

PHONOLOGICAL RESTRICTIONS ON LENITION IN SCOTTISH GAELIC

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There has been extraordinary attention devoted to the Celtic mutations over the years, with various authors arguing for phonological, morphological, or lexical treatments (and various blends thereof). Strikingly, this literature is virtually bereft of any mention of the phonological restrictions that can sometimes limit the applicability of mutation. In this article, we provide a detailed experimental and corpus-based investigation of the phonological restrictions on Scottish Gaelic mutation. Using both techniques, we show that the phonological restrictions are alive yet are in a state of flux. The continued productivity of these phonological aspects of the mutation system argues that any analysis of mutation must attend to them.*

Keywords: mutation, lenition, Scottish Gaelic, Celtic, phonology, morphology

1. INTRODUCTION. In this article, we report on a unified behavioral and corpus investigation of phonological restrictions on lenition in Scottish Gaelic. Lenition is an instance of productive morphologically triggered consonant mutation, a remarkable grammatical process found in a number of languages, but most notably in all of the extant Celtic languages. Basically, mutation refers to the process whereby initial consonants undergo various phonological changes in specific morphosyntactic contexts. Historically, mutation is the residue of sandhi triggered by phonological material that is, in most cases, now gone. While triggered morphosyntactically in the modern language, there are a number of phonological restrictions on the phenomenon in Scottish Gaelic. These restrictions are discussed in traditional grammars like Gillies 1896 and in modern pedagogical grammars like Spadaro & Graham 2009. They are also discussed in the theoretical literature, for example, Rogers 1972, Pyatt 1997, Stewart 2004, 2013, and so forth.

Our data suggest that the phonological restrictions in Scottish Gaelic are in flux and that the patterns observed behaviorally and in corpora are very different from what the grammatical descriptions would have. Though the original phonological conditioning for the mutations has been lost, there is still a phonological side to the mutations: phonological restrictions apply in both the behavioral and corpus data. Thus the phonological restrictions on lenition in Scottish Gaelic are a productive part of the phenomenon. In fact, our data suggest that the phonological restrictions are becoming MORE productive.

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The organization of this article is as follows. We first review the general grammatical system of lenition in Scottish Gaelic and the phonological restrictions that apply to it. We next present our experimental data, showing how the phonological restrictions are different from the grammatical description: they are generalizing in some ways, and becoming more transparent in others. We then compare these patterns with corpus data, which show somewhat different generalizations. Finally, we put the patterns together in a general description, focusing specifically on the productivity of the restrictions.

2. LENITION IN SCOTTISH GAELIC. Scottish Gaelic is one of the modern Celtic languages, together with (Irish) Gaelic, Welsh, Breton, Manx, and Cornish. All of these languages exhibit consonant mutation, a process whereby initial consonants of words are changed phonologically in morphosyntactic contexts. For example, in Welsh (King 2003), the possessive pronoun *ei* [i] ‘his’ triggers soft mutation on a following word, for example, *pen* [pen] ‘head’ vs. *ei ben* [i ben] ‘his head’. That this relationship is phonological is evidenced by the fact that any word beginning with a [p] in this context will surface with a [b]. That the context is morphosyntactic is evidenced by the fact that items with exactly the same phonology do not trigger soft mutation in different morphological contexts. Hence, the segmentally and orthographically identical feminine possessive pronoun triggers a different mutation, for example, *ei phen* [i fen] ‘her head’. Very parallel facts obtain in Scottish Gaelic, as we review below.

There are several different mutation-like processes in Scottish Gaelic. We focus here on what is termed **LENITION** in the Scottish Gaelic literature. The term is historically connected to the general process of lenition, but the name is deceptive in a modern context: it is simply one particular mutation pattern in the language. In particular, we focus on the lenition that is present orthographically; as noted below, lenition is not marked for all consonants. We do this for two reasons. First, we can then investigate the distribution of this feature with written corpus resources. Second, like others, the native speaker we have been most closely working with (the seventh author) does not lenite in contexts where lenition does not show up in the orthography.

