both regressive and progressive directionalities, albeit to different relative degrees), or it could arise via a different pathway. In the following section, we pursue the latter type of explanation for STz'. Crucially, once we take as a given that progressive directionality is in principle representable by the grammar, a question arises that is relevant for our discussion: what kind of surface evidence would a learner need in order to *not* analyze STz' examples as progressive harmony? If our proposal in the next section on the emergence of harmony in STz' is on the right track, then the relevance of Hansson's observations to assess our analytical arguments is even more limited, since we argue for a diachronic pathway that has nothing to do with the relative frequency of regressive versus progressive speech errors.

5 Diachronic hypothesis

We showed before that STz' sibilant harmony is truly progressive. As a result, we concluded that this directionality must be representable in the grammar. At this juncture, we move from the synchronic dimension to the diachronic one and formulate a hypothesis about how sibilant harmony arose in STz', what we have now concluded must be a cross-linguistically improbable, though not impossible phonological phenomenon (see §5.4 below on Sakapultek as well).

Let us observe the phenomenon once again in (69) (repeated from (39)), in order to remind ourselves of the phonological innovation that needs to be explained:

(69) Sibilant harmony in contemporary STz'
ʃ→ [+ANTERIOR] / [+ANTERIOR, +STRIDENT] ... _ (obligatory)

In what follows, we lay out a concrete hypothesis about the diachronic origins of (69). Our proposal explicitly implements a suggestion by Rose and Walker (2004) regarding how long-distance consonantal harmony arises. In a nutshell, these authors posit that harmony patterns develop from the "analogical extension" of co-occurrence restrictions that hold for consonants within specific domains (e.g., the root domain—see §5.1 below). We will observe that a particular combination of facts that were (and continue to be) specific to the lexicon of STz' set the stage for learners to hypothesize that an "extension" of this sort was part of their target grammar, triggering thus the innovation.

For the purposes of the phenomenon at hand, we take an I-language approach to sound change and phonologization (Hale et al., 2015), positing that sound change occurs through a relation between two grammars during the course of acquisition.[24] Let us call the two grammars G1 and G2. G1 is the grammar that exists prior to the sound change and provides the input for the learner; G2 is the grammar that is constructed by a learner on the basis of the G1 input and contains the innovative phonological process:

(70) The relevant elements in phonologization

a. G1: the grammar that exists before the change (i.e., a grammar that does not represent a sibilant harmony process)
b. G2: the grammar that exists after the change (i.e., a grammar that represents progressive sibilant harmony)
c. G2 = input from G1 + whatever the learner brings to the acquisition process

What we mean by phonologization is encapsulated in (70-c) above: in brief, a learner misanalyzes an aspect of the data provided by G1, attributing an observable pattern to the target phonology. As a result, the learner constructs a G2 representing a phonological process that is consistent with the data, even though the source of the pattern in the input was not, in fact, in the phonological component for the relevant speakers possessing G1.[25]

We illustrate our proposal by considering a single acquisition scenario within the STz' speech community at some point in the past. We will discuss this scenario repeatedly, returning to the perpetuation of the pattern across a speech community via multiple scenarios that play out in the same way in §5.3. The core of our proposal is that three factors laid the ground for the innovation of progressive sibilant harmony in STz':

(71) Factors contributing to the innovation of progressive sibilant harmony in STz'

a. A sibilant co-occurrence restriction on roots (part of G1).
b. An asymmetrical distribution of sibilant types in the lexicon: all sibilant-containing prefixes have /ʃ/, while a subset of suffixes contain /ʃ/ and a subset of suffixes contain /s/ (part of G1).

[24] See Stanford (2015) for a summary of proposals dating back to the 19th century that have placed the burden of sound change (at least partially) on learners during the course of acquisition.

[25] Authors like Garrett (2014) use phonologization for cases when "an automatic phonetic property evolves into a language-specific phonological one". It will become clear in what follows that we use the term phonologization in a broader sense, since we propose that the innovation in STz' did not stem from the misanalysis of a *phonetic* aspect of the input grammar, but rather a *lexical* property involving a co-occurrence restriction on root sibilants.

c. An asymmetrical token frequency of affixes with a sibilant: such prefixes are frequent, while such suffixes are less frequent (part of input from G1).

In isolation, any of the three factors above would not necessarily have resulted in the emergence of sibilant harmony in STz'. Working in tandem, though, we will observe that they provided the right combination of circumstances—a perfect storm, if you will—to give rise to (69).

Before moving on, note that we are not claiming that the factors just listed would inevitably give rise to the harmony process we described. Among the Mayan languages in the K'ichean branch, only STz' and Sakapultek (see §5.4) seem to have innovated the process, whereas other closely-related languages like Kaqchikel and K'iche' possess similar characteristics, but no sibilant harmony in any of their dialects (for dialectal variation across K'ichean languages, see Patal Majzul et al. 2000 for Kaqchikel, Par Sapón and Can Pixabaj for K'iche', Caz Cho 2007 for Q'eqchi', Malchic Nicolás et al. 2000 for Poqomam and Poqomchi'). In this section, it will become clear how it seems to be mere happenstance whether the right combination of ingredients (in enough acquisition scenarios) did or did not lead to the emergence of a harmony process like (69) that established itself across speakers in a community. We will not address the question of why this accident in history occurred in the manner and frequency that it did, so we will not speculate on how often harmony of the STz' type is expected to arise in other contexts. In other words, we will not tackle the actuation problem (Weinreich et al. 1968; see Garrett 2014)—the issue of explaining why innovations occur only in a subset of languages that share the same characteristics that set the stage for them.[26]

To summarize our general approach, we adopt the viewpoint that a phonological process can be innovated when a learner constructs a grammar containing a statement that can capture the input data but that was not, in fact, the source of the pattern for the speakers who provided the input.[27] In §5.1–5.3, we discuss each of the factors in (71). Finally, we show in §5.4 that closely-related Sakapultek exhibits the same sibilant harmony as STz'.

