The Instability of Rhythmic Syncope in Irish: Insights from Latin Loanwords

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Abstract Recent work has highlighted acute instability in rhythmic syncope systems, with Bowers (2019) reporting that a nascent rhythmic syncope system in Nishnaabemwin collapsed as soon as the first generation attempted to acquire it, while Rose (2019) reports a pronounced loss of productivity within a century of the initiation of rhythmic syncope in Mojeño Trinitario . We gauge the duration of productive rhythmic syncope in Irish by the number of loan words that entered Irish around the time rhythmic syncope was innovated, and find that very few words entered Irish during the syncope phase of the language. This is consistent with Irish being another language where rhythmic syncope rapidly obsolesced, and at a minimum is a failure to furnish positive evidence of stable long term syncope.

1 Introduction

Rhythmic syncope, the deletion of alternating syllables from an iterative stress pattern, has attracted attention in theoretical phonology due to the difficulty parallel Optimality Theory (OT, Prince and Smolensky 2004 [1993]) has generating the pattern (Kager 1997, McCarthy 2008, Hao and Bowers 2019). It also appears that human language learners may have difficulty acquiring rhythmic syncope, since the advent of rhythmic syncope in Nishnaabemwin triggered a rapid and far-reaching restructuring of the grammar (Bowers 2019 and sources therein). Observations of rhythmic syncope undergoing rapid obsolescence date at least to Isačenko (1970) for Eastern Slavic, and further cases of less than robust rhythmic syncope are described by Rose (2019) and Kaplan (2020; 2022). This raises the possibility that the theoretical devices intended to rescue parallel OT from rhythmic syncope are unnecessary, since if humans fail to learn rhythmic syncope it is not important that our models generate it. More instances where rhythmic syncope was rapidly abandoned are needed to solidify this argument.

Irish is another language that developed rhythmic syncope, doing so in the sixth century CE (Jackson 1953:143, McManus 1983:31, McCone 1996:127). Early Irish manuscripts contain indications that rhythmic syncope was no longer productive at the time they were written (Armstrong 1976; McCone 1985), but even the earliest of these manuscripts were composed some time after syncope began, and so cannot reveal how quickly syncope decayed. However, the flow of Latin loanwords into Irish around the

time of syncope can diagnose whether rhythmic syncope also decayed quickly in Irish. Simulations reveal that not very many loans entered Irish during the syncope period, which suggests that it may have been quite brief.

The paper will proceed as follows. Section 2 gives background on Irish and our collection of loans. Section 3 highlights the predictions modern theories of loan adaptation make for the application of rhythmic syncope to loan words. Section 4 briefly sketches how the (non-)application of Irish phonological processes diagnoses the time of entry into Irish, with detailed discussion of the phonology appearing in the appendix. Section 5 describes how we simulate the flow of loans into Irish. Section 6 describes the results of our simulations, and section 7 discusses their interpretation. Section 8 concludes.

2 Irish Historical Background

Irish is one of the languages of modern Ireland and its history is known to us via a continuous tradition of writing in Latin letters dating to the seventh century CE (Thurneysen 1946:4-10), and via stone inscriptions in the Ogam alphabet, which likely began a few centuries earlier still (McManus 1991). Further inferences can be drawn via comparison with other Celtic languages, particularly the other Insular Celtic languages, which include Scots Gaelic and the Brittonic languages Welsh, Cornish and Breton, though there is debate over whether Insular Celtic is a geographic or genetic grouping (Schmidt 1977, Koch 1992, de Bernardo Stempel 2006, McCone 1996, Schrijver 1995, Schumacher 2004). Our approach to the Latin loans in Irish follows the mainstream consensus in Irish historical linguistics, as represented by Jackson (1953) and McManus (1983), with some updates to the understanding of the phonology following McCone (1996).

We are fortunate to be able to rely on written records from the Old Irish period. These manuscripts are not contemporaneous with the Latin loans of interest, but at least are not too distant from them. Since our data is necessarily orthographic, we accompany phonological representations in [square brackets] with the attested orthographic forms in ⟨angle brackets⟩. We reserve /slashes/ for explicitly discussing underlying representations.[1]

The written records have a solid phonological interpretation, despite the vagaries common in pre-modern orthographic systems. This interpretation rests on various streams of evidence, such as (a) Old Irish metrical forms, which have strict rules for syllable counts as well as rhyme and alliteration systems that are based on groupings of consonants and vowels according to phonological features (Murphy 1961), (b) regular correspondences between Irish written in the Ogam and in the Latin alphabets, (c) comparison of Old Irish to the writing system and phonology of Modern Irish, and crucially (d) the distribution and orthography of initial consonant mutation, especially in early

[1] We use the following abbreviations for glossing examples: ADJ = 'adjective', ACC = 'accusative', AGEN = 'agentive', DIM = 'diminutive', FEM = 'feminine', IMPV = 'imperative', MASC = 'masculine', NOM = 'nominative', NEUT = 'neuter', PL = 'plural', PCL = 'proclitic', PST = 'past', SG = 'singular'. Abbreviations for manuscripts found in ciatations are: Ml. = 'Milan Glosses', Sg. = 'St. Gall Glosses', and Wb. = 'Würzburg Glosses'.

medieval Brittonic from which Old Irish borrowed much of its spelling system (Harvey 1990a:178–180). There are some minor controversies, such as whether some cases of orthographic ⟨u⟩ represent 'u-coloring' of a vowel or labialization of a consonant (Hock 2019), but our discussion does not hinge on any non-standard or disputed interpretations of the orthography. Accessible student grammars of Old Irish include McCone (2005), Stifter (2006), Tigges and Ó Bearra (2006), and de Vries (2013). The standard reference and historical grammar remains Thurneysen (1946). For the interpretation of Old Irish and early medieval Brittonic orthography and its relation to the phonology, see Watkins (1966), Ó Buachalla (1982), Harvey (1989, 1990a, 1990b, 1991, 2011), Sims-Williams (1991), and Hamp (2000). References explicitly treating the phonological development of Irish include McCone (1996) and Jaskuła (2006). Section 4 briefly reviews the phonology relevant to dating loans, which is more comprehensively illustrated in the appendix.

2.1 Time period for borrowing

The events of concern to us here belong to Early Irish, the spoken and written language of Ireland before the thirteenth century (Stifter 2009:55). More precisely, Latin loans began to enter Irish during what is commonly called the Primitive Irish period, before 600 CE. Some of the loans could have entered via trade (Fomin 2018), but the great majority are ecclesiastical terms, and must therefore be connected with the introduction of Christianity. This allows us to narrow down the beginning of the borrowing period to around the early fifth century CE. We know this because Prosper of Aquitaine's chronicle for the year 431/432 (Mommsen 1892) presupposes the existence of a fledgling Christian community in Ireland. Over the following centuries, the connection to the Latin world via Christianity deepened (Flechner and Ní Mhaonaigh 2016), as evidenced by the beginning of the Irish monastic tradition in the sixth century, and the later Irish manuscripts found throughout Continental Europe as a result of the Irish missions to the continent during the sixth and subsequent centuries of the early medieval era (Flechner and Meeder 2017).

Prosper of Aquitaine's chronicle also allows us to tentatively fix a date to some of the earliest phonology we will consider, since many Christian ecclesiastical loans undergo a lenition process (discussed further in section 4). Assuming the ecclesiastical loans entered with the introduction of Christianity, lenition must have emerged shortly thereafter. If Christianity took root in 431/432, then putting the date for lenition at around 450 gives time for a body of ecclesiastical loans to accumulate before leniting.

The next key development is the onset of rhythmic syncope. Rhythmic syncope is generally thought to have emerged in the mid-to-late sixth century (Jackson 1953:143, McManus 1983:31). although there is some evidence for a slightly earlier date (Sims-Williams 2003:346). Direct support for 6th-century syncope is found in syncopated poetry by Colmán mac Lénéni, a poet who died in 606 (Carney 1971; Sims-Williams 2016 *inter alia*). Syncope also appears in inscriptions on stone written in the Ogam alphabet dating to the early seventh century (McManus 1986:2-4). This demonstrates that syncope could not have been initiated after the beginning of the seventh century.

Close cultural contact between Britain and Ireland, which was needed for borrowing from British Latin to occur, continued through the development of rhythmic syn-

cope (Bauer 2015:5-8), though, as we will show, not many borrowings can be attributed to this phase of the language. We are certain that borrowing continued after rhythmic syncope, because there are many unsyncopated loans in manuscripts composed during the seventh to tenth-century Old Irish period, and beyond.

To summarize, we have evidence of roughly a century between lenition and syncope, and at most a few decades of separation between any intervening processes. We turn now to a description of rhythmic syncope in Irish, and an examination of the prior evidence that it lost productivity.

2.2 Syncope in Irish

Rhythmic syncope in Irish removed even-numbered non-final syllables when counting from left to right. Primary stress was assigned to the first syllable, though the first verbal proclitic, if any, was omitted from the stress calculation (Thurneysen 1946:27-31, Stifter 2006:21-22). Initial stress, and the alternating character of deletion, are consistent with left-aligned trochaic feet. In familiar phonological terms, syncope simply targeted the weak branch of all non-final feet.

The sensitivity of stress to procliticization set up paradigmatic alternations. In these examples, we mark proclitic boundaries with '='. For instance, consider the native verb /to=ro=xar-adar/ 'they fell' (Bieler and Kelly 2004 [1979]:176§13.7) and its form with a further proclitic /ko^{+voi}=to=ro=xar-adar/ 'until they fell' (Stokes and Strachan 1901:93, Ml. 36d13), which surfaced as illustrated in (1).[2]

(1)	/ko^{+voi}=to=ro=xar-adar/	/to=ro=xar-adar/	UR
	ko^{+voi}=(ˈtoro)(ˌxara)(ˌdar)	to=(ˈroxa)(ˌradar)	Stress
	ko^{+voi}=(ˈtor_)(ˌxar_)(ˌdar)	to=(ˈrox_)(ˌradar)	Syncope
	ko=(ˈdor_)(ˌxar_)(ˌdar)	do=(ˈrox_)(ˌradar)	Other Rules
	[ko=ˈdorxardar]	[do=ˈroxradar]	SR
	⟨con torchartar⟩	⟨dorochratar⟩	Orthography

Notice that the addition of a proclitic at the leading edge of the stress domain causes a ripple of deletion and non-deletion throughout the word. Such paradigmatic alternations are the calling card of rhythmic syncope.

2.2.1 Fall of Syncope

That rhythmic syncope was eventually abandoned in Irish is well established. Even a casual overview of the textual record highlights the decline of syncope in Irish. The Old Irish manuscripts, composed from the seventh to tenth centuries, largely abide by rhythmic syncope patterns, though numerous exceptions occur. Middle Irish, generally held to have begun in the mid-tenth century, also attests many prominent deviations from the historically expected syncope patterns (see McCone 1997:163ff. for a general overview of Middle Irish verbs). Finally, in the twelfth century the classical modern

[2]The 'other rules' invoked at the end of (1) are the so-called nasalization mutation triggered by the proclitic [ko^{+voi}=], in which a voiceless obstruent receives a floating voicing feature left over from an original nasal (viz. orthographic ⟨n⟩ in ⟨con torchartar⟩), and an independent process voicing /to=/ when domain initial (Stifter 2014).

literary standard emerged, which featured widespread paradigm leveling to remove rhythmic syncope alternations. Indeed, "there are very few genuine survivals" of many characteristic Old Irish alternations, including rhythmic syncope alternations, in any variety of the modern language (McCone 1997:191).