Scottish Gaelic has or had a grammatical case system (Gillies 1896, Lamb 2003, Spadaro & Graham 2009), with nominative, genitive, dative, and vocative cases being marked by a combination of lenition, final-consonant palatalization (‘slenderization’), and changes to the definite article. We set aside contexts involving grammatical case in this article, since the case system is extremely variable and is most likely being lost (Dorian 1973, 1976, 1978, 1981). We also set aside cases involving the definite article, since lenition after the article is inextricably tied to case. Our own informal examination suggests that lenition in these contexts is extremely variable.

Bearing in mind these considerations, in this section, we review the basic phonological inventory and some of the patterns of lenition in contexts where the definite article is not involved. We explain which sounds exhibit lenition, what contexts it occurs in, and what restrictions apply to it. We focus our discussion on lenition contexts relevant to the behavioral data we treat in §3 and the corpus data in §4, though we treat some additional salient lenition contexts as well. Our focus is on the phonological restrictions cited in the previous section (and to be discussed in depth below).

Scottish Gaelic has the vowels in Table 1. Note that in addition to height, backness, and rounding, vowels contrast in length and nasalization. The consonant inventory is given in Table 2. Some descriptions include nasalized fricatives, but recent phonetic investigation suggests that these are actually fricatives in nasal vowel contexts (Brenner et al. 2011, Warner et al. 2011, Warner et al. 2015).

	FRONT	CENTRAL	BACK	
			ROUNDED	UNROUNDED
HIGH	i, i:, î, î:		u, u:, û, û:	ɯ, ɯ:, ɤ̃, ɤ̃:
MID HIGH	e, e:		o, o:	ɤ, ɤ:
MID LOW	ɛ, ɛ:, ẽ, ẽ:		ɔ, ɔ:, ȳ, ȳ:	
HIGH		a, a:, ă, ă:		

TABLE 1. Scottish Gaelic vowels.

	LAB.	DENT.	ALV.	PAL.		VEL.	GLOT.
				COR.	DORS.		
STOP	p ^h , p	t ^h , t		t ^h , t ^j	k ^h , k ^j	k ^h , k	
NASAL	m		n	ɲ		n ^ɣ	
FRIC.	f, v		s	ʃ	ç, ʝ	x, ɣ	h
LAT.			l	l ^j		l ^v	
RHOTIC			r	r ^j		r ^ɣ	
APPROX.				j			

TABLE 2. Scottish Gaelic consonants.

Let us now consider which segments participate in lenition and the differences induced by lenition. These are shown in Table 3. In some dialects, the coronal sonorants also participate in lenition, but the differences are not reflected in the orthography.¹

ORTHOGRAPHIC		PLAIN		PALATALIZED	
UNLENITED	LENITED	UNLENITED	LENITED	UNLENITED	LENITED
p	ph	p ^h	f	—	—
b	bh	p	v	—	—
t	th	t ^h	h	t ^h	ç
d	dh	t	ɣ	t ^j	ʝ
c	ch	k ^h	x	k ^h	ç
g	gh	k	ɣ	k ^j	ʝ
f	fh	f	∅	—	—
s	sh	s	h	ʃ	ç
m	mh	m	v	—	—

TABLE 3. Lenition changes.

Lenition generally appears in consonant clusters, except where the second consonant in the cluster is a consonant that would exhibit lenition itself. Hence words beginning with *sp* [sp], *st* [st], *sg* [sk], and *sm* [sm] do not exhibit lenition, while words beginning with *sn* [sn], *fl* [fl], *fr* [fr], and so forth do.² Table 4 gives examples of lenition in various clusters with the prenominal adjective *droch* [trɔx] ‘bad’. (The first column gives the pronunciation of these clusters in other contexts without lenition.) Clusters where lenition does not occur are marked in bold.³

We now turn to some of the principal environments for lenition in verbs, nouns, and adjectives. Lenition with verbs is fairly straightforward. For example, it occurs in the simple past and the negative future tense with the particle *cha(n)*. This item occurs in two pronunciations: *cha* [xa] and *chan* [xan]. We characterize the first variant as having a ‘covert’ coronal nasal. With this particle, lenition does not occur when the verb begins with a coronal obstruent. These are exemplified in Table 5. Note that the *chan* variant,

¹ They also do not occur in the speech of the primary consultant we worked with or in that of many of our experimental subjects (Skye).