5.1 Ingredient 1: a sibilant co-occurrence restriction on roots

The first factor that played a role in the innovation of progressive sibilant harmony in STz' is a co-occurrence restriction between sibilants at the root level.

Mayan languages across different branches of the family exhibit a similar co-occurrence restriction on sibilant combinations in roots (Edmonson, 1988; Bennett, 2016), which are mostly of the form C_1VC_2 (England and O. Baird, 2017). For example, C_1 and $C2_2$ sibilants match in [αANT] in Tseltal and Tsotsil (Kaufman, 1972), and in Ch'ol (Gallagher and Coon, 2009). In Chuj, C_1 and C_2 affricates match in [αANT] as well (Hopkins, 1967), and Wastek exhibits a similar restriction (Edmonson, 1988). These illustrative examples involve languages that are members of distinct branches of the Mayan family and that are distant from the K'ichean branch, of which Tz'utujil is a member, as illustrated in Figure 1.

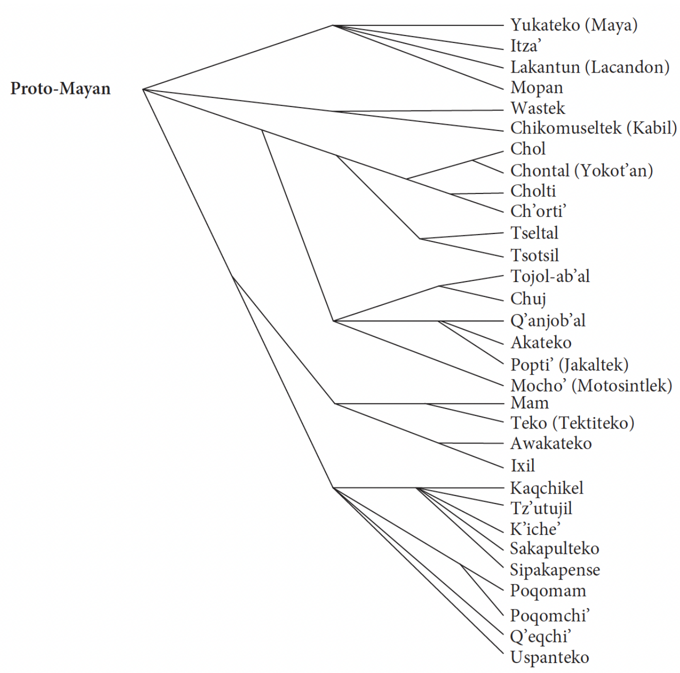

Figure 1: Mayan language family in Law (2014), based on Kaufman (1990).

Given that the co-occurrence restriction exists across the family, it is reasonable to posit that it is a shared retention among most (if not all) of the languages that exhibit it–otherwise, one would need to assume that

[26]Not all K'ichean languages possess the right lexicon for sibilant harmony to be innovated or detectable. For example, whereas a passive suffix in Kaqchikel and K'iche' bears the same kind of sibilant as in STz' (Patal Majzul et al., 2000; Par Sapón and Can Pixabaj, 2000)—Poqomam appears to lack any suffix with a [–ANT] sibilant that could undergo an alternation conditioned by a preceding [+ANT] trigger (Benito Pérez, 2007).

[27]Note that our proposal for STz' is similar in spirit to the hypothesis that harmony processes arise from frequent speech errors in the input being reanalyzed by a learner; see Hansson (2010) and our prior discussion. The core difference is that tokens in an input that are the result of speech errors are not generated licitly by a G1 (hence the "error").

languages across the family independently innovated such a fact about their lexicons.

Turning now to Tz'utujil, (Dayley, 1985: p.31) observes that in the San Juan la Laguna dialect "sibilants and affricates co-occur with other sibilants and affricates, respectively, only if they agree in the feature anterior; that is, s does not occur with x [ʃ] and tz(') does not co-occur with ch(') [tʃ]." Lyskawa and Ranero (2021a) note that a dictionary confirms Dayley's observation (Pérez Mendoza and Hernández Mendoza, 2001). In a similar manner to the available descriptions of other Tz'utujil dialects, all STz' roots that we have encountered adhere to the same co-occurrence restriction (except for one root shown in (49) in §3.3).