It would be a mistake to read the general adherence to rhythmic syncope patterns in Old Irish manuscripts as evidence that rhythmic syncope was still active in the seventh through tenth centuries. The Würzburg and Milan glosses (Stokes and Strachan 1901) have played a central role in recovering Old Irish grammar, and were composed before the mid-ninth century. Nonetheless, they contain a number of deviations from the expected norm (Armstrong 1976). For instance, in (1) we saw that underlying /ko^{+voi}=to=ro=xar-adar/ surfaces as expected as [ko=dor_xar_dar] 'until they fell'. However, we also find [kon=tor_x_radar] ⟨con-torchratar⟩ 'they fell together' (Stokes and Strachan 1901:148, Ml. 48c28), which is missing vowels from adjacent syllables, and so cannot be derived from /kom=to=ro=xar-adar/ via the original syncope process.

According to McCone (1985, 1997), these deviations are in fact early instantiations of innovative patterns that flourished in Middle Irish, and that were ultimately standardized in Modern Irish. This strongly suggests that Old Irish records partially reflect an 'artificially fostered learned and literary standard' (McCone 1997:167). It is impossible to know what the living spoken language of the Old Irish period was, but it is not beyond the realm of possibility that the innovations were already displacing the old patterns or had even become regular.

Such innovations can be found in texts still older than the Würzburg and Milan glosses. For instance, Latin [puɡ-ill-aːri-a] 'writing tablets (lit. 'fist-DIM-AGEN-NEUT.NOM.PL)' shows effects from a harmony process, as well as a compensatory lengthening process, that suggest it was borrowed via Vulgar Latin †[puɡ-l-aːri-a] during the pre-syncope phase of Irish (McManus 1983:38). The derivation in (2) spells out how such a loan must have developed.

(2)	puɡ-ill-aːri-a	Latin
	puɡ-l-aːri-a	Vulgar Latin
	/puɡl-aːrij-a/	Irish UR
	puɣlaːrija	Lenition
	puɣlarija	Shortening
	poɣlareja	Harmony
	poɣlare_	Apocope
	poːlare	Compensatory Lengthening

The expected next stage of development for this word is that it would syncopate to †[poːl_re], and presumably at some time such a form existed. Strikingly, however, this word never shows syncope in any source. The earliest attestation of this word is dated to the turn of the seventh and eighth centuries, where it appears as [poːl-ərʲe] ⟨poolire⟩ (Bieler and Kelly 2004 [1979]:176§13.5).

What seems to have happened is that the Latin agentive suffix [-aːri] was segmented off from this and other loans like Latin [osti-aːri-us] 'doorman (lit. door-AGEN-MASC.NOM.SG)', which became Irish [asʲtʲ-ərʲe] ⟨aistire⟩. It then became a productive Irish suffix [-ərʲe], as seen by its application to native Irish roots as in [ex-ərʲe]

⟨echaire⟩ ‘groom (lit. horse-AGEN)’ and [riːṽ-ərʲe] ⟨rímaire⟩ ‘calculator (lit. ‘number-AGEN)’ (Thurneysen 1946:172). Since sound change operates on phonetic forms without respect to morphological considerations (cf. Kawahara 2011, Bermúdez-Otero 2015), this suffix must have been subject to syncope, and Kelly (1990:232) shows cases where syncope occurred in this suffix. However, as [poːl-ərʲe] ‘writing tablet’ and other early cases like [nod-ərʲe] ⟨notire⟩ ‘scribe’ (lit. ‘note-AGEN’) (Stokes and Strachan 1901:678, Wb. 27d16) show, it clearly became immune to syncope. These forms indicate that rhythmic syncope no longer applied automatically and could even be overturned by the turn of the seventh and eighth centuries.

2.2.2 Significance of Latin Loans

The textual record leaves roughly a one and a half-century period when rhythmic syncope could have flourished between its development in the mid-to-late sixth century and the earliest indications of its loss at the turn of seventh/eighth centuries. Our goal is to estimate how much of this period syncope was active for. We can approach this fairly directly via Latin loan words. If many loans entered Irish during the syncope phase of the language, this indicates that syncope was active for an appreciable amount of time. However, if few loans entered Irish during that time, this suggests either that syncope was not active for very long, or that the rate of borrowing had decreased.

Our next topic is a description of the historical manuscripts and other sources we used to collect our data and our methods for collecting the data. After a brief consideration of what must be assumed about loan adaptation for rhythmic syncope to be enforced in loans, we will then illustrate how dates of entry can be determined for a loan from the phonological processes that did or did not apply to it. This feeds our ultimate goal of determining the global picture of when loans entered Irish, specifically, how many loans can be allocated to the syncope period of the language.

2.3 Historical Data Sources

To get a meaningful picture of how many loans entered Irish during the syncope period, we must apportion loans to the various pre-syncope periods and the post-syncope period. Such a task requires a representative corpus of the early Latin loan vocabulary. Our primary source for this vocabulary is manuscripts containing Old Irish material. While there are multiple such manuscripts to choose from, most are in fact copies written much later than the Old Irish period. We set the tenth century as a cutoff point in order to exclude material that entered the language much later than syncope, and included all loans from the contemporary Old Irish manuscripts before that date.

Fortunately, the recently available Corpus Paleo-Hibernicum (CORPH, Stifter et al. 2021), a searchable web-based lexicon of pre-tenth century Irish, has made searching for loanwords during this period straightforward. From CORPH, we draw on the material in the Milan (Stifter et al. 2021; Stokes and Strachan 1901) and St. Gall (Stifter et al. 2021; Stokes and Strachan 1903) manuscripts, which contain Old Irish glosses on Latin texts and a large number of loanwords from Latin. They are standardly dated to the late eighth or early ninth centuries and the mid-ninth century, respectively. We also draw from fifty-eight so-called “minor” glossed manuscripts dated to the seventh to the

tenth centuries (Lash 2021) and the mid-eighth-century poems of Blathmac (Barrett 2021, see Stifter 2015 on the dating of Blathmac). To round out the picture of securely pre-tenth-century loans, we draw on the Thesaurus Paleohibernicus (Stokes and Strachan 1901, Stokes and Strachan 1903), which includes manuscripts not found in CORPH, including the eighth-century Würzburg manuscript (of which Kavanagh 2001 provides a useful lexicon).

The above sources do not provide a complete sample of the early Irish loan vocabulary, because they do not contain many loans whose adaptations clearly point to a pre-syncope entry date.[3] We draw these loans from McManus (1983), which is a thorough, albeit not exhaustive, collection. One loan from McManus (1983:65), Irish [saʟənd] ⟨salland⟩ 'act of singing (psalms)' from Latin [psalːendum] cannot be confidently dated to before syncope, but appears in a securely dated Old Irish text. We include it on this basis and because it is theoretically possible that it entered before syncope.

The contributions of each source to our corpus are shown in (3), where loans are only counted towards the earliest source in which they are attested.[4]

(3)

Source	Pre-syncope	Post-syncope	Either	Total
Würzburg	36	17	78	131
Blathmac	14	4	31	49
Milan	18	11	40	69
St. Gall	23	27	68	118
Minor Glosses	23	10	38	71
Thes. Pal.	0	0	1	1
McManus	91	0	1	92
Total	204	70	257	531

2.3.1 Latin vs. Irish Perspective

The corpus contains loans without Irish derivational morphology. For example, Irish borrowed [korp] ⟨corp⟩ 'body' (Stokes and Strachan 1901:581, Wb. 3a4) from Latin [korpus], but we exclude Irish derivatives such as [korp-əx] ⟨corpach⟩ 'corporeal' (lit. 'body-ADJ') (Stokes and Strachan 1903:148, Sg. 125a5). We also exclude multiple case forms of the same loan.

[3] An additional complication is that many of the loans in the early texts are literary and may have never been nativized or only existed in writing. A philological approach to such loans may be successful in determining when they entered Irish, but we do not attempt this here.

[4] There are several words in our sources that have occasionally been categorized as loan words from Latin but which we have rejected from the corpus because their etymology remains unclear to us. These are: [kolve] ⟨collbe⟩ 'pillar' (Lat. [kolumna]?), [diəθʲərʲ] ⟨diathir⟩ 'diameter' (Lat. [diametrus]?), [iðən] ⟨idan⟩ 'pure' (Lat. [idoːneus]?), [laɴ] ⟨lann⟩ 'thin plate' (Lat. [laːmina]?), [oxre] ⟨ochra(e)⟩ 'leggings' (Lat. [okreai]?), [regʲlʲeːs] ⟨reiclés⟩ 'oratory, small church' (Lat. [reklusum] or [ekːleːsia]?), ⟨sciobaidh⟩ 's/he snatches' (Lat. [skoːpa] with an Irish verbal ending?), ⟨scioból⟩ 'barn' (Lat. [skoːpaːrium]?), ⟨Teothas⟩ 'Theodotion' (Lat. [teodotioː]?). Apart from these, the large number of biblical personal names that were filtered through Latin were excluded because, being derived largely from Hebrew, they do not necessary attest to purely Latin phonotactic traits.

There is however some ambiguity in how to determine what counts as a separate loan. For instance Irish borrowed [uṽəldoːdʲ] ⟨umaldóit⟩ 'humility' (Stokes and Strachan 1901:581, Wb. 13a17) from Latin [umilitaːtem]. From the perspective of Irish, [uṽəldoːdʲ] must be a separate borrowing from the borrowing [uṽəl] ⟨umal⟩ 'humble' (Stokes and Strachan 1901:532, Wb. 5d27), since there is no native word formation process that creates nouns with this shape. However, the Latin sources for [uṽəldoːdʲ] ⟨umaldóit⟩ and [uṽəl] ⟨umal⟩ are transparently related by regular morphology in Latin, making these words a single loan from the Latin perspective.

The conservative choice is to count loans from the Latin perspective, because our simulations rely on phonotactic frequencies drawn from the Latin nominal lexicon. For completeness, we also compiled the set of loans from the Irish perspective, resulting in 20 additional loans. The simulation results do not differ appreciably between these different collections.

2.3.2 Re-borrowed Loans

An additional wrinkle is that the same Latin lexeme could be borrowed multiple times. For instance, Latin [apostol-us] 'apostle-MASC.NOM.SG' appears as a very early loan in Irish [axsəl] ⟨axal⟩ 'apostle' (McManus 1983:48) and as a later loan in [abstəl] ⟨apstal⟩ 'apostle' (Stokes and Strachan 1901:527, Wb. 5b17). In such cases we included both Irish words as separate borrowings.

2.3.3 Hand Dating

Finally, 60 loans could not be dated purely mechanically by following the methodology laid out in section 4 and the appendix. This was usually because they had inconsistent phonological cues to their date of entry. A typical case is [uespəsʲiən] ⟨Uespisian⟩ 'Vespasian' (Barrett 2021, S0005-114), which has no orthographic cues to the vowel length in Latin [wespasiaːn-us] 'Vespasian-MASC.NOM.SG', and so possibly underwent shortening (a pre-syncope change), but which is also clearly unsyncopated, which would place it after syncope. For each such inconsistent form we provided our best guess for the dates of entry by hand. In the case of [uespəsʲiən] ⟨Uespisian⟩ 'Vespasian', we disregarded the putative shortening, attributing it to Latin orthography omitting length marking, which is especially likely given the literary nature of a reference to a long-deceased Roman emperor. All data and source code is available at `https://www.github.com/bowersd/lat2sgaloans`.