² This generalization is more complex in those dialects where coronal sonorants do undergo lenition. In those dialects, clusters like *sn* [sn], *fl* [fl], and *fr* [fr] can still undergo lenition.

³ We treat word-initial clusters in more detail below.

[p ^h l]	droch phlannt	[trɔx flawnt]	‘bad plant’
[p ^h r]	droch phreas	[trɔx fr̥es]	‘bad larder’
[pl]	droch bhlas	[trɔx vlas]	‘bad taste’
[pr]	droch bhràthair	[trɔx vrahəɾʲ]	‘bad brother’
[t ^h r]	droch thràigh	[trɔx hra:j]	‘bad beach’
[t ^h l]	droch thlachd	[trɔx hlaxk]	‘bad pleasure’
[tr]	droch dhrochaid	[trɔx ɣroxɪʲ]	‘bad bridge’
[tl]	droch dhleasnas	[trɔx ɣlesnəs]	‘bad duty’
[k ^h r]	droch chrioch	[trɔx xɾi:ɔx]	‘bad border’
[k ^h l]	droch chliabh	[trɔx xliəv]	‘bad creel’
[kr]	droch ghrunnd	[trɔx ɣrũ:nd]	‘bad fishing grounds’
[kl]	droch ghleann	[trɔx ɣlawɲ]	‘bad valley’
[fr]	droch fhrasan	[trɔx rasən]	‘bad showers’
[fl]	droch fhliuchadh	[trɔx ɸuxɔ]	‘bad watering’
[sl]	droch shluagh	[trɔx hluəɣ]	‘bad people’
[s(t)r]	droch shròn	[trɔx hɾɔ:n]	‘bad nose’
[sp]	droch sprèidh	[trɔx spr̥ie:]	‘bad cattle’
[st]	droch stà	[trɔx sta:]	‘bad use’
[sk]	droch sgian	[trɔx skʲiən]	‘bad knife’
[sm]	droch smachd	[trɔx smaxk]	‘bad control’
[sn]	droch shneachd	[trɔx hn̥ɛxk]	‘bad snow’

TABLE 4. Lenition with Scottish Gaelic clusters. Lenition does not occur in the clusters marked in bold.

cha phòg	[xa fɔ:k]	‘will not kiss’
cha bhuail	[xa vuəɪʲ]	‘will not hit’
cha tig	[xa t̪ʲik]	‘will not come’
cha dèan	[xa t̪i:ən]	‘will not make/do’
cha chluinn	[xa xluɲ]	‘will not hear’
cha ghabh	[xa ɣav]	‘will not take’
chan fhaic	[xan eçkʲ]	‘will not see’
cha fhreagair	[xa rɪkɪɾ]	‘will not answer’
cha fhliuch	[xa ɸux]	‘will not water’
cha seas	[xa ʒes]	‘will not stand’
cha mhinich	[xa vmiç]	‘will not explain’

TABLE 5. Lenition in verbs in the negative future tense. Lenition does not occur when the verb begins with a coronal obstruent (marked in bold).

where the [n] is overt, occurs before vowel-initial verbs, including lenited forms with [f] that end up vowel-initial. Lenition also occurs in the negative past tense, marked with the particles *cha do* [xa to]. Unlike with *cha(n)* in isolation, here coronals do undergo lenition (Table 6).⁴

Certain inalienable possessive markers constitute one frequently cited simple environment for lenition on nouns: *mo* ‘my’ [mə], *do* ‘your’ [tə], and *a* ‘his’ [ə]. Examples with *mo* are given in Table 7. These same inalienable possession markers can occur with verbs to mark the direct object.