Let us focus now on the acquisition scenario that illustrates our proposal. Recall that we consider that phonologization can occur when a learner building G2 (their grammar) misanalyzes an aspect of the input provided by G1. For the reasons outlined above, the sibilant co-occurrence restriction is an older innovation than sibilant harmony in STz', so it must have been part of G1. The learner constructing G2, then, observed roots of a certain phonological shape, and never observed others (capital S is shorthand for all sibilants—fricative, non-glottalized affricate, and glottalized affricate):

(72) Input from G1 that serves for the construction of G2

a. $\sqrt{}\mathrm{S}_{[\alpha\text{ANT}]}\mathrm{VS}_{[\alpha\text{ANT}]}$ ✓(observed)

b. $\sqrt{}\mathrm{S}_{[\alpha\text{ANT}]}\mathrm{VS}_{[\beta\text{ANT}]}$ ✗ (not observed)

Some representative examples of roots in Tz'utujil that (non-vacuously) comply with the co-occurrence restriction are given below:

(73) Roots with sibilants matching in [αANT] (Pérez Mendoza and Hernández Mendoza, 2001)

a. [+ANT]: √saas 'liver', √siis 'koati', √si's 'chicken louse', √soots' 'bat', √suuts' 'cloud'

b. [–ANT]: √tʃ'uutʃ' 'baby', √tʃiiʃ 'shit', √ʃiitʃ' 'dry booger', √ʃaaʃ 'thin'

Why should a co-occurrence restriction in the input be an ingredient that is relevant for the diachronic development of a productive, long-distance harmony process, like we propose here? In a paper advocating for the ABC approach to the analysis of consonantal harmony, Rose and Walker (2004: p.489) comment briefly on diachrony and hypothesize that harmony can be innovated due to "analogical extension" from co-occcurrence restrictions of the above type (see Hansson 2010: p.378 for additional comments). In a nutshell, the authors seem to propose that the learner takes a surface generalization that they observe within a particular, limited domain (e.g., the root) and overextend said generalization into the affixal fields.

Let us take seriously the programmatic proposal by Rose and Walker and be explicit regarding how the co-occurrence restriction was a crucial component for the arising of harmony as attested today in STz'. First, we need to assume that a learner constructing G2 considers it significant that, whenever they observe roots with two sibilants, those sibilants are always of the same nature (i.e., either both [+ANT] or both [–ANT]). Crucially, however, we also need to assume that they consider significant the fact that the input never contains roots with two sibilants that mismatch in the [αANT] feature. We propose that a learner could hypothesize that the presence of matching sibilants across many roots, as well as the absence of mismatching sibilants in the root domain, is evidence that there is some sibilant harmony process in the target grammar that is responsible for the data distribution. As a result, this learner entertains the hypothesis of a harmony process that is consistent with the data distribution they observe, even though the speaker(s) possessing G1 that provided the input did not, in fact, represent a sibilant harmony process in their phonology at all (rather, the co-occurrence restriction was a static fact about their lexicon).[28]

At this juncture, notice that we have not derived the innovation of progressive harmony where only [+ANT] sibilants function as targets. We must thus look elsewhere in the input for other factors that could drive a learner to narrow down on this specific configuration of sibilant harmony. We therefore pivot now to the distribution of sibilants across the prefixal and suffixal fields in G1 and show how this grammar-particular fact provided the learner with another ingredient.

5.2 Ingredient 2: an asymmetric distribution of sibilant types in affixes

The second ingredient that played a role in the diachrony of STz' sibilant harmony is also related to the lexicon. Specifically, there exists an asymmetry in the distribution of sibilant types ([+ANT] vs. [–ANT]) across the affixal fields: only the [–ANT] sibilant /ʃ/ is observed in the prefixal field, whereas both /ʃ/ and the [+ANT] /s/ are observed in the suffixal field.

First, notice that there are three prefixes in the language bearing a sibilant. All of these bear the [–ANT] /ʃ/ and none bears a [+ANT] sibilant:

(74) Prefixes with a sibilant—/ʃ/ across the board

a. /ʃ-/ completive aspect

b. /iʃ-/ ABS.2PL agreement

c. /ʃt-/ potential aspect

There are also three suffixes that bear a sibilant. In contrast to the prefixes, though, two suffixes bear /ʃ/ and one does the [+ANT] /s/:

(75) Suffixes with a sibilant—both /ʃ/ and /s/ observed

[28] We are aware that it is up for debate whether co-occurrence restrictions that are limited to specific domains such as the root are represented synchronically in the phonology (see discussion in Rose and Walker 2004 and Hansson 2010). We will assume that the co-occurrence restriction in G1 was lexical, though it is ultimately irrelevant for the point we make henceforth.

a. /-Vʃ/ passive voice
b. /-ʃik/ deverbal nominalizer
c. /-saa/ causative

Returning to the acquisition scenario, we will assume that the lexicon of G1 included the six affixes just highlighted. Thus, a learner constructing G2 could have been exposed to the distributional asymmetry of sibilants in the affixal fields, depending on the make-up of the input (see the following section §5.3). We contend that this asymmetry played a role in the diachronic emergence of the specific kind of sibilant harmony observed in STz'—progressive and where [+ANT] is the sole trigger.