2.3.4 Local Summary

This concludes our overview of the history of Irish, the rise of syncope, its fall by the time of the first manuscripts, and the historical sources we rely on for loans. We turn now to a pair of issues concerning how loan adaptation was carried out. Namely, we suspect that if syncope were to be enforced on new loans, it would be by a phonological adaptation process, rather than by perceptual deafness to alternating vowels. We also review somewhat surprising evidence that the Irish nativization process involved separating Latin roots from inflectional suffixes, and re-applying Irish suffixes in their

place. Subsequently, we will resume the main thread and illustrate how the application of Irish processes can diagnose when a loan entered Irish, and leverage that data to estimate how many loans entered at specific times in Irish.

3 Loan adaptation considerations

The current literature on loan word adaptation features a debate between perceptual processing (Silverman 1992, Peperkamp and Dupoux 2003, Peperkamp 2005) and phonological accounts (LaCharité and Paradis 2002; LaCharité and Paradis 2005) of loan word adaptation. Since the variety of Irish we are treating has long since ceased to be spoken, by and large this debate cannot inform this study. However, the two approaches may make differing predictions for whether deletion would be enforced in new loans entering during the syncope period. We are not concerned here with already nativized loans, as they are expected to undergo sound changes with the rest of the native vocabulary.

Perceptual processing accounts of loan adaptation highlight 'perceptual deafness' to non-native structures. Under such an approach, unfaithful loan adaptations are the result of the perceptual system mapping illegal percepts to native ones. Such a mechanism may not be able to enforce rhythmic syncope in new loans.

Schematically, in a left aligned trochaic rhythmic syncope system, a pentasyllabic input CVCVCVCVCVC is mapped to CVC_CVC_CVC. Clearly, speakers in such a language must still be able to perceive vowels. If this alternating deletion pattern is to be enforced by perceptual deafness, speakers exposed to pentasyllabic words must be selectively deaf to the second and fourth vowels, but not the third, even though they are all in the same local environment. This presupposes parsing the foreign word prosodically, which is typically viewed as the domain of phonology, not perception. In general, purely surface-based analysis cannot correctly select which vowels to delete for all inputs (McCarthy 2008, Hao and Bowers 2019).

Under the phonological approach to loan word adaptation, highly proficient bilinguals (as can be supposed to have existed in our period, cf. Bisagni 2013–2014, Moran 2015, Stam 2017, Moran 2022) apply native phonological processes to an input that is reasonably faithful to the source language. This is the most plausible way for rhythmic syncope to be applied to loans that entered during its heyday. Under such an account, if syncopating Irish speakers encountered a British Latin word like [abostol] 'apostle', they would construct a representation like /abostol/, foot it as (ˈabos)(ˌtol), and apply syncope to create [(ˈab_s)(ˌtol)], which eventually reaches us as [abstəl] ⟨apstal⟩ (Stokes and Strachan 1901:527, Wb. 5b17). Under this approach, Latin loanwords would be expected to undergo syncope for as long as it remained an active part of Irish phonology.

The debate between phonetic processing and phonological accounts of loan word adaptation does not significantly concern the remainder of the processes involved in the Latin loans. Phonetic processing accounts may predict that a process could be applied to loans before it had been phonologized, and so could predict more rapid application of processes to loans. Otherwise, the appendix discusses how the knowledge of particular processes, particularly their surface opacity, could have affected their application to

loan words.

3.1 Suffix Substitution

Theoretical questions aside, one of the initially more surprising aspects of the Latin loans in Irish is that roots, rather than whole inflected words, were borrowed. We know this because many loans show phonological effects that would only be possible if Latin suffixes were removed and Irish suffixes applied in their place (McManus 1984). The key phonological process responsible for this is a harmony process targeting vowel height, described in further detail in section 4. The evidence for suffix substitution setting up the harmony environment is somewhat indirect because by the time these loans were captured in writing, an apocope process had been developed, which counterbled the harmony process by removing the suffix.

By way of example, the original Latin form [kipː-us] 'stump-MASC.NOM.SG' is harmonic for vowel height, so we would not expect to see any changes to the root vowel if it was borrowed into Irish with the Latin suffix. However, vowel harmony appears to have lowered the root vowel in Irish, as seen in [kʲep] ⟨cepp⟩ (McManus 1983:37). The solution to this is that Irish speakers applied the native case suffix [-as] or its later lenited variant [-ah] to this word. The result was a disharmonic sequence †[kip-as] or †[kip-ah] 'stump-MASC.NOM.SG' (we mark unattested hypothetical forms with †, since * is reserved for ungrammatical forms). The disharmonic sequence was repaired as illustrated in (4).[5] In light of examples like these, we substitute Latin suffixes with the appropriate Irish suffix in examples.

(4)

kipː-us	Latin
/kip-as/	Irish UR
kipah	Lenition
kepah	Harmony
kep_	Apocope
kʲep	Other Rules
[kʲep]	SR
⟨cepp⟩	Orthography

Ultimately, suffix substitution reveals an ability to morphologically parse Latin words. This may not be highly surprising, because Primitive Irish was an obviously close cousin of Latin (as well as Greek and Sanskrit). More to the point, however, it is well known that educated Irish speakers of the early medieval period were steeped in grammatical learning and possessed a highly developed literacy in Latin (Law 1982, 1997, Esposito 1988, Johnston 2013, Hayden and Russell 2016). This deep engagement with Latin and the general interest in linguistic modes of analysis on the part of the Irish must have played a role in the suffix substitution phenomenon.

With these general preliminaries on Irish and the nature of loan adaptation in hand, we now return to the main narrative. In the next section we illustrate how the processes that were or were not applied to loans reveal when they entered Irish. This provides the

[5]For simplicity, we depict loan adaptations with phonological rules proceeding from a faithful source language representation, see Boersma (1998) and Boersma and Hamann (2009) for a more realistic approach.

raw data for our simulations, and thus our ultimate quantification of how many words entered Irish during the syncope period.

4 Date Ranges via Process Application

In order to estimate how many Latin loans entered during the rhythmic syncope period, we follow the method established by Jackson (1953) and McManus (1983), which dates loans according to the Irish phonological processes that applied to them. We sketch the key facts briefly in this section, and because the referenced sources can be difficult for non-specialists in Irish, we provide an explicit walk-through of the phonological developments in the appendix.

The Latin loans give a remarkably granular picture of the phonological development of Irish, because rhythmic syncope was simply the final one of six phonological processes that developed in quick succession. These six phonological developments demarcate the boundaries between seven periods in the phonological history of Irish (one for each of the six processes, plus the post-syncope period). The major milestones for dating the Latin loanwords in Irish are listed below brief descriptions where necessary:

1. [p]→[k]: replacement of [p] with [k].
2. Lenition: weakening of post-vocalic stops (except [p]) to fricatives and debuccalization of sibilants.
3. Harmony: regressive left to right short vowel height harmony.[6]
4. Shortening: vowel shortening in non-initial syllables.
5. Compensatory lenghtening: loss of [θ, ð, x, ɣ] before [r, l, n] with compensatory lengthening of the preceding vowel.
6. Rhythmic syncope

When these processes stopped applying to loan words, the result was an early group of loans that underwent the process, and a later group that did not undergo it. For instance, there are loans that underwent [p]→[k], such as Latin [pluːm-a] 'plumage-FEM.NOM.SG', which became Irish [kluːṽ] ⟨clúm⟩ (McManus 1983:48) by the historical derivation shown in (5). These loans must have entered before [p]→[k] ceased to apply.

(5)

pluːm-a	Latin
/pluːm-aː/	Irish UR
kluːmaː	[p]→[k]
kluːṽaː	Lenition
kluːṽ_	Apocope
[kluːṽ]	SR
⟨clúm⟩	Orthography

[6]The diachronic literature on Irish typically treats vowel harmony as two processes: lowering or a/o affection and raising or i/u affection.

There are also numerous loans that retained Latin [p] faithfully. One such loan is Latin [pareːki-a] 'parish-FEM.NOM.SG', which avoided [p]→[k] but underwent lenition of [k] to [x] (among other processes), as seen in Irish [parʲxʲe] ⟨pairche⟩ (Stokes and Strachan 1901:632, Wb 21a12). Clearly, [parʲxʲe] ⟨pairche⟩ 'parish', must have entered between the end of [p]→[k] and the end of lenition. The full historical derivation of this loan is spelled out in (6). We use 'X' to mark processes that do not apply because the loan entered too late. We also include two counterfactual derivations illustrating the expected outcome if the borrowing had happened earlier (column 2) or later (column 3).

(6)	pareːki-a	pareːki-a	pareːki-a	Latin
	/pareːkij-a/	/pareːkij-a/	/pareːkij-a/	Irish UR
	X	kareːkij-a	X	[p]→[k]
	pareːxija	kareːxija	X	Lenition
	parexija	karexija	parekija	Shortening
	parexeja	karexeja	parekeja	Harmony
	parexe_	karexe_	pareke_	Apocope
	(ˈpare)(ˌxe)	(ˈkare)(ˌxe)	(ˈpare)(ˌke)	Footing
	(ˈpar_)(ˌxe)	(ˈkar_)(ˌxe)	(ˈpar_)(ˌke)	Syncope
	(ˈparʲ)(ˌxʲe)	(ˈkarʲ)(ˌxʲe)	(ˈparʲ)(ˌkʲe)	Other Rules
	[parʲxʲe]	*[karʲxʲe]	*[parʲkʲe]	SR
	⟨pairche⟩	⟨cairche⟩	⟨pairce⟩	Orthography

Less specific inferences about dates of entry can also be drawn. Remaining within the loans that retained Latin [p], there are cases where lenition was not applicable, but later processes were, so we conclude that the loan could have entered Irish after the end of [p]→[k] and before the end of whichever process applied. For instance, vowel harmony is partially responsible for Latin [stupː-a] 'flax-FEM.NOM.SG' appearing as Irish [sop] ⟨sopp⟩ 'wisp' (McManus 1983:37), forcing the conclusion that the loan entered after the end of [p]→[k] but before the end of vowel harmony. A roughly contemporaneous minor process of [st] cluster simplification (see appendix section A.3.2) also applied, as did the later process of apocope, as is illustrated in (7).

(7)	stupː-a	Latin
	/stup-aː/	Irish UR
	X	[p]→[k]
	supaː	[st] cluster simplification
	sopaː	Harmony
	sop_	Apocope
	[sop]	SR
	⟨sopp⟩	Orthography

It is of course also also possible for a loan to not be bracketed by starting and ending information. For instance, the only useful dating criterion in Irish [ofʲ_rʲənd] ⟨oifrend⟩ 'office of the Mass' from Latin [ofːerendum] (McManus 1983:62) was syncope. In such a situation we can only conclude that the loan entered sometime prior to the process that applied. Nearly a quarter of our data is like Latin [oleum], which was

eligible for no informative changes en route to becoming Irish [ole] ⟨olae⟩ 'oil' (Stokes and Strachan 1901:410, Ml 121c4). Such loans are maximally undetermined, and so could have entered at any point in our timeline. In the simulations below, we calculate the date ranges of all loans, and search for the most plausible allocations of these loans to the different phonological periods (see section 5).

4.1 Local Summary

In sum, we have now established that syncope had risen and fallen by the time the extant manuscripts were composed, and outlined our collection of loans and our method of dating them. In the next sections we allocate loans to phonological periods by reconciling the dates gleaned from the corpus with phonotactic probabilities derived from the Latin lexicon. As we will see, the syncope period emerges from this with a remarkably small population of loans.