We do not treat the possessive prefixes or object markers in our analyses below. There are two reasons for this. First, the possessive prefixes are restricted to inalienable possession, thus greatly reducing the number of instances and variety of nouns we might find in corpus studies. Second, the third person is the most common object mark-

⁴ The situation with nouns is much more complex. When the definite article is present, lenition marks case, number, and gender, though not in a simple way. These categories are also marked by palatalization, vowel-quality changes, and suffixation. As noted above, we set aside the lenition patterns with the definite article.

cha do phòg	[xa to fɔk]	'did not kiss'
cha do bhuail	[xa to vuəlʲ]	'did not hit'
cha do thig	[xa to hik]	'did not come'
cha do dhèan	[xa to ʝi:ən]	'did not make/do'
cha do chluinn	[xa to xlunʲ]	'did not hear'
cha do ghabh	[xa to ɣav]	'did not take'
cha do fhaic	[xa to eɕkʲ]	'will not see'
cha do fhreagair	[xa to rɪkɪr]	'did not answer'
cha do fhliuch	[xa to ʲlʊx]	'did not water'
cha do sheas	[xa to ɕes]	'did not stand'
cha do mhinich	[xa to vɪnɪɕ]	'did not explain'

TABLE 6. Lenition in verbs in the negative past tense.

mo phàiste	[mə fa:ʃtʲə]	'my child'
mo bhean	[mə vɛn]	'my wife'
mo thuras	[mə hʊrəs]	'my journey'
mo dhùthaich	[mə ɣu:wiɕ]	'my country'
mo chridhe	[mə xɾʲiə]	'my heart'
mo ghlùin	[mə ɣlu:nʲ]	'my knee'
mo fhradharc	[mə rɾɔrk]	'my eyesight'
mo shaoghal	[mə hu:əl]	'my world'
mo mhala	[mə valə]	'my eyebrow'

TABLE 7. Lenition with the possessive marker *mo* 'my'.

ing or possessor marking in our corpora, and the third-person singular forms for masculine and feminine are identical except for their mutation effects. This makes these unusable if what we are interested in examining is, in fact, mutation effects. The problem is that, without a semantic analysis that would tell us whether the possessor is masculine or feminine, the presence or absence of mutation with these could be attributed to selecting the other possessor marker, rather than application of mutation per se.

Another simple context for lenition with nouns involves prenominal adjectives; this case turns out to be quite useful in our analyses. While adjectives generally follow the noun, there is a small class of adjectives that precede the noun, for example, *sean* 'old' [ʃawn], *droch* 'bad' [trɔx], *deagh* 'great' [tʲo:], and so forth.⁵ Table 8 gives examples of these leniting following nouns. As with *cha(n)* above, *sean* does not trigger lenition if the following noun begins with a coronal. Thus we get *sean phris* 'old price' [ʃawnfri:ʃ], but *sean duine* 'old man' [ʃawntu:nʲə], not *sean dhuine*.⁶

droch phris	[trɔx fri:ʃ]	'bad price'
sean bhalla	[ʃawn valə]	'old wall'
deagh thuathanach	[tʲo: huəhənəx]	'great farmer'
droch dhuine	[trɔx ɣu:nʲə]	'bad man'
sean chù	[ʃawn xu:]	'old dog'
deagh ghille	[tʲo: ʝilə]	'great lad'
sean fhacal	[ʃawn axkəl]	'old word (proverb)'
droch shluagh	[trɔx hluəɣ]	'bad crowd of people'
deagh mheasgadh	[tʲo: vɛskʊ]	'great mix'

TABLE 8. Lenition with prenominal adjectives.

⁵ The adjective *sean* is pronounced [ʃawn] in prenominal position and [ʃɛn] elsewhere.

⁶ The definite article *an* is also subject to this restriction. For example, before a feminine singular noun in the common case, lenition is blocked if the noun begins with a coronal stop, for example, *a' phris* [ə frʲi:ʃ] 'the price', *a' chrìoch* [ə xɾʲi:əx] 'the border', but *an traigh* [ən tʲra:ʝ] 'the beach'. As noted above, because of other complications, we set aside lenition with the article.

Summarizing, the pattern of lenition as described in grammars occurs in a fairly random set of morphosyntactic contexts with no unifying phonological conditioning environment. That said, phonology plays a role in three ways.

First, the pattern of substitution is determined by the initial consonant of the word exhibiting lenition. For example, if a nonlenited word begins with *b* [p], its lenited counterpart begins with *bh* [v], and so forth; thus the lenition relationships diagrammed in Table 3 above are consistent.

Second, certain onset clusters do not exhibit lenition, that is, the clusters *sp*, *st*, *sg*, *sm* [sp, st, sk, sm]. This set is defined phonologically as those clusters where the second element could itself display overt lenition if it occurred alone in the same environment. This was summarized in Table 4; we refer to this pattern below as the CLUSTER RESTRICTION.