We can now put together the two ingredients proposed thus far: a learner constructing G2 hypothesizes on the basis of the root co-occurrence restriction that there exists a sibilant harmony process in her target grammar. However, when she is faced with sibilants in the affixal field alongside root sibilants, and this conflagration of sibilants across morphological boundaries mismatch in the value of [αANT], she can re-assess her hypothesis in either of two ways. First, she could discard the harmony hypothesis altogether, attributing the co-occurrence restriction to a lexical fact, and no sound change occurs. Alternatively, she could maintain the harmony hypothesis and carve out its precise nature, thus narrowing down the scope of the process and ultimately innovate the phenomenon as observed today. We will pursue this latter possibility. In order to do so, we turn to the final necessary ingredient: a particular frequency of different affixes in the input.

5.3 Ingredient 3: an asymmetric token frequency of affixes

We have proposed two ingredients thus far that contributed to the emergence of STz' sibilant harmony as attested today: (i) G1 exhibited a co-occurrence restriction on root sibilants and (ii) the lexicon of G1 displayed an asymmetry regarding the distribution of sibilant types ([+ANT] vs. [–ANT]) across the affixal fields. We discuss in this section one final ingredient: the unbalanced distribution *in the input to G2* of tokens containing the affixes that we discussed. In a nutshell, we will show via a corpus investigation that the frequency of some of the prefixes is significantly higher than the frequency of the suffixes. We will take this fact about STz' today as a proxy for our past acquisition scenario. This will entail that a learner constructing G2 was rarely exposed to suffixes containing a [+ANT] sibilant, while she was much more frequently exposed to prefixes containing [–ANT] sibilants. We contend that this specific unbalanced distribution led our learner to rule out certain types of harmony, narrowing down as a result on one specific type which became the innovation.

The data set we will discuss is a small corpus of speech that stems from our work with four STz' consultants (825 utterances totalling 5260 words). The corpus consists of narrations of the Pear Story (Chafe, 1980), traditional stories related to Lake Atitlán and its environs, and food recipes.[29] Let us begin by observing the overall distribution of [+ANT] versus [–ANT] sibilants in the corpus:

(76) Distribution of [+ANT] vs. [–ANT] sibilants in STz' corpus

[+ANT]:	601
[–ANT]:	1185
TOTAL:	1786

We observe that there are about twice as many [–ANT] sibilants as [+ANT] ones. What is relevant for us is how these sibilants are distributed across prefixes vs. suffixes:

(77) Distribution of sibilants in affixes in STz' corpus

a. [–ANT] in prefixes

/ʃ-/	completive aspect:	386
/iʃ-/	ABS.2PL agreement:	0
/ʃt-/	potential aspect:	8

b. [+ANT] in prefixes
N/A

c. [–ANT] in suffixes

/-Vʃ/	passive voice:	9
/-ʃik/	deverbal nominalizer:	2

d. [+ANT] in suffixes

/-saa/	causative:	27

Again, let us take this corpus as a proxy for the kind of data distribution that the learner in our acquisition scenario might have been exposed to. What emerges from (77), then, is the possibility of an unbalanced input: [–ANT]-containing suffixes are the least frequent (77)c, the [+ANT]-containing suffix is somewhat more frequent (77)d, while [–ANT]-containing prefixes are clearly more frequent than any other type of affix in the list (77)a. Furthermore, the lexicon does not include any [+ANT]-containing prefix.

Recall that our proposal assumes that the co-occurrence restriction on sibilants within *roots* led our learner to consider the hypothesis of sibilant harmony in her target grammar. We propose that the asymmetric distribution revealed by our corpus allowed the learner to actively rule-out specific types of harmony—i.e., whether

[29] We are aware that analyzing a corpus of child-directed speech would be a better proxy. However, we do not know of such a corpus existing for Tz'utujil presently, so there is no additional way to illustrate our proposal. We leave for the future an evaluation of corpora of child-directed speech in related languages that exhibit a comparable lexicon to STz' regarding the distribution of sibilants, such as K'iche' (consider for example the data sets available at almaya.org); for a summary of acquisition work on Mayan languages, see Pye et al. (2017).

the harmony is triggered symmetrically, whether it involves stem-control or regressive directionality, etc.—based on multiple sibilants occurring together across the *word*. Let us go over this step-wise.

For example, a word where a prefix bears a [–ANT] sibilant and there is a [+ANT] sibilant later in the word (in whatever morphological position) would be relevant in order to rule out regressive or dominance-control harmony with a [+ANT] trigger. Based on the sheer frequency of the completive aspect prefix (see (77)a), we assume that such evidence was readily available to our learner (example repeated from (64)):

(78) /ʃ- ee- qa- ts'et/ → [ʃiqats'et]
COM- ABS3PL- ERG1PL- $\sqrt{}$see
'We saw them.'

This kind of data is worth analyzing closer, since we assume that it also allowed the learner to rule out other kinds of harmony. First, since the sibilant in the root surfaces as [+ANT], then progressive harmony triggered by [–ANT] is excluded as well. Second, since the prefix surfaces as [–ANT], then stem-control triggered by [+ANT] is also excluded.

Summing up our proposal so far, our learner is narrowing down on the precise nature of the harmony process that she blamed for the co-occurrence restriction. We argued that she had enough evidence to rule-out sibilant harmony with certain characteristics. For the sake of expedience, we will set aside a discussion of what evidence rules out other conceivable combinations of properties.