5 Timeline Estimation Method

We seek to estimate when each Latin loan entered Irish. As stated in section 4 and further elaborated in the appendix, there are seven discrete blocks of time in which a loan could enter, corresponding to [p]→[k], lenition, vowel harmony, shortening, compensatory lengthening, rhythmic syncope and the post-syncope period. Recall also that section 4 provided some examples of loans that could only belong to one phonological period, because it underwent the process pertaining to that period, while the preceding process was applicable but did not apply. If all, or even most, loans were so specific, loans could be assigned to periods by hand. This is not the case, as the vast majority of loans in the Latin perspective dataset could enter in a span of two or more periods, as detailed in (8).

(8)

Span length	Count
1	101
2	77
3	62
4	53
5	77
6	32
7	129

Despite the large amount of uncertainty, the points that we can be certain of are still very valuable. To see this, first consider (9), which breaks out the most highly specified loans by which period they are specific to.[7]

[7]Under an alternative interpretation of lenition, the 10 loans specific to the harmony period could also enter during lenition (see appendix section A.2). We ran simulations reflecting this assumption, with results otherwise indistinguishable from those reported below, except that the lenition and harmony periods received roughly the same number of loans as each other.

(9)

Specific to	Count
[p]→[k]	18
Lenition	3
Harmony	10
Shortening	0
Comp. Length	0
Syncope	0
Post-Syncope	70

Our intuition is that while 18 loans certainly entered during the [p]→[k] period, we doubt that they were the only loans to do so. Given that [p] only appears in roughly 19% of the Latin vocabulary, if borrowed words were a random sample of the Latin phonotactic space, we would expect the number of words that entered during the [p]→[k] period to be closer to 95.[8] Of course, we cannot simply assign 77 loans without [p] to the [p]→[k] period, because some of them may have been eligible for, say, harmony, which could unbalance the set in another direction. We must try to maintain the balance of all phonotactic properties in a period. Such logic is equally applicable to the other periods, giving rise to a solvable, but clearly unwieldly problem.

Because the combinatoric space of possible dates of entry is very large (on the order of 10^{166} combinations), we resort to simulations to balance these countervailing factors. We do not know which combinations of words assigned to which periods will give the best results, so we let the simulation try random solutions and build upon previous successes. In a nutshell, a simulation starts by randomly assigning loans to one of the possible dates of entry dictated by their phonological adaptations. The simulation proceeds by changing some dates of entry, and seeing if this results in an improvement of the probability of the overall timeline. The probability of the overall timeline is calculated from how well each period reflects the rates of the relevant phonotactic properties in the Latin lexicon. The simulation continues changing dates of entry until the probability of the overall timeline ceases to improve.

5.1 Implementation Summary

To enable the simultaneous exploration of multiple regions of the combinatoric space, we implemented a non-linear optimization strategy known as genetic search (Holland 1975, De Jong 1975, Yang 2021). Genetic search is an abstract characterization of biological evolution, where organisms consisting of genes with particular alleles are selected for fitness before passing their genes to the next generation. In our case, the organisms are timelines, the genes are words, and the alleles are the particular time periods the words are assigned to. Genetic search has been widely applied to problems such as graph coloring, the travelling salesman problem, and multi-objective engineering optimization.

[8] It is reasonable to assume that the Latin loans were an unbiased sample of the Latin phonotactic space. For instance, the frequency of the word-initial segment of the Latin donor words is highly correlated to their frequency in the Latin nominal lexicon, with $r^2 = 0.68$.

5.1.1 Hypothesis creation and convergence

Genetic search works by first by creating 'mutations', that is, random assignments of words to time periods, from which the m most fit specimens according to an evaluation metric are selected for retention in the 'gene pool'. The retention of multiple hypotheses in the gene pool allows multiple regions of the search space to be explored, and also helps mitigate the risk of starting the search at a single starting point. After initialization to random parameter values, mutation changes only a subset of the genes of each organism in the gene pool. This is how the algorithm explores new regions in the search space, by taking previous successes and randomly changing only a few of their genes.

In the next step, the gene pool undergoes 'recombination', where the selected specimens swap parameter values between each other, and once again the m most fit specimens are retained. In essence, the recombination step allows successes found in one area of the search space to propagate to other hypotheses. Because organisms/timelines are able to receive alleles/allocations from other hypotheses, the hypotheses in the gene pool are encouraged to converge towards a single solution. The search proceeds by iterating between mutation and recombination phases until fitness no longer improves or a set number of generations has been reached.

In our implementation, the gene pool contained the 100 most fit time courses. In the mutation phase, each timeline was mutated 1,000 times. The mutation rate declined over successive generations, starting at 5% of changeable dates, and halving each time the mutation phase failed to add new hypotheses (i.e. new hypotheses that were more fit than any pre-existing member of the gene pool). This gradual reduction in the mutation rate allowed the algorithm to progressively make more refined modifications to its hypotheses as it approached a good solution. In the recombination phase, each member of the pool created 20 offspring with each other member of the pool by randomly swapping dates of entry between them. The algorithm was halted when new members ceased to be added to the gene pool and the mutation rate was too low to change any dates, which typically occurred between the 40th and the 60th generation.

5.1.2 Fitness measure

The measure of timeline fitness evaluates phonotactic balance within each period. To do this, we obtained the rates at which a set of phonotactic properties ϕ appeared in the Latin nominal vocabulary, using a comprehensive collection of Latin nouns provided by Adam Albright. We prioritize nouns because the loan vocabulary almost exclusively features nouns.

We treat the phonotactic probability Φ_p of each period p in the timeline T as the joint binomial probability of the number of words $n_w \in p$ bearing each phonotactic property $f \in \phi$. As an informal example, consider the situation where the [p]→[k] period has 50 words in it. Φ_p is the probability that there would be 18 words with Latin [p] in the [p]→[k] period, given that 19% of the nouns in Latin have [p], multiplied by the probability that all of the other tracked phonotactic properties are attested some number of times in the 50 words, given their rate of occurrence in Latin nouns. This is given in the following formula, where n_f is the number of words in p bearing phono-

tactic property f and r_f is the rate of occurrence of phonotactic property f in Latin nouns.

$$\Phi_p = \prod_{f=1}^{|\phi|} \text{binomial}(n_f, |p|, r_f)$$

The probability of timeline T is the product of each probability Φ_p for all periods p.

The phonotactic set ϕ could conceivably contain all of the structural descriptions for the Irish processes that were applied to loans. However, the structural descriptions overlap with each other, and would overemphasize the importance of some properties for fitness if left unmodified. Accordingly, we assigned overlapping cases to a single parameter whenever possible. See the online source materials for the actual implementation.

6 Timeline Estimation Results

We report the results of 20 simulations, 10 simulations each for the Latin-perspective and Irish-perspective datasets.[9] For reference, we consider a naive model that does not attempt to provide phonotactic balance within periods, but instead evenly allocates loans between the periods in which they could have entered Irish. This results in a fairly equal allocation of loans to each period, as would be expected if the rate of borrowing was constant and all periods had the same duration. We find that the phonotactic model and the naive model diverge radically for the shortening, compensatory lengthening, and syncope periods. Crucially, the syncope period in all simulations has very few loans assigned to it. This can be seen in Figure 1.

Note that our results reflect the intuition behind the simulations. In particular, loans that are specific to a period, represented by black squares in Figure 1, attract many other loans to the period. It is straightforward to surmise that this is the result of allocating extra loans to these periods in order to dilute their core loans with highly specific phonotactic traits. This diluting comes at the expense of the shortening, lengthening, and syncope periods, which have less skewed distributions at their core.

This is highly informative for understanding the syncope period in relation to the other periods. The naive model clearly illustrates that we could not know *a priori* that the syncope period was poorly populated, because there were many loans that could in principle have entered during that period. By valuing phonotactic balance, however, we see that these potential syncope entrants melt away to join other periods, leaving behind only a few stragglers.

7 Discussion

Our key concern is whether rhythmic syncope was a flash-in-the-pan phenomenon, which we term the 'brief-blip' hypothesis. The paltry number of loans assigned to

[9] Given the availability of an alternative interpretation of lenition (see the appendix section A.2), we also ran 10 simulations on each dataset while allowing loans with Brittonic lenition to enter alongside, instead of after, loans showing Irish lenition. This only resulted in the lenition and harmony periods having roughly equal numbers of loans assigned to them.

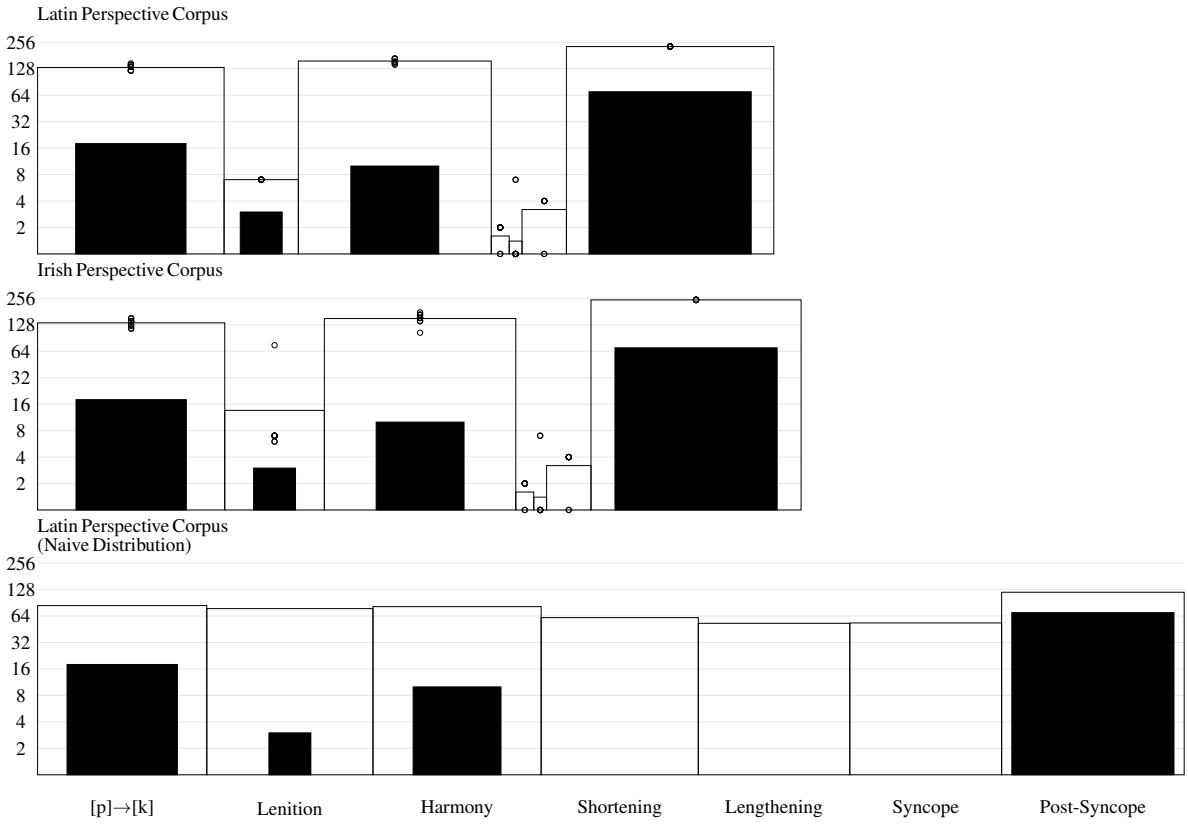

Figure 1: Loans allocated to each phonological period, faceted by sub-corpus. The vertical axis is on a logarithmic scale, and to avoid large negative values, raw values between 1 and 0 are rounded up to 1. Circles represent the number of loans assigned to a period by an individual run of the search algorithm. White squares represent the average loans assigned to a period, black squares represent loans that can only be assigned to a period. The length of a side of a square is proportional to the number of loans. The bottom panel represents an even division of loans over the periods they were eligible to enter, for the Latin perspective sub-corpus.

the syncope period is certainly consistent with the brief-blip hypothesis. If rhythmic syncope was only active for a very short time, then it is plausible that very few loans would have entered during the window in which it would have affected them.