Finally, the coronals *d*, *t*, *s* [t, t^h, s] do not exhibit lenition if the preceding element ends in a coronal nasal, whether overtly as in the leniting prenominal adjective *sean* ‘old’ or covertly as in the future negation *cha(n)*. This is summarized in Table 9; we refer to this below as the CORONAL RESTRICTION.

	UNLENITED	IN LENITION ENVIRONMENT
examples after [n]	t ^h	t ^h
	t	t
	s	s
	p ^h	f
	p	v
	f	∅
examples elsewhere	t ^h	h
	t	Y
	s	h
	p ^h	f
	p	v
	f	∅

TABLE 9. Coronal restriction.

3. THE EXPERIMENT. In this section, we report on the results of an experiment we conducted to test the phonological restrictions on lenition. Recall from above the two restrictions of interest:

- (i) Cluster restriction: Lenition does not occur in clusters when the second element can itself undergo orthographically overt lenition. Hence, a word beginning with *s* [s] will undergo lenition, as will a word beginning with *s/* [sl], but not a word beginning with *sp* [sp].
- (ii) Coronal restriction: A word beginning with a coronal cannot undergo lenition if the preceding item ends in an overt or covert coronal nasal, for example, in *sean* and *cha*, respectively.

To investigate these, we chose a translation task where subjects were simply asked how to say various short sentences in Scottish Gaelic. This task had a number of advantages:

- It is very convenient in that we could conduct it conversationally, with no required technology, such as headphones, button boxes, and so forth.
- It is been used before to measure Scottish Gaelic language features by Dorian (1981).
- It is fun, easy, and low-tech. We ran a number of other studies in the same session, including ultrasound and reaction-time experiments. It was therefore very useful to intersperse those tasks with tasks like ours.

Note that the point of the task was not to assess subjects’ ability to translate. Rather, our goal was to elicit subjects’ use of lenition in particular structural and lexical contexts without drawing attention to those variables directly. Our informal debriefings after the task confirmed that very few subjects had any idea that we were interested in lenition.

Scottish Gaelic is, of course, an endangered minority language, and this has consequences for the type of experiment we can run and the kind of subject population we can draw on. The most obvious limitation is that there are relatively few speakers. We were quite fortunate in being able to run as many as twenty-six participants. Another consideration is that in a minority language situation like this, fluent speakers tend to be older. We were lucky enough to get subjects as young as nineteen, but the average age of our subjects was sixty-four. Literacy in the language can also be low, with speakers literate in the dominant language, English, but not in the language of interest. This latter consideration dictated that we do the experiment orally, not in writing. Finally, subjects can be remote, living in small villages far from universities and internet access. This last factor meant that we had to do the study in person.

While the subject numbers are fairly low from the perspective of similar experiments on languages like English, they are huge from the perspective of experimental work on Scottish Gaelic. It is possible that, with more subjects, some of our results might change, that with additional statistical power, we could probe more deeply the patterns we observe.

3.1. MATERIALS. There were twenty nouns and twenty verbs used in the task. These items were selected to span a range of lexical frequencies. We were not able to include very rare items since we wanted to ensure that our subjects would be familiar with the words we were asking for. Items were categorized into five groups, according to the types of the initial consonants, as shown in Table 10.⁷ These categories were designed to tap into two questions. First, does the cluster status of a word onset affect lenition? Second, does the place of articulation of the first consonant affect lenition?

1. /p ^h , p, k ^h , k, m, f/	pòs	‘marry’	cù	‘dog’
2. /s/	seall	‘see’	sealgair	‘hunter’
3. /sl, sr, sn/	snàmh	‘swim’	sròn	‘nose’
4. /sp, st, sk, sm/	smoc	‘smoke’	sgoil	‘school’
5. /t ^h , t/	teagasg	‘teach’	duine	‘man’

TABLE 10. Types of the initial consonants and examples.