What is crucial for our purposes is the following—since there is no reason for our learner to exclude progressive harmony a priori (see §4.4), it is a hypothesis that she considers. In contrast to how the available data allowed her to rule out certain harmony types, however, we argue that she did *not* have enough evidence to rule out progressive harmony triggered by [+ANT]. The crucial evidence would consist of words provided by G1 with a [+ANT] sibilant followed by [–ANT] later in the word (in whatever morphological position). From our description of the lexicon of STz' (which lacks a [+ANT] sibilant in the prefixal domain) we know that a leftmost [+ANT] sibilant would be either (i) in a root or (ii) in the causative suffix. This sibilant would in turn need to be followed by a [–ANT] sibilant in the passive suffix /-Vʃ/ or the deverbal nominalizer /-ʃik/. Notably, we have found very few instances of this configuration in our corpus, as shown below:

(79) Distribution of [+ANT] sibilant followed by [–ANT] in a word
a. [+ANT] followed by [–ANT] in passive suffix: 4
b. [+ANT] followed by [–ANT] in deverbal nominalizer suffix: 0

From the counts in (76), (77), and (79) a telling picture emerges, then. Notice that [+ANT] sibilants are overall not so frequent compared to [–ANT] ones: 601 in our corpus compared to 1185, respectively (an effect that appears to be driven largely by the ubiquitous appearance of the completive aspect prefix). Since only one affix in STz' contains a [+ANT] sibilant (the /-saa/ causative), we infer that most instances of such sibilants occur in roots. However, it seems that roots with [+ANT] sibilants do not appear frequently with the kind of suffix that would allow the learner to discard progressive harmony with a [+ANT] trigger. Progressive harmony triggered solely by [+ANT] is therefore the representation that we propose could have been constructed in the light of the absence of the crucial evidence just described. In brief, then, the phonologization of progressive harmony in STz' as attested today was the result of a particular misnalaysis that was allowed by the grammatical idiosyncracies of G1, a specific asymmetry in the input regarding the distribution of sibilants across the affixal fields, and a misanalysis that a learner refined over the course of acquisition.

It is worth emphasizing that the single acquisition scenario that has illustrated our proposal is an idealized stand-in for multiple contexts in which learners phonologized the harmony pattern we observe today in the manner we proposed. We can now ponder on the next generation of learners, who received input from individuals possessing G2 in order to construct G3. We contend that sibilant harmony was perpetuated in an incremental fashion with each subsequent generation, since the learners constructing G3 might (i) go through the same process we described for learners constructing G2, where they phonologize the pattern due to a misanalysis and a lack of crucial data, or (ii) they might, in fact, be exposed to *positive* evidence for the productive harmony process in G2. In other words, the crucial configurations where the sibilant in the passive and deverbal nominalizer suffixes alternate between [–ANT] and [+ANT] now provide a direct route for the learner to represent the harmony process—though they might be infrequent in the input, observing a certain number of these alternations might prove sufficient for the learner constructing G3.

As already noted, we do not intend to argue that harmony (progressive or of any type at all) will always arise given the presence of the ingredients invoked here—after all, other K'ichean languages, including other dialects of Tz'utujil, share the same relevant properties with STz' but do not exhibit progressive sibilant harmony (see fn.26). While it is outside the scope of the paper to determine why some languages innovated this process and others did not, our proposal is supported by the fact that at least one other K'ichean language, Sakapultek, did indeed develop such a cross-linguistically improbable harmony system. In the following section, we discuss the available data for this language and show that its sibilant harmony appears to be identical to the one in STz'.

5.4 Sakapultek—another exemplar of progressive sibilant harmony

We argued that sibilant harmony in STz' shows that progressive directionality must be representable in the grammar. We thus countered proposals that seek to reduce all (apparently) left-to-right harmony to independent considerations like prominence control. While a single case study would suffice as compelling evidence for our main concern in this paper—establishing what can be a possible grammar, not a probable one—it would be desirable to establish independent replications of the results we presented. Furthermore, establishing that a second language is parallel to STz' would lend credence to our hypothesized source for the harmony process diachronically, in particular if the same ingredients that we took to be the source of the innovation are also shared with this additional case.

That replication appears to be found in Sakapultek, another Mayan language from the K'ichean branch, since DuBois (1981) presents data that echo the data in STz'. Observe the sibilant alternation in the following examples, which is triggered left-to-right:[30]

(80) /ʃ- ∅- par -a -ʃ -ek/ → [paraʃek]
COM- ABS3S- burn -TR -PASS -INTR
'It was burned.'

(81) /ʃ- ∅- **s**ik'i -ʃ/ → [**s**ik'is]
COM- ABS3S- √read -PASS
'It was read.'

(82) /ʃ- ∅- kuʔum -a**s**a -ʃ/ → [kuʔuma**s**as]
COM- ABS3S- √move -CAUS -PASS
'It was moved.'

(83) /ʃ- ∅- **s**at -ab' -a -ʃ -ek/ → [**s**atab'asek]
COM- ABS3S- √be.discoidal -VS -TR -PASS -INTR
'It was left (discoidal object).'

The examples in DuBois (1981) are only suggestive of a parallel, since they do not show whether a sibilant to the left of the trigger fails to undergo the alternation—notice, for example, how the leftmost /ʃ/ in (83) does not surface at all.[31] For this reason, Lyskawa and Ranero (2021a) merely point to the similarity between the languages, but do not conclude that Sakapultek is identical to STz'.