The briefest possible blip for rhythmic syncope is a single generation. Concretely, assume generation g of speakers who exagerrated rhythmic reduction to near deletion, and a following generation g' who perceived it as categorical deletion, but failed to acquire a rhythmic syncope grammar. Under this scenario, there would have been at most a couple of decades for generation g to innovate extreme reduction and adapt loans with rhythmic syncope. After that point, generation g' would comprise a significant proportion of the adult speech community, and would comprise the entirety of the students encountering Latin in Irish and British monasteries. Even if it is not yet known what grammar generation g' would have, if it did not enforce rhythmic syncope, they would not apply rhythmic syncope to fully voweled Latin words, and may even contest syncopated adaptations where the Latin original was known.

The brief-blip hypothesis is not the only possible explanation of the results. A low number of loans during a period could be due to a slackening of the rate of borrowing, which we dub the 'slow-flow' hypothesis. Under the slow-flow hypothesis, rhythmic syncope could have been productive for a reasonably long period of time; we would simply lack evidence of this productivity due to the fact that no loans arrived to bear its mark.

A possible point in favor of the slow-flow hypothesis is that it may be able to give a unified explanation for the lack of loans assigned through the post-harmony shortening, compensatory lengthening and rhythmic syncope periods. Under the slow-flow hypothesis, there could have been a generalized decline in borrowing throughout a broad period. In contrast, a purely chronological approach like the brief-blip hypothesis must make the (not unreasonable) argument that the shortening period was quickly ended by the compensatory lengthening period, which was quickly followed by the rhythmic syncope period.

Caution is in order, however, because a slower flow of loans would ideally coincide with a broader cultural rupture, but the evidence points to closer ties being formed. To be specific, the rupture would begin in roughly the tail end of the 5th century, and would ideally last until at least the beginning of the 7th century. The significant problem with this view is that during this time, the Christian church strengthened in Ireland and southern Britain (Flechner and Ní Mhaonaigh 2016), with many monasteries being founded during this time. This is particularly inconvenient for the slow-flow hypothesis, since ecclesiastic contexts were the main point of contact for Irish speakers with Latin. In light of the strengthening church, it would be unwise to insist on a break in contact between Irish and Latin.

It may be tempting to point to the traditional date for the fall of of the Western Roman empire in 476 CE as sufficient evidence of cultural turmoil during this period. However, this is only a spurious correlation, primarily because the Christian church was relatively untroubled by the military breakup of Rome (Brown 1989). Furthermore, the actual dates for the decline of the Roman empire in the neighborhood of Ireland do not align well with this period, since imperial Roman authority ceased in Britain in 410 CE, and was tenuous in Gaul even before it catastrophically collapsed in 455 CE.

The most plausible way to reconcile the slow-flow hypothesis with deepening Irish-

Latin contact is to postulate a shift to a more formal mode of contact. The thoroughly adapted loans that are assigned to the span including the [p]→[k] and harmony periods could be the result of early, oral, informal transmission, possibly via trade. Meanwhile, the later loans could have come through more formal contact with writing and formal instruction in monastic settings. Continuing the riverine metaphor, the flow only slowed in the original spoken channel because the current of loans had been been diverted into a new written channel.

Under the diverted channel interpretation, many of the loans assigned to the post-syncope period by our model could have entered during the projected post-harmony doldrums. Since they entered during a period of formalized contact, it would not be surprising if these loans were exempted from native Irish phonology.

The diverted channel scenario is not a wholly satisfactory resolution for the slow-flow hypothesis, because these relatively less adapted loans were still nativized in Irish, most saliently with palatalization, vowel reduction and morphological consonant mutations. The slow-flow hypothesis must still contend with why some processes were enforced, but rhythmic syncope was not. On the other hand, under the brief-blip hypothesis, rhythmic syncope was ephemeral and would not be expected to be a core part of loan adaptation.

None of these considerations is necessarily fatal to the slow-flow hypothesis. For this reason, the prudent choice is to adopt a hybrid perspective, whereby the rate of borrowing into the spoken language dwindled while syncope ignited and burned out quickly. What we certainly lack is positive evidence that rhythmic syncope persisted.

8 Conclusion

We have used a simple set of phonotactic heuristics to allocate Latin loans to periods in early Irish. By and large the model predictions concur with the intuitions of previous scholarship, in that there was a large group of loans that underwent early phonology, and another large group of loans that was exempt from early phonology. Specifically, our model spreads the early group of loans over several periods, before entering a pronounced lull during the shortening-rhythmic syncope phase, and finally resuming borrowing in the post-syncope period.

An interesting suggestion from our model is that a large tranche of loans is allocated to the oldest [p]→[k] period instead of being evenly spread over the more general pre-lenition period. This may bolster a theory that serious contact with Christianity and Latin occurred substantially before the 431/432 Palladian mission mentioned by Prosper of Aquitaine (Esposito 1957; Koch 1990). It could equally well give some flexibility to the 450 date for lenition (also postulated by McCone 1996:89), which was placed at that post-431 juncture to allow for some time for conversion to Christianity. Of course, our results are also still consistent with lenition occurring around 450 and the [p]→[k] period simply ending before lenition.

Our simulations cannot definitively prove that rhythmic syncope was a flash in the pan. This is because there are competing explanations for the dearth of loans during the syncope period. These include the possibility that the slow-flow hypothesis is correct despite a deepening ecclesiastic presence in Ireland, or even the possibility that loan

adaptation uses mechanisms like perceptual adaptation that may not enforce patterns like rhythmic syncope. Although we cannot disprove these alternatives, we note that there is certainly a lack of positive evidence that syncope was productive for a long time.

Setting aside this uncertainty, Irish is in good company if its rhythmic syncope system quickly lost productivity. For instance, in Nishnaabemwin innovative non-syncopatory patterns are judged favorably by speakers who were children when extreme reduction crossed into deletion (Bowers 2019). Isačenko (1970, see especially pp. 95-6) shows that rhythmic syncope in Eastern Slavic collapsed immediately after it arose. Furthermore, in Mojeño Trinitario, rhythmic syncope developed sometime between 1898 and 1957, but it is no longer productive in the modern language and fails to apply to approximately 40% of eligible vowels (Rose 2019).[10] In Southern Pomo, dates for the development of rhythmic syncope are not available, but Kaplan (2020; 2022) highlights innovative deletion patterns that suggest speakers carried out a re-analysis. With Irish being the newest potential member of the class of languages that quickly lost rhythmic syncope, the imperative to precisely establish the descriptive facts for rhythmic syncope only grows more urgent.

A Major Phonological Processes in Loans

This appendix provides a more thorough description of the processes that provide dates for Latin loans. We give special attention to loans that are specific to a period as evidenced by the application of a process even though the immediately preceding one did not apply. These loans are important because they establish that the bins used in our simulations are discrete.

In addition to the processes that help date loans, there are some processes that have little evidentiary value but still must be discussed. Chief among these is apocope, which is known to have developed before syncope (McManus 1991:94-6), and is responsible for the lack of original final syllables, which were almost always case suffixes. Apocope cannot be used to diagnose loans because both early and late loans lack original final syllables.

Our data reflects additional processes besides the relevant ones discussed here (see McCone 1996 ch. 3-4), most prominently palatalization and the later reduction of word-medial syllables or closed word-final syllables. These orthogonal processes are included in derivations to preserve the relationship with the observed orthography, but further attention will not be given to them.

[10]The failure of rhythmic syncope to apply in large swaths of the Mojeño Trinitario vocabulary is reminiscent of what is reported for the Tonkawa lexicon in Hoijer (1949). Strikingly, Hoijer's (1933; 1946) description also suggests that the morae of deleted vowels were preserved via consonant lengthening, in much the same way as Rose (2019) proposes for Mojeño Trinitario. See also Rose (2014) for a robust class of morphological exceptions to syncope. Note that further research has shown that classifier suffixes in Mojeño Trinitario are not wholly immune to syncope, contrary to what is claimed in the paper (Françoise Rose, p.c.).

A.1 [p]→[k]

Several sound changes characteristic of Celtic languages resulted in Irish completely lacking /p/ prior to contact with Latin. As a result, Latin [p] was illegal in Irish and was replaced with [k] for some time, as illustrated by the adaptation of Latin [paːsk-a] 'Easter-NEUT.NOM.PL' in example (10), drawn from McManus (1983:48).[11] Eventually /p/ became a marginal phoneme of Irish and the [p]→[k] replacement was no longer enforced.

(10)	paːsk-a	Latin
	/paːsk-aː/	Irish UR
	kaːskaː	[p]→[k]
	kaːsk_	Apocope
	[kaːsk]	SR
	⟨cásc⟩	Orthography

When determining timelines, we conclude that a loan entered during this first period if Latin [p] is adapted as [k], its lenited variant [x], or [ɣ], which is a later variant of [x] in unstressed syllables. Latin [p] that is adapted as [p] indicates that the loan entered after the [p]→[k] period.

A.2 Lenition

The adaptation of Latin loans was affected by a confluence of consonant lenitions that originated not only in Irish, but also in Brittonic and even Proto-Celtic (McCone 1996:81-98 and references therein, see Iosad 2022 for discussion of the modern morphological lenition systems of Celtic languages). Lenition in the Celtic family appears to have developed in three waves. The first wave mapped post-vocalic voiced singleton stops [b, d, g, m] to [v, ð, ɣ, ṽ] in an early ancestor of several attested Celtic languages. The second wave debuccalized post-vocalic [s, s^w] to [h] and †[h^w] in only Irish and Brittonic (†[h^w] ultimately became [f] in Irish and [xw] in the descendants of Brittonic). During the third wave, postvocalic voiceless stops [t, k] were spirantized to [θ, x] in Irish, and voiced to [d, g] in Brittonic.

The lenition of voiceless stops is the most useful for dating loans, since that is the only phase that is certainly contemporary with the period of contact with Latin. Irish spirantizing lenition is observed in many loans, as in example (11), which illustrates the adaptations of Latin [bakul-um] 'staff-NEUT.NOM.SG' to Irish [baxəl] ⟨bachall⟩ (Bieler and Kelly 2004 [1979]:176§13.5) and Vulgar Latin †[siːtul-a] 'vessel-FEM.NOM.SG' to Irish [sʲiːθəl] ⟨síthal⟩ (Lash 2021, S0050-82).

[11] The replacement of [p] with [k] is standardly analyzed as involving the following stages: [p]→[k^w]→[k]. In the shift from [k^w] to [k], the labial feature may be transferred to following short vowels. For details, see McCone (1996:118).