Each target word was embedded into a short phrase, with a preceding lenition trigger: *sean* ‘old’ and *droch* ‘bad’ for nouns, and *cha do* ‘did not’, *cha* ‘will not’, and *ga* ‘him’ for verbs.⁸ These triggers were selected to tap into two questions. First, does the presence of a final coronal nasal block lenition with following elements that begin with a coronal? Second, does the overt/covert status of that nasal have an effect on lenition? There were eighty sentences in total: forty with the target nouns, and forty with the target verbs. Of these, forty exhibited the coronal restriction, twenty overtly and twenty covertly. Modulo exclusions for bad coding or nonresponses, and factoring in consonant type as above, this provided for four items for each combination of factors for all subjects. All items are given in Appendix A along with the factors they instantiate.

⁷ Within each category, we had palatalized and nonpalatalized examples.
⁸ We excluded responses for the *ga* items from our analyses because we compare these results with corpus data, and *ga*, as already noted, is ambiguous between ‘him’, which triggers lenition, and ‘her’, which does not.

3.2. SUBJECTS. Subjects were recruited on the Isle of Skye via a network of friends and employees at the Gaelic College (Sabhal Mòr Ostaig). Subjects were all monolingual Scottish Gaelic speakers until at least age five, or came from strong Scottish Gaelic home settings.⁹ Subjects came from a variety of places in Scotland, though the largest representation was naturally from Skye. Figure 1 gives the basic geographic spread of our subjects. All subjects used the language to varying degrees in their current lives. We had fourteen female and twelve male participants. We had a broad range of ages, with a minimum age of nineteen years old and a maximum of seventy-five, with an average of sixty-four.

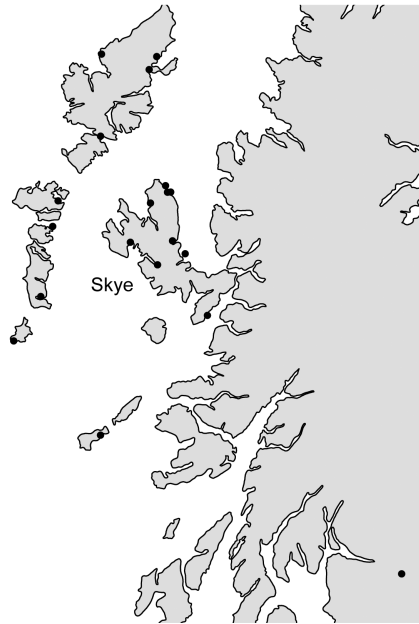


FIGURE 1. Geographic distribution of subject birthplaces in Scotland (many points represent more than one speaker).

3.3. PROCEDURE. Items were pseudo-randomized into a single order. The pseudo-randomization was to avoid close repetition of the same lexical items or structures. A single order was used to avoid potential miscoding problems in the field. Each of the twenty-six participants was asked to orally translate the eighty English sentences into Scottish Gaelic. They were asked to use Scottish Gaelic in a way that they would normally use with friends and family. Subjects were prompted to use specific words and structures if their initial translation did not contain the desired triggers and/or target words. Items were discarded if the subjects never used the relevant trigger or target, even when prompted. Items were elicited by an English-speaking experimenter with some knowledge of Scottish Gaelic. There was a break in the middle of the experiment during which subjects completed a different, unrelated task before returning to finish the experiment.

⁹ Two of our subjects grew up in balanced bilingual contexts, but were judged by our native-speaker author to be fully native in linguistic competency. The linguistic environment for Gaelic speakers is heavily bilingual and has been for the past 100 years; there are no monolingual adults.

3.4. CODING. There were five coders who recorded the responses from each participant during the task: they circled or wrote down the sounds they thought they heard. The responses were later coded as *LENITION*, *NO LENITION*, or *NONRESPONSE*. Each item for each subject received only one such coding.

Coders, of course, did not always agree. For each item, if four or more coders agreed on a particular sound, that sound was coded based on its lenition status. For each item, if fewer than four of the five coders agreed on a particular sound, that item was rechecked against the recordings. Acoustic analysis using Praat (Boersma & Weenink 2014) was conducted if the sound could not be distinguished by ear. If the sound still could not be distinguished by acoustic analysis, the response that received the majority selection was coded based on its lenition status.