However, corpus data confirm that sibilant harmony in Sakapultek is indeed identical to the STz' phenomenon.[32] Consider the following examples in addition to the above and observe that the sibilant alternation occurs to the right of the trigger, but not to its left:

(84) /ʃ- e- **ts'**ib' -iʃ -ek/ → [ʃe**ts'**ib'isek]
COM- ABS3PL- √write -PASS -INTR
'They were written.'

(85) /ʃ- e- kam -**s** -iʃ -ek/ → [ʃekam**s**isek]
COM- ABS3PL- √die -CAUS -PASS -INTR
'They were killed.'

Based on the above, we conclude that Sakapultek exhibits true progressive harmony as well.[33]

This replication speaks to one of our key concerns throughout the paper: what can we conclude from typological observations regarding limitations on the grammar? First, these data show that STz' is not a single outlier within the typological landscape. Given that languages exhibiting consonantal harmony are infrequent to begin with, adding one more to the pool of those displaying true progressive harmony strengthens our conclusion that the grammar must be able to represent left-to-right directionality. Second, the parallelism between STz' and Sakapultek provides some support for DuBois (1981: p.55–56)'s remarks that Sakapultek shares a particularly strong affinity to Tz'utujil among the K'ichean languages, based on their shared innovations. It thus seems reasonable to investigate further whether STz' and Sakapultek harmony is a shared retention, as opposed to instantiating two independent innovations.[34] Note however, that the same ingredients that we described for the lexicon in STz' appear to apply to Sakapultek's as well. Thus, it is possible that the process was independently innovated by Sakapultek along the same lines as our proposal for STz'.

[30] We provide a modified breakdown of the underlying morphemes in these examples, in accordance with DuBois's description elsewhere in the grammar. The author appears to have omitted the aspect and agreement morphemes for (81) and (82), and he provides a breakdown of the *surface* form for (80) and (83). We keep DuBois's designation of the /-ab'/ and /-a/ suffixes as "versive" and "transitive/transitivizer" respectively for (80) and (83).

[31] The completive aspect /ʃ-/ deletes in Sakapultek before a consonant DuBois (1981: p.139); contrast these examples with (84)-(85). DuBois (1981: p.53) claims (via personal communication with Jon Dayley) that the same deletion occurs optionally in Tz'utujil, but we have not found this to be accurate for STz'.

[32] We thank Jack DuBois for sharing with us his annotated corpus of Sakapultek.

[33] A more recent Sakapultek grammar does not mention harmony in its chapter on phonology, but does describe an alternation between [-s] and [-ʃ] for the passive suffix Mó Isém (2007: p.205). According to Mó Isém, this alternation is driven by the category of the root: [-s] attaches to stems that have a verbal or adjectival root, whereas [-ʃ] attaches to stems that have a nominal or positional root. Intriguingly, all examples that are given with the [-s] variant do have a verbal or adjectival root, but they also exhibit a [+ANT] sibilant before the relevant segment: [kamsi**s**ek] 'it was killed', [ʃitinse**s**ek] 'it was bathed', [tsuχu**s**ek] 'it was counted', and [ʃaχsaqɓi**s**ek] 'we were cleaned'—other examples can be found peppered in the grammar that show the same thing, like [nimirsi**s**ek] 'it was enlarged' (p. 160). As a contrast, two examples are given in the section on the passive that surface with [-ʃ]: [waɓ**ʃ**ek] 'it was made to stand' and [tʃun**ʃ**ek] 'it was whitewashed', where the roots are the positional √waɓ 'to stand' and the nominal √tʃun 'lime'. It is possible, however, to demonstrate that Mó Isém's non-phonological generalization is on the wrong track, since many examples show that stems with verbal roots surface with [-ʃ] as long as they are not preceded by a [+ANT] sibilant: [ʃattʃaplaʔ**ʃ**ek] 'you were grabbed multiple times', [ʃetʃ'uplaʔ**ʃ** riʃaaq] 'its leaves were cut', where the relevant roots are √tʃap 'grab' and √tʃ'up 'cut' (p. 204). It appears, then, that the data in Mó Isém (2007) shed light on the same sibilant harmony process as DuBois (1981), even though the relevant sibilant alternations are not described in phonological terms.

[34] To assess the shared retention hypothesis and its potential consequences for our understanding of the K'ichean branch of the Mayan family, we would need to delve into issues like the geographic distance between Santiago Atitlán and Sacapulas, as well as contact among the languages (issues already discussed by DuBois). One would have to wonder as well why only STz' and Sakapultek display the retention, but no other dialect of any K'ichean language does. We leave all of this for future research.

Finally, and related to the previous two points, opening this discussion could also lead us to re-evaluate how we count instances of harmony in our typology and assess their significance. In other words, if we conclude that sibilant harmony in STz' and Sakapultek constitute a shared retention, should we then collapse these two languages as only one instance of true progressive harmony among the languages of the world? If so, should we then collapse together other clusters of cases that can be reconstructed to a single innovation? For instance, the Omotic languages listed in (4) could be counted as *one* example of apparent progressive sibilant harmony that can be reduced to stem-control, since this process has been argued to be a retention from proto-Omotic (Hayward 1988; see Hansson 2010: p.387). The relative frequency of some type of harmony (e.g., stem-controlled) versus another (truly regressive or progressive), then, would thus be affected by our revised counting metric, and changes of this nature within the already limited pool of languages exhibiting consonantal harmony would alter the empirical picture and the theoretical conclusions one should draw from it. These concerns, of course, are part and parcel of doing typology and constructing a sample that can inform our ultimate theoretical goals (on phonological typology specifically, see Gordon 2016). We leave a more in-depth assessment of these questions for the future.