(11)	bakul-um	si:tul-a	(Vulgar) Latin
	/bakul-a:/	/si:tul-a:/	Irish UR
	baxula:	si:θul-a:	Lenition
	baxola:	si:θola:	Harmony
	baxol_	si:θol_	Apocope
	baxəʟ	sʲi:θəl	Other Rules
	[baxəʟ]	[sʲi:θəl]	SR
	⟨bachall⟩	⟨síthal⟩	Orthography

It will be our practice in other sections to discuss evidence that a process was active during a different time period than prior processes. The separation between lenition and [p]→[k] was already shown in (6), so we will not repeat it here.

A.2.1 Loans with Brittonic Lenition

Even more prominent in the loan data is the application of Brittonic voicing lenition, as in Latin [pa:triki-us] 'Patrick-MASC.NOM.SG', which appears as [pa:drəgʲ] ⟨Pátraic⟩ (McManus 1983:69), with Latin [t] and [k] being mapped to [d, g], respectively. The appearance of Brittonic lenition in Latin loans to Irish is standardly attributed to Irish borrowing Latin loan words from British speakers of Latin. Because so many loans show Brittonic voicing lenition and because other evidence of close cultural contact is so strong (see Bauer 2015:5-8 and references therein), most Latin loans in Irish are thought to have come through British Latin (David Stifter, p.c.).

Since Brittonic lenition was not an Irish process, we cannot employ the same reasoning to conclude that a loan showing its effects entered Irish before any particular point in Irish history. We can only be certain that loans showing Brittonic voicing lenition arrived in Irish after lenition happened in Brittonic. However, since Brittonic lenition redirected Latin [p] to [b], in order for [p]→[k] to be able to apply in Irish, we tentatively conclude that loans with Brittonic lenition arrived after [p]→[k]. It may be possible to further conclude that loans with Brittonic lenition entered after Irish lenition ceased to apply in loans, but as the next paragraphs will show, this is somewhat contingent on the status of geminates in Irish.

A.2.2 Late Brittonic Lenition Scenario

A straightforward interpretation of loans with Brittonic lenition of voiceless stops is that Irish lenition ceased to apply productively to new vocabulary, and that these loans were borrowed during the aftermath of Irish lenition. This accounts for the striking failure of the post-vocalic voiced stops [d, g] derived by Brittonic lenition to lenite further to [ð, ɣ] in Irish. That is, under this interpretation of loans with Brittonic lenition, the development of Latin [nota] through British Latin †[noda] and ultimately Irish [nod] ⟨not⟩ 'mark, sign' (Stokes and Strachan 1903:52, Sg. 3b17) follows the left-hand column of (12) instead of the counter-factual right hand column.

(12)	not-a	not-a	Latin
	nod-a	nod-a	British Latin
	/nod-aː/	/nod-aː/	Irish UR
	X	noðaː	Lenition
	nod	noð	Apocope
	[nod]	*[noð]	SR
	⟨not⟩	⟨nod⟩	Orthography

The plausibility of this interpretation rests on when post-vocalic singleton obstruents became legal in Irish. It is possible that Irish lenition was a chain shift, whereby singleton stops became fricatives and geminates simplified. Under this view, post-vocalic singleton obstruents were legal as soon as lenition developed. Importantly, if this happened, British Latin loans like [paːdrəgʲ] ⟨Pátraic⟩ 'Patrick' would not violate any phonotactic bans once lenition occurred.

However, that situation is ultimately speculative. What is known is that original geminates were occasionally spelled differently than lenited obstruents in the post-vocalic environment in the Old Irish manuscripts.[12] Furthermore, the earliest acoustic recordings of spoken Irish show that these former geminate obstruents were no longer phonetically long in the 20th century (Wheatley and Iosad 2021). What is not known is when the original geminates became singletons.

Note that data from modern languages shows that even if a chain shift occurs in the alternation system of a language, it is liable to be underlearned (Zhang, Lai, and Sailor 2009; Zhang 2016; Zhang 2019; Nagle 2020). Even if loan adaptation occurs by applying native phonology to a representation that is essentially faithful to the source language, as argued by La Charité and Paradis (2002, 2005 *et seq*), it is not certain that a lenition chain shift would be enforced in loan words once it developed. So long as loans with Brittonic lenition entered after an Irish lenition chain shift began, the voiced stops from Brittonic lenition should not be expected to be modified in Irish.

A.2.3 Early Brittonic Lenition Scenario

However, given that we only have evidence that loans with Brittonic lenition entered after [p]→[k], it is also possible that loans with Brittonic lenition entered before or during Irish lenition.[13] Because post-vocalic voiced singleton stops had been mapped to fricatives by the first wave of lenition, the post-vocalic voiced singleton stops from Brittonic lenition would violate an exceptionless phonotactic constraint in Irish at this

[12]For voiced obstruents, the original geminates were spelled using graphemes associated with voicelessness in other languages, as seen the unlenited spelling ⟨tocad⟩ 'luck.MASC.NOM.SG', which corresponds to [toɡəð] and comes from original phonological form †[togːed-as] (Thurneysen 1946:126). Lenited voiced obstruents were spelled using graphemes familiarly associated with voicing, as in ⟨teg⟩ 'house.NEUT.NOM.SG' corresponding to [tʲeɣ], from †[tegos] (Thurneysen 1946:49). Originally geminated voiceless obstruents could be spelled with doubled consonants, as in ⟨rucce⟩ 'shame-NEUT.NOM.SG' for Old Irish [rukʲe], which corresponds to an original phonological form †[rukːij-an] (Thurneysen 1946:92). Lenited voiceless obstruents were spelled with digraphs, as in ⟨droch⟩ 'bad.MASC/FEM/NEUT.NOM.SG' for [drox], from original †[druk-as/aː/an] (Matasović 2009:105).

[13]Allowing loans with Brittonic lenition to enter during the Irish lenition period would seem to be incompatible with post-[p]→[k] loans showing Irish lenition, like [parʲxʲe] ⟨pairche⟩ 'parish'. Such a problem can be avoided by positing that such forms were borrowed from Continental varieties of Latin.

point. Since the British Latin singleton voiced stops did not spirantize in Irish, we must conclude that if they entered before degemination, then they must have been adapted as geminate voiced stops. That is, instead of British Latin †[paːdrig] 'Patrick' being faithfully borrowed as [paːdrig], it would have been borrowed as [paːdːrigː].

While degemination could have been part of Irish lenition, it was not necessarily so, and later dates have been proposed.[14] For instance, Stifter (2017:1199) lists degemination as occurring after syncope. However, Stifter's claim does not concern the date of an actual phonetic sound change, but when the ancestral geminate/singleton contrast must give way to the Old Irish unlenited/lenited contrast at the structuralist morphophonological level (David Stifter p.c.).[15] We are not wholly convinced of a post-syncope date for degemination (and thus the probable end of lenition in loanword adaptation), since there are syncopated loans with unlenited [m] like Latin [kamisi-a] 'shirt-FEM.NOM.SG', which appears as Irish [kamʲsʲe] ⟨caimmse⟩ (McManus 1983:39) or Latin [memori-a] 'death.monument-FEM.NOM.SG', which appears as [mɛmrɛ] ⟨membræ⟩ (Lash 2021:S0027-20).[16] These loans presumably entered after lenition and before syncope.

Nonetheless, not wishing to prejudice the case, we ran simulations reflecting both scenarios. In late Brittonic lenition simulations, the timeline is fairly neat, with loans that undergo Irish lenition entering before the end of Irish lenition and loans undergoing Brittonic voicing lenition (or that otherwise fail to lenite) entering after Irish lenition. In early Brittonic lenition simulations, loans that undergo Brittonic voicing lenition, or otherwise fail to lenite, may enter before Irish lenition, but not before the end of [p]→[k]. Ultimately, early Brittonic lenition simulations did not produce materially different results, so for the sake of simplicity, further discussion will proceed under the

[14]McCone (1996:89) also tersely speculates that degemination was likely later than lenition, though ultimately it appears his proposal requires the same post-degemination entry for loans with Brittonic lenition as our initial proposal. To be concrete, McCone seeks to enforce Irish lenition of voiceless stops in ecclesiastic loans while assuming that Irish lenition happened much earlier than the first known formal Christian presence in 431/432 CE. That is, if Latin [parekia] entered long after lenition, there must be an explanation for why it appears in Irish as [parʲxʲe] ⟨pairche⟩ (Stokes and Strachan 1901:632, Wb. 21a12), instead of *[parʲkʲe]). McCone's proposed solution is that degemination occurred some time after Irish lenition, so that at the time Latin [parekia] was encountered, post-vocalic [k] was illegal, but [x] and [kː] were not. Presumably because the perceptual distance was shortest between [k] and [x], voiceless singletons were adapted as fricatives instead of geminates.

Clearly, a different story must be told for the voiced stops from Brittonic lenition, which remained stops in Irish. Beyond simply stipulating that [x] was a better alternative to [kː] for [k], while [gː] was a better alternative to [ɣ] for [g], we can state that loans with Brittonic lenition entered after degemination. That is, before degemination Latin [k] was better adapted as [x] than as [kː], then degemination happened and British Latin [g] can be perfectly adapted as [g] instead of [ɣ]. This is equivalent to our original proposal that loans with Brittonic lenition were borrowed after lenition ceased to apply in loan words, albeit with stronger assumptions about the underlying timeline.

[15]The reasoning for post-syncope degemination at the structuralist morphophonological level goes as follows. Prior to apocope and syncope, the original morphophonological opposition between geminates and singletons can still be posited. This is because lenition has a well defined surface post-vocalic environment, and so belongs to the phonetic/allophonic level. Once apocope and syncope occur, lenited phones lose their well defined surface distribution, and so must be treated at the morphophonological level. Without singletons to oppose geminates, the historical gemination contrast is no longer tenable, and so degemination is held to have occurred at the morphophonological level.

[16]Note that Latin [memori-a] was also borrowed before lenition, as seen in Irish [mʲeṽurʲ] ⟨mebuir⟩ 'memory' (Stokes and Strachan 1901:626, Wb. 20a5).

assumption of the late Brittonic lenition scenario.

A.2.4 [f]→[s]

Eleven loans with [f] in Latin appear in Irish with [s], as in Irish [su:st] ⟨súst⟩ 'flail' (McManus 1983:29), from Latin [fu:stis]. These adaptations could have arisen by Latin [f] being mapped to Irish †[s^{w}], which had [f] as a lenited allophone, and was eventually delabialized to [s].[17] These adaptations could also have been the result of [f] being directly mapped to [s].

Unfortunately, the current understanding of lenition as a gradually developed process makes it very difficult to date these loans. Recall that the lenition of [s] and †[s^{w}] is common to both the Brittonic languages and Irish. Taking these shared traits as evidence of inheritance puts the lenition of [s] to [h] and †[s^{w}] to †[h^{w}] in the ancestor of Irish and Brittonic.[18] After this common development, Irish must develop many Irish-specific sound changes, many of which were not applied to Latin loans and so presumably happened before Irish began to borrow from Latin.

The upshot of this is that the lenition of sibilants was too remote to give precise dates for these loans. While it is plausible that there were active alternations between †[s^{w}] and [f], or only static restrictions on where [f] could occur during the time of contact with Latin, we only know that mapping [f] to a sibilant could have been early. In fact, the best move is to limit [f]→[s] loans to the early portion of our time line. This is because all three of the eleven [f]→[s] loans that were eligible for lenition or harmony, underwent those processes.[19] Accordingly, we treat loans that underwent this adaptation as entering no later than the immediately post-harmony period described in section A.4.