3.5. ANALYSIS. Given twenty-six subjects and eighty items, there were 2,080 possible data points. There were 107 nonresponses, leaving a total of 1,973 usable data points. We have two random variables, subjects and items, so mixed-effects modeling is appropriate. Since the dependent variable, lenition status, is a binary one, the data were analyzed using mixed-effects logistic regression (Jaeger 2008).¹⁰ In all of our analyses, we follow the recommendations of Barr and colleagues (2013), using maximal design-based models with random slopes as appropriate.

We ran and report the results from eight linear mixed-effects models. Multiple tests naturally increase the possibility of an apparently significant result simply because of their number. The literature is unclear on how to deal with this. The most aggressive strategy is the traditional Bonferroni correction, where the significance level is divided by the number of tests (Keppel 1991). In our case, this would be $0.05/8$, which yields a final significance level of 0.00625. Less aggressive approaches also exist, but we report this one as the most cautious.¹¹

We ask two general questions. First, is lenition sensitive to the general distinction between leniting and nonleniting clusters? Second, does the coronal restriction limit lenition with relevant items in relevant environments?

CLUSTERS. Recall that the clusters *sp*, *st*, *sg*, *sm* [*sp*, *st*, *sk*, *sm*]—coded as *sC* (*non*) in subsequent tables—do not have lenited counterparts because the second element of the cluster can itself undergo lenition. This distinguishes these clusters from the four other onset types we coded for: noncoronals *p*, *b*, *c*, *g*, *m*, *f* [*p^h*, *p*, *k^h*, *k*, *m*, *f*]; strident coronal [*s*]; [*s*] plus coronal-sonorant clusters *sl*, *sr*, *sn* [*sl*, *sr*, *sn*]—coded as *sC* (*len*); and coronal stops *t*, *d* [*t^h*, *t*]. Indeed, this shows up very clearly in a comparison of mean rate of lenition (in non-coronal-restricted contexts), as in Figure 2.

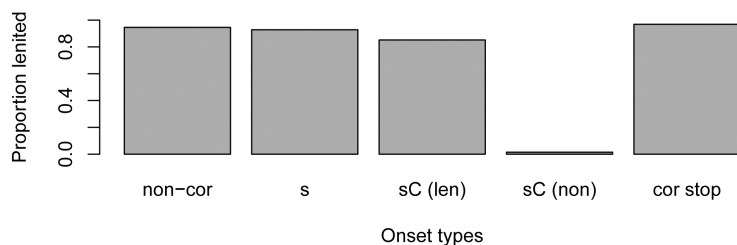


FIGURE 2. Mean rates of lenition for onset types: noncoronal onsets, [*s*], leniting *sC* clusters, nonleniting *sC* clusters, and singleton coronal stops.

¹⁰ These were performed using the R (version 1.2.3) lme4 package (version 1.1-8).

¹¹ There is also an approach that has been applied specifically to linear mixed effects: that of Hothorn et al. 2008. This procedure is applicable only when a single model can be constructed. Our factor structure is too complex and our data too sparse over that full structure to allow us to use this technique.

This distinction is significant at the 0.05 level and at the adjusted 0.00625 level, as shown in Table 11.¹² The negative coefficient in the lower left of the table reflects the fact that these *sp, st, sg, sm* [sp, st, sk, sm] clusters exhibit significantly less lenition than other onsets. Here the baseline is leniting clusters.

	COEFF. EST.	SE	Pr(> z)
INTERCEPT	4.44	0.667	0.00000
NONLENITING CLUSTERS	-12.60	3.143	0.00006

TABLE 11. Mixed-effects logistic regression results for nonleniting clusters.

Inspection of the graph in Fig. 2 suggests that *sC* clusters generally show less lenition. However, if we set aside *sp, st, sg, sm* [sp, st, sk, sm] clusters and compare the remaining *sC* clusters, *sl, sr, sn* [sl, sr, sn], to all other clusters (in non-coronal-restricted contexts), the difference is not significant at either 0.05 or 0.00625, as shown in Table 12.¹³ Here the baseline is all other clusters.

	COEFF. EST.	SE	Pr(> z)
INTERCEPT	4.545	0.652	0.00000
[sl, sr, sn] CLUSTERS	-0.993	0.968	0.30483

TABLE 12. Mixed-effects logistic regression results for *sl, sr, sn* [sl, sr, sn] clusters.