5.5 Summary of diachrony

In this section, we put forward a hypothesis regarding how progressive sibilant harmony arose in STz', providing a concrete illustration of a diachronic pathway suggested by Rose and Walker (2004). We proposed that three ingredients paved the way for a reanalysis by learners constructing a grammar (G2) on the basis of input from a grammar (G1) that did not represent the harmony process as attested today: (i) a sibilant co-occurrence restriction within roots, (ii) a lexical asymmetry in the distribution of [+ANT] vs. [−ANT] sibilants in the affixal fields, and (iii) an asymmetry in the frequency of certain combinations of sibilants in the presumed input that the relevant population of learners were exposed to. We made it clear that these ingredients might not always give rise to the phonologization that we argued occurred in STz', but in the absence of any bias or ban against representing progressive harmony, a learner might entertain it as a plausible process in their target grammar. Furthermore, by laying out all the elements that needed to work in tandem, we illustrated why such systems might be cross-linguistically rare, giving rise thus to typological gaps that had until now resulted in analytical conclusions that require revision in the manner we have proposed. Finally, we discussed data from Sakapultek, a closely related language to STz' that shares the relevant grammatical and lexical properties that fueled our analysis. The existence of an identical harmony pattern in Sakapultek corroborates our synchronic claim that a harmony system encoding progressive directionality is representable and gives support to our diachronic hypothesis regarding the circumstances that could lead to the innovation of the process.

6 Summary and parting thoughts

Our contributions in this paper have been threefold, which we elaborate on further in this closing section.

First, we presented data from STz' that exemplify progressive sibilant harmony. We argued on empirical and conceptual grounds that these data are an instance of true (rather than apparent) progressive harmony, and showed why this analysis is superior to alternatives.

Our second contribution was a discussion throughout of how the theory of the representation of harmony processes in the grammar can inform and be informed by the distinction between possible versus probable harmony systems. We concluded that interpreting a typological gap as an indication of an impossible grammar is unwarranted for the phenomenon at hand, given the rarity of consonantal harmony to begin with, alongside the complexity of establishing whether a harmony pattern can be reduced to only *one* type of control or not. In fact, we commented on how the degree of rarity attributed to a particular pattern changes depending on the comparison base we set along different dimensions. For example, whether we consider sibilant harmony only, consonantal harmony only, or consonantal and vowel harmony. This consideration, in turn, relies on the theoretical assumptions we adopt regarding the extent to which consonantal and vowel harmony processes are subsumed by identical, or distinct, mechanisms. At this juncture, we could even bring in a discussion of tone and the directionality of tone spread, given the surface similarity between the phenomena (though we have not engaged with the question of whether tone is different in some way; e.g., see Hyman 2002 on why tone should indeed be discussed separately). Finally, whether we consider a shared innovation among different languages (or dialects of a language) as a single data point or multiple data points in our typological count, will also tip the balance regarding the ratios under consideration.

Our final contribution pertained to the diachronic origin(s) of synchronically active harmony patterns, through the lens of our specific case. While speech errors and co-articulation tendencies are widely assumed sources for harmony, we argued through the STz' and Sakapultek data that there exists at least one more possible avenue. Given that the bias for speech errors and co-articulation that has been documented in the literature is in the opposite direction to how harmony operates in the languages we analyzed, we put forward a proposal where the innovation arose from the perfect storm of several ingredients: (i) language-specific properties of the lexicon, (ii) the existence of a sibilant co-occurrence restriction on roots in the input grammar, and (iii) the possibility of a learner considering as viable the hypothesis of progressive harmony in her target grammar. If we assumed that progressive harmony could not be represented at all, then the pathway we argued for would have no legs to stand on. All in all, then, we advocated for a grounded and explicit proposal for phonologization that distinguished biases from universals, pointing out how beneficial it can be to interpret a correlation between specific properties of a harmony pattern (i.e., directional-control versus stem-control), other properties of the language at hand, and how a learner might interpret the input data in constructing her target grammar.

To close out or investigation, it is worth taking a step back to recognize some broader implications. Our discussion throughout has been permeated by an overarching concern of how we use the results from typology to inform our theory of the mental grammar. This concern becomes particularly relevant when we encounter an empirical gap, as opposed to a situation where one pattern is more frequent than others. In such an event, we are faced with the question of whether the gap is purely accidental, but represents a learnable pattern in principle, or whether the gap is meaningful in the sense that it demonstrates the existence of some limitation on the grammar. Both types of gaps, accidental and non-accidental (in the previous senses), are informative for the purpose of theory-building. However, they are not necessarily informative for the *same* theories—while the former might primarily contribute to our theory or diachrony and language change, the latter might contribute directly to the theory of linguistic competence. Thus, in using typological conclusions, it is crucial that we identify what kind of gap we are dealing with.