A.3 Vowel Harmony

The next major process after lenition was vowel harmony (see section A.4 for discussion of shortening, which technically began between lenition and harmony). Vowel harmony applied from left to right across the word, causing non-low short vowels to agree with the following syllable for the feature [HIGH]. There were two restrictions on this process. First, [e, e:] did not trigger agreement in the preceding syllable. Second, [i, i:, u, u:] only triggered agreement in initial syllables, and could be blocked by an intervening voiceless consonant (McCone 1996:110).[20] Harmony is illustrated in

[17] If [f]→[s] loans were borrowed with †[s^{w}], at some point they joined the [s]→[h] morphological lenition pattern along with all but one of the native words that originally began with †[s^{w}], i.e. ⟨siur⟩ 'sister' (lenited ⟨fiur⟩) from †[s^{w}esu:r]. See Iosad 2022 for a comprehensive discussion of morphological lenition.

[18] The controversy over whether Irish and Brittonic form an Insular Celtic subgrouping does not affect the existence of a common ancestor for Irish and Brittonic.

[19] That is, Latin [furn-us] 'oven-MASC.NOM.SG' and [fe:ri-a] 'holiday-FEM.NOM.SG' were evidently borrowed as †[s$^{(w)}$urn-as] and †[s$^{(w)}$e:rij-a:] before undergoing harmony and apocope to become the attested forms [sorn] ⟨sorn⟩ (McManus 1983:28) and [s^{j}e:r^{j}e] ⟨séire⟩ (McManus 1983:55), while Latin [flok:-us] 'fluff-MASC.NOM.SG' may have become Vulgar Latin †[flo:k-us] (Petersson 1913) and become Irish †[s$^{(w)}$lo:k-as] en route to undergoing lenition and apocope to become the attested form [slo:x] ⟨slóch⟩ 'snowflake' (McManus 1983:55).

[20] McCone (1996:110) recognizes that the full account of which consonant sequences block vowel raising has not been worked out. Thurneysen (1946:47-49) gives a list of clusters that did not block raising: [nd, mb,

(13), which shows the mapping from Latin [pult-em] 'porridge.FEM-ACC.SG' to [kolt] ⟨colt⟩ (McManus 1983:48).[21]

(13)	pult-em	Latin
	/pult-an/	Irish UR
	kultan	[p]→[k]
	koltan	Harmony
	kolt_	Apocope
	[kolt]	SR
	⟨colt⟩	Orthography

The fact that harmony applied iteratively from left to right, while targets were to the left of their triggers, meant that it was a self-counterfeeding process. In particular, high vowels in initial syllables could be followed by derived cases of the lowering trigger [o]. The subsequent development of apocope further opacated harmony by deleting many harmony triggers, as shown in (13).

A substantial body of literature discusses whether opacity is underlearned (Sanders 2003; Kawahara 2015; Andersson 2018; Jurgec 2019), and Kaplan (2008) argues specifically that self-counter-feeding opacity is unattested as a phonological phenomenon. However, we refrain from asserting that this self-counter-feeding opacity triggered underlearning of all aspects of the harmony process. That said, even if it was fully learned, Irish speakers had to permit some disharmonic sequences in surface forms. As was the case for lenition, the presence of surface disharmonic sequences opens the door to not adapting disharmonic loans that entered while harmony was being developed. For the sake of simplicity, we treat all disharmonic sequences as being faithfully adaptable once harmony began to appear, not just [i/u…o] sequences.

Due to the later application of vowel reduction in word-medial syllables, only initial and word-final syllables are informative for whether a word underwent vowel harmony.[22] To be concrete, we conclude that a loan was borrowed before harmony if the conditions for harmony were met in the initial or final syllable (after apocope) and harmony applied. If the conditions for harmony were met, but harmony did not apply, we conclude that the loan was borrowed after harmony. Because Latin case suffixes were replaced by Irish case suffixes, Latin monosyllabic stems may or may not have met the harmony environment once Irish suffixes were applied. If harmony applied in Irish to monosyllabic stems, we assume that the environment for harmony was met. If, however, harmony did not apply in a monosyllabic stem, we assess the morphological paradigm of the loan to determine whether the environment for harmony could have been met, and date the loan accordingly.

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l̃, r̃, ðv, dr, or gl]. Thurneysen also writes that intervening ⟨cc⟩ (= [k]) permits raising, but the evidence for this is equivocal at best. In cases where a vowel fails to raise, we only conclude that this is due to post-harmony borrowing if the intervening consonant is voiced, or a member of Thurneysen's list.

[21] McManus (1983:48) erroneously claims that [kolt] ⟨colt⟩ 'porridge' comes from Latin [pult-a] 'knock-2SG.IMPV'.

[22] See McManus (1991:94) for evidence from Ogam inscriptions that vowel harmony applied in word-medial syllables.

A.3.1 Separating lenition and harmony

Loans with Brittonic lenition began to enter Irish before harmony was completed. For instance, Latin [kokʷiːn-a] 'kitchen-FEM.NOM.SG.' was adapted as [kugən̲] ⟨cucann⟩ (McManus 1983:59). We can explain the raising of Latin [o] to Irish [u] as being the result of the harmony process enforcing raising due to the following high vowel.

The derivations in (14) provide the history of Irish [kugən̲] ⟨cucann⟩ 'kitchen', as well as the counterfactual derivations illustrating the expected outcome if the word had been borrowed before lenition (column 2), or after harmony (column 3). These derivations follow the assumption that Brittonic voicing lenition only appeared in loans borrowed after Irish lenition (see section A.2.1). If that assumption is abandoned, then we can only conclude that loans of this type entered Irish after [p]→[k] and before harmony.

(14)	kokʷiːn-a	kokʷiːn-a	kokʷiːn-a	Latin
	kogiːn-a	kokiːn-a	kogiːn-a	British Latin
	/kogiːn-aː/	/kokiːn-aː/	/kogiːn-aː/	Irish UR
	X	koxiːnaː	X	Lenition
	koginaː	koxinaː	X	Shortening
	kugenaː	kuxenaː	X	Harmony
	kugen_	kuxen_	kogin_	Apocope
	kugən̲	kuxən̲	kogən̲	Other Rules
	[kugən̲]	*[kuxən̲]	*[kogən̲]	SR
	⟨cucann⟩	⟨cuchann⟩	⟨cocann⟩	Orthography

Note that the shortening of Latin [iː] to Irish †[i] is not informative for dating this word, because shortening began after lenition (McCone 1996:110-115), and continued through harmony and apocope before being ended by the development of compensatory lengthening (see section A.4). The long duration of shortening is also the reason that in the second counterfactual derivation shortening has been implicitly applied in the apocope stage.

A.3.2 [st]→[s]

In the native vocabulary, inherited †[st] clusters became †[sː] and were subsequently degeminated to [s]. Many Latin loans were adapted similarly, as in Irish [kasʲəl] ⟨caisel⟩ 'castle', from Vulgar Latin †[kastilːum] (McManus 1983:58), or Irish [sraθər] ⟨srathar⟩ 'pack-saddle' (Stokes and Strachan 1903:290, Sg. 229a), from Latin [straːtuːra] or Vulgar Latin †[stratuːra]. Though it would be natural to date such words as entering before lenition, Latin [straːt-a] 'street-FEM.NOM.SG.' appears as Irish [sraːdʲ] ⟨sráit⟩ (McManus 1983:54), with simplification of [st] to [s] but showing the potentially post-Irish lenition feature of Brittonic lenition of the stem-final consonant.

In order to preserve the intuition that [st] → [s] simplification was early, while not limiting these loans to entering before lenition, this trait is taken as evidence of adaptation before harmony in the simulations below. Faithful maintenance of [st] clusters is not taken as evidence of any date of entry (McManus 1983:54).

A.4 Shortening

Vowel shortening targeted vowels in non-initial syllables except before [h] (McCone 1996:110-112). This process pre-dates vowel harmony, since Latin long vowels were shortened and harmonized as in (14). Despite this early beginning, vowel shortening is standardly thought to have persisted until compensatory lengthening re-introduced long vowels in word medial syllables.

This raises the possibility that some loans could have entered too late for harmony to apply, but early enough for shortening to have applied. There are two examples that potentially could establish a post-harmony shortening period beyond a doubt, like Irish [iðənʲ] ⟨idain⟩ 'pure.PL' (Stokes and Strachan 1901:700, Wb. 31c13), which is potentially from Latin [ido:neus], and Irish [fʲirʲmʲənʲtʲ] ⟨firmint⟩ 'firmament' (Stokes and Strachan 1901:115, Ml. 42b22), from Latin [firma:mentum]. Unfortunately, proceeding under that assumption would be controversial. Despite McManus (1983:59) attributing a Latin origin to [iðənʲ], this is not a widespread conclusion (cf. the entry for ⟨idan⟩ in eDIL (2019) at `https://www.dil.ie/27179`, accessed July 27, 2022). Furthermore, though shortening and syncope could have removed [a:] from Latin [firma:ment-um] 'firmament-MASC.NOM.SG', the usual outcome of deleting a back vowel in Irish was a non-palatal cluster, but the spelling of the word in Irish as ⟨firmint⟩ clearly diagnoses a palatal cluster. We are thus inclined to accept an alternative analysis, whereby [a:] was deleted by syncope within Latin, producing †[firm_ment-um], and that the resulting [rm] cluster was palatalized in Irish by the flanking front vowels.[23]

A.5 Compensatory Lengthening

After the development of vowel harmony, Irish deleted dental and velar fricatives before consonantal sonorants [r, l, m, n], and lengthened the preceding vowel, as in the native word [kʲenʲe:l] ⟨ceneel⟩ 'race' (Stokes and Strachan 1901:681, Wb. 28b1), from †[kenеθl] (where the †[θ<t] has a reflex in Old Welsh [kenedl] ⟨kenetl⟩ McCone 1996:122). Example (15) illustrates this in the loan vocabulary for Latin [sign-um] 'sign-NEUT.NOM.SG.' (Lash (2021:S0022-78).

(15)		
	sign-um	Latin
	/sign-an/	Irish UR
	siɣnan	Lenition
	seɣnan	Harmony
	seɣn_	Apocope
	se:n	Compensatory Lengthening
	sʲe:n	Other Rules
	[sʲe:n]	SR
	⟨sén⟩	Orthography

Very few Latin loanwords met the environment for compensatory lengthening. Compensatory lengthening is instead a major milestone for dating Latin loans because

[23] Admittedly, this proposal suffers somewhat from the fact that Latin syncope typically did not affect short [a] or any long vowels (Adams 2013:90).

it overrode vowel shortening. Latin loans that preserve vowel length must have entered at some point after this development. For instance, Latin [altaːre] 'altar', after undergoing the later Brittonic change of [aː] to [ɔː] (Stifter 2017:1200), maintained vowel length when it was adapted into Irish as [altoːrʲ] ⟨altóir⟩ (Stokes and Strachan 1901:527, Wb. 5b6).

The precise point after compensatory lengthening that vowel length began to be preserved is somewhat open to interpretation. If speakers of Irish did not recover the deleted fricative at the time of compensatory lengthening, vowel length would need to be specified in inputs, and faithfulness constraints to protect vowel length would need to be promoted. A second, more restrictive possibility, would only protect underlying vowel length before sonorants. On the other hand, if Irish speakers were aware of the deleted fricative, they could have maintained a grammar that enforced shortening and restricted long vowels to arising via compensatory lengthening.