Age of subjects might be relevant here. Figure 3 shows overall mean proportion of lenition in environments not subject to the coronal restriction. There are a couple of outliers in the middle range, at least one of which may be because of dialect differences, and responses appear flat in the higher age ranges, but there is a generally lower lenition rate for younger subjects (columns get taller to the right). We plot the difference between [sl, sr, sn] and other clusters (except *sp, st, sg, sm* [sp, st, sk, sm] again) for younger speakers (< thirty-eight years old) in nonrestricted environments in Figure 4.

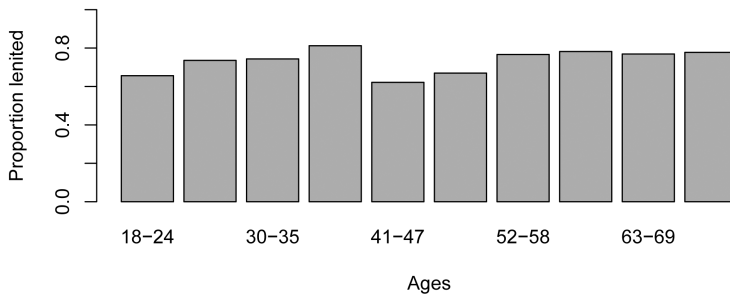


FIGURE 3. Mean rates of lenition for speakers of different ages.

An age effect here is questionable though. The only way this becomes significant is if we test the lenition rate for *sl, sr, sn* [sl, sr, sn] clusters vs. others (except *sp, st, sg, sm* [sp, st, sk, sm] clusters as above) within speakers younger than thirty-eight, to avoid the outliers and flat higher responses. This comparison exhibits a significant effect, as seen in Table 13.¹⁴ Here the baseline is all other clusters. Note that this does not pass muster at the more stringent adjusted level of 0.00625.

We conclude first that there is a general effect of cluster-type lenitability whereby lenition is blocked with the clusters *sp, st, sg, sm* [sp, st, sk, sm]. However, we have also

¹² R code: `len ~ cluster + (1|words) + (1 + cluster|subjects)`.

¹³ R code: `len ~ cluster + (1|words) + (1 + cluster|subjects)`.

¹⁴ R code: `len ~ cluster + (1|words) + (1 + cluster|subjects)`.

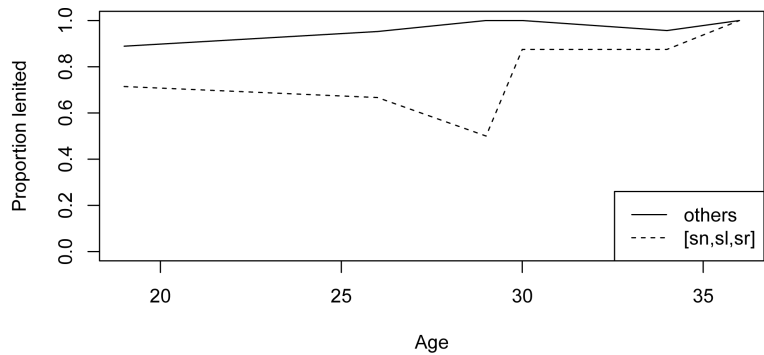


FIGURE 4. Difference in lenition in nonrestricted context for younger speakers for *sl, sr, sn* [sl, sr, sn] vs. other clusters (except *sp, st, sg, sm* [sp, st, sk, sm]).

	COEFF. EST.	SE	Pr(> z)
INTERCEPT	5.07	1.57	0.00127
[sl, sr, sn] CLUSTERS	−3.00	1.45	0.03864

TABLE 13. Mixed-effects logistic regression results for *sl, sr, sn* [sl, sr, sn] clusters for younger subjects.

seen that it is possible that younger speakers may be extending this to the clusters *sl, sr, sn* [sl, sr, sn]; those clusters for younger speakers resist lenition much as [sp, st, sk, sm] do. We return to this latter class of clusters in the next section.

CORONALS. In this section, we consider the coronal restriction on lenition, the fact that after an [n]—whether covert as in *cha(n)* or overt as in *sean*—lenition is blocked in words beginning with a coronal. Figure 5 shows the means for different onset types based on whether the trigger is