Let us start in the abstract with a situation where there is a typological gap and we want to argue that it is non-accidental. Assume, in other words, that we make the strongest claim—namely, that the gap is explained because the pattern for which there is a gap is not representable in the grammar. We could bolster our proposal in the following two ways:

(86) a. The proposal not only explains the gap but also simplifies our grammar (given a notion of simplicity that needs to be explicitly defined).
b. The proposal generates and bears out some non-trivial predictions (e.g., it is supported by correlations in independent phenomena for which we have an explicit linking theory).

Perhaps paradoxically, the simplicity argument in (86-a) is itself not simple at all. Under Occam's razor, simplicity is in principle an oft-desired property of an analysis, all else being equal. Frequently, however, there are several dimensions along which simplicity can be achieved, and these dimensions may not be fully orthogonal to one another. This becomes particularly relevant when an analysis X is argued to be superior to a putative alternative Y because it simplifies property A, but it is not explicitly acknowledged that analysis X complicates another property B at the same time. Let us observe, now, how this issue pans us with respect to harmony and previous work.

In our research on this topic, it has often been suggested to us that a theory of harmony than does not represent progressive directionality is "simpler" because it generates less data, specifically the data for which there is a gap. Let us call this generative simplicity. In other words, by having a constraint on harmony such that truly progressive patterns cannot be generated, such a pattern cannot be constructed under that representation to begin with (i.e., they cannot be learned). Presumably, this leads to some explanatory gains.

The notion of generative simplicity is rather precarious in light of potentially interacting considerations like the role of morphological structure, phonological domains, prosody, and others in representing harmony (see §4.3). That is, by manipulating parameters such as excluding prefixes from the domain of harmony, or allowing the analysis to refer to prosodically prominent targets, we may end up with the same coverage of empirical data as a theory (such as ours) that does allow progressive harmony.

Moreover, note that this notion of simplicity is at odds with another notion of simplicity at the level of the grammar itself. As we have pointed out throughout the paper, there is a consensus that *regressive* directionality exists and must be representable by the grammar. Thus, we argue that all else being equal, allowing for the representation of its mirror image (i.e., progressive directionality), is actually computationally simpler than banning such a representation—in other words, a grammar that bans progressive directionality *contains a stipulation* that we have removed. Let us refer to this notion of simplicity—achieved by the removal of such a stipulation—as representational simplicity.

Why should the notion of generative simplicity trump the notion of representational simplicity when assessing competing analyses? We currently see no a priori reason to favor one notion over another, at least for the phenomenon at hand. To reiterate, by simplifying one aspect of an analysis but complicating another, in the end we are not simplifying the overall picture, we are just rearranging the deck of cards. It may turn out that a given phenomenon like harmony is, for whatever reason, not consistent with our notion of representational simplicity, but we believe this would require a convincing argument in favor of the ban on progressive directionality. Such an argument was indeed put forward by Hansson (2010), who considered significant a correlation between an asymmetry in the typology of harmony controllers and tendencies in speech errors, the latter of which are arguably related to speech planning (see §4.4). This argument gives us a segue to assess (86-b).

In a nutshell, a proposal that argues that a typological gap is non-accidental in the manner we discussed—i.e., that it stems from a limitation on the grammar—should generate testable predictions. As an illustrative example, then, consider once again how Hansson (2010) argues for a meaningful correlation between a proposed limitation on progressive directionality in harmony and the tendency for speech errors to be regressive, not progressive. At first glance, this seems to be an instance of (86-b), a desirable result. However, there is an issue—it is not the case that speech errors are categorically regressive. Rather, there exists a tendency where regressive errors are more frequent than progressive ones to a degree that is far from categorical. Furthermore, the theory that links the patterns of directionality in speech errors and the patterns in phonological harmony is, at best, sketched, but not fully developed. In other words, limiting representations could be bolstered by some categorical pattern in a phenomenon that we convincingly argue has some foundational relation to the representation in question. This is not the case for the argument put forward by Hansson, nor is it the case for Hyman 2002's discussion of a connection between coarticulation tendencies and patterns in vowel harmony (though see our comments in §4.4 on the degree of both these authors' commitments to the linking of harmony to these independent phenomena).

Another prediction satisfying (86-b) would be that the relevant pattern could not be acquired by a child, or perhaps an adult learner. In testing this prediction, artificial language experiments could become useful. One could conduct an experiment where participants are exposed to patterns of harmony that are consistent only with true progressive directionality and not reducible to any other analysis like stem-control. While such experiments seem promising, constructing and interpreting them seems highly complex to us. First, designing stimuli that would be consistent solely with progressive directionality appears challenging, especially in the light of the plethora of potentially interacting considerations like morphological structure, phonological domains, prosody, and others (see §4.3)—a recurring problem in our discussion. Even if such stimuli were designed without confounds, if we find that participants do not learn the pattern, we end up with a null result—we cannot be certain why a pattern was not learned; i.e., is it because a pattern is truly non-representable, or is it because the stimuli have not reached a certain threshold for input frequency, salience, etc? Thus, while in principle artificial language experiments may shed some light on the theory of harmony in the phonology, in order for them to be interpretable, they would need to be done with extreme care. We leave this possibility for future work.

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