It is unlikely that Irish speakers recovered the underlying fricatives and maintained productive compensatory lengthening. The primary paradigmatic context that speakers could use to recover the process was quite specialized. Some verbs beginning with stop-sonorant clusters formed the past tense via initial consonant reduplication, which set up a CVCR sequence that triggered compensatory lengthening to CVːR. This can be seen in the past tense of [kre-n-əðʲ] ⟨crenaid⟩ 's/he buys', which in the first person past tense became [keːr] ⟨cér⟩ 'I bought' (Thurneysen 1946:428). The historical progression leading to [keːr] ⟨cér⟩ 'I bought' is laid out in (16).

(16)	kikra	Pre-lenition
	kixra	Lenition
	kexra	Harmony
	kexr	Apocope
	keːr	Comp. Len
	⟨keːr⟩	Orthography

By the time of the Early Irish manuscripts we find innovative reduplicated forms. These provide concrete evidence that compensatory lengthening was not acquired, and thus that vowel length outside the initial syllable must have become contrastive. For instance, the reduplicating verb meaning 'dig' appears without consonant loss or a long initial syllable, so that /RED-klað-adar/ appears as [kexləðədər] ⟨cechladatar⟩ 'they dug' (Stokes and Strachan 1901:526, Wb. 5a24), instead of compensatorily lengthened *[keːləðədər] or its syncopated version *[keːldədər].[24]

Unfortunately, we do not know whether the process was abandoned before or after the development of rhythmic syncope, which created a cavalcade of surface fricative-sonorant clusters. We only know that compensatory lengthening had progressed far enough before syncope that there are pre-syncope Ogam stone inscriptions which have solitary sonorants in place of etymological fricative-sonorant sequences (McManus 1991:96). These inscriptions establish that syncope and compensatory lengthening did

[24]The form [ke-xləðədər] ⟨cechladatar⟩ also illustrates how the rhythmic syncope system had broken down by the time of the Old Irish manuscripts. If syncope had been applied to the reformed reduplicated form starting in [kex…], we would expect to find *[kexldadar] or possibly *[kexəldədər] with regular epenthesis before stranded sonorants.

not happen at exactly the same time, but they cannot tell us what the contrastive status of vowel length was in the grammars of speakers.

However, following our decisions to preserve granularity by recognizing a post-harmony shortening period and placing the entry of loans with Brittonic lenition after Irish lenition, we assume that Irish speakers had grammars that enforced a length contrast in all word medial syllables before syncope. That is, we analyze word-medial vowels that undergo shortening as entering the language before compensatory lengthening. Furthermore, we conclude that a loan was borrowed before compensatory lengthening if the Latin original meets the environment for compensatory lengthening and it is carried out. Meanwhile, loanwords that maintain vowel length word-medially are thought to have entered after compensatory lengthening restored the vowel length contrast. If a Latin original has a cluster that was made illegal by compensatory lengthening, and that cluster is not simplified, we conclude that it was borrowed after compensatory lengthening. That is, such a loan must have entered during or after the syncope period, which re-created these consonant clusters.

A.6 Syncope

As stated in section 2.2, rhythmic syncope targeted even-numbered non-final syllables when counting from left to right. The derivation in (17) illustrates the application of syncope to Latin [apostol-us] 'apostle-MASC.NOM.SG.' to create Irish [axsəl] ⟨axal⟩ (McManus 1983:48).

(17)		
	apostol-us	Latin
	/apostol-as/	Irish UR
	akostolas	[p]→[k]
	axostolah	Lenition
	axosolah	[st]→[s]
	axosol_	Apocope
	(ˈaxo)(ˌsol)	Footing
	(ˈax_)(ˌsol)	Syncope
	(ˈax_)(ˌsəl)	Other Rules
	[axsəl]	SR
	⟨axal⟩	Orthography

In the simulations in section 5, we take the removal of vowels from even-numbered non-final syllables as evidence that a word entered Irish before or during the syncope period. Vowels may be deleted from other syllables, as in /kon=to-ro-xar-adar/ → [kon=torxradar] ⟨con-torchratar⟩ 'they fell together' (discussed above in section 2.2.1), or more commonly, may fail to be removed from the expected syllables. Either of these deviations are taken as evidence of entry after the syncope period. See section A.6.2 for further dating criteria using the adaptation of consonant clusters.

A.6.1 Separating syncope and other processes

At least two loans may have entered between the beginning of compensatory lengthening and before the end of syncope. Latin [kandel-aːri-us] 'candle-AGEN-MASC.NOM.SG.'

appears in Irish as [kanʲdʲlʲoːrʲ] ⟨caindl(e)óir⟩ ‘candle-bearer’ (Stokes and Strachan 1901:703, Wb. 24b32). This word shows both syncope and the retention of the long vowel [aː], which had been rounded to [ɔː] in Brittonic before becoming Irish [oː]. The adaptation of this word is illustrated in (18), alongside counterfactual derivations for early (column 2) and late (column 3) entry. We use ↓ to mark a possible point of entry where the listed process does not apply.

(18)	kandelaːri-us	kandelaːri-us	kandelaːri-us	Latin
	kandeloːr	kandeloːr	kandeloːr	British Latin
	/kandeloːrʲ/	/kandeloːrʲ/	/kandeloːrʲ/	Irish UR
	X	kandelorʲ	X	Shortening
	↓	—	X	Comp. Len
	(ˈkande)(ˌloːrʲ)	(ˈkande)(ˌlorʲ)	X	Stress
	(ˈkand_)(ˌloːrʲ)	(ˈkand_)(ˌlorʲ)	X	Syncope
	(ˈkanʲdʲ)(ˌlʲoːrʲ)	(ˈkanʲdʲ)(ˌlʲərʲ)	kandəloːrʲ	Other rules
	[kanʲdʲlʲoːrʲ]	*[kanʲdʲlʲərʲ]	*[kandəloːrʲ]	SR
	⟨caindleóir⟩	⟨caindler⟩	⟨candalóir⟩	Orthography

However, this case is controversial, because [kanʲdʲlʲoːrʲ] ⟨caindleóir⟩ may have been formed within Irish from borrowed morphemes, rather than the whole word being borrowed directly from Latin. That is, Latin [kandeːla] ‘candle’ was borrowed into Irish as [kanʲdʲəl] ⟨caindel⟩ (Lash 2021, S0027-57), where the shortening of Latin [eː] indicates that it entered Irish before compensatory lengthening. Furthermore, the suffix [-oːrʲ] ‘AGEN’ was extracted from other Latin loans and was applied even to native roots, such as the word [foxʲlʲ-oːrʲ] ⟨foichleóir⟩ ‘curator’ from [foxʲəl] ⟨fochell⟩ ‘attention, heed, caring for’ (Thurneysen 1946:172).[25] Concatenating /kanʲdʲel/ and the suffix /-oːrʲ/ produces /kanʲdʲel-oːrʲ/, which would undergo syncope to become [kanʲdʲ_lʲ-oːrʲ] ⟨caindleóir⟩. Although our model does not treat Irish-internal neologisms, in this case the distinction between borrowing and neologism is so faint that we include this word in our simulations.[26]

The second loan that could have entered in this time span is Latin [deprekaːtioː] ‘deprecation’, which appears either as Irish [dʲebrʲəgoːdʲ] ⟨deprecóit⟩ (McManus 1983:68) or [dʲibʲərgoːdʲ] ⟨dibercoit⟩ (eDIL 2019 `https://www.dil.ie/15240`). Though at first blush neither form would seem to comply with the expected output of syncope, the vocalism of the latter is the expected outcome of epenthesis repairing sonorants stranded between consonants by syncope (Thurneysen 1946:70). Furthermore, similar variation is seen in the clearly pre-syncope loan of the Latin name [paːtrikius] ‘Patrick-MASC.NOM.SG’, which appears both as [koθrəɣʲe] ⟨Cothrige⟩ (Thurneysen 1946:571) and [kaθʲərʲɣʲe] ⟨Cathirge⟩ (McManus 1983:62, fn. 122). We date

[25]This suffix remains productive even in the modern language.

[26]There are three other potential loans that lack a Latin vowel and retain a long vowel. Latin [triːnitaːt-em] ‘trinity-FEM.ACC.SG’ appears as [triːndoːdʲ] ⟨tríndóit⟩ (attested in a different case form ⟨tríndóti⟩ in Stokes and Strachan 1901:9, Ml. 2d2), Vulgar Latin [antitaːt-em] ‘antiquity-FEM.ACC.SG’ became Irish [andoːdʲ] ⟨andóit⟩ ‘mother church’ (McManus 1983:61), and Latin [feːriaːl-is] ‘pertaining to a weekday-MASC/FEM.NOM.SG’ appears as [feːroːlʲ] ⟨féróil⟩ (Lash 2021, S0058-40). However, syncope of front vowels in Irish triggers palatalization on the neighboring consonants (as seen in examples 6 and 18). The lack of palatalization of the medial consonant or clusters in these words indicates that the missing Classical Latin vowel was lost in either British Latin or Vulgar Latin.

[dʲebrʲəgoːdʲ] ⟨deprecóit⟩ ‘deprecation’ to either the syncope or compensatory lengthening periods.[27]

A.6.2 Juxtaposed Consonants

The deletion of vowels via syncope created consonant clusters, some of which had been illegal in Irish and were repaired when they appeared in loanwords. McManus (1983:60-62) points out that some loanwords do not undergo these repairs, which is plausibly attributable to syncope having legalized them. Specifically, faithful adaptation of [ns, nf, ks] diagnoses entry after syncope, while a repair of Latin [nf] to Irish [v] diagnoses a pre-syncope loan. However, Irish and Vulgar Latin both repaired [ns, ks] to [s], making it impossible to determine anything about date of entry from these repairs.

Furthermore, nasal-voiceless stop clusters [ŋk, nt] were often repaired by voicing the stop (see McManus 1983:61 for discussion). We analyze cases of voicing as evidence that a word entered the language before syncope. We cannot draw any conclusions from the failure of voicing to apply, because there are early loans that do not show voicing. For instance, Latin [intelːekt-us] ‘intellect-MASC.NOM.SG’ appears in Irish as [inʲtʲlʲuxt] ⟨intliucht⟩ (McManus 1983:62), which has undergone syncope and shows evidence of a pre-syncope process known as u-coloring or u-affection (Hock 2019, McCone 1996:111-112).

In addition to the consonant clusters discussed by McManus (1983), syncope relegalized the consonant clusters that were simplified by compensatory lengthening. Latin originals with these clusters are extremely rare in our loan data, but if they were faithfully adapted, it would be evidence for adaptation that occurred after syncope.

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[27] Two further loans have a similar consonant configuration but without the variation in vocalism. These are Irish [mʲedrəbəlʲ] ⟨metrapoil⟩ ‘metropolis’ (Stokes and Strachan 1901:361 Ml. 106d6) from Latin [meːtropolis] and Irish [akrʲəsʲəndəvʲ] ⟨acrisiondaib⟩ (Stokes and Strachan 1903:85 Sg. 32b25). The latter is a dative plural adjective derived within Irish from a Latin proper name [akrisioneː]; it is also a *hapax legomenon* from a mid-ninth-century (well after the time of syncope) gloss on a Latin text containing the clearly unsyncopated Latin form. This could therefore be an instance of a literary loan (cf. section 2.3). Nonetheless, we lack direct evidence of syncope and subsequent vowel epenthesis for these words, but we recognize the possibility that the observed forms could have been developed this way with subsequent metathesis. Accordingly, we allow these words to enter during both the pre-syncope and post-syncope periods.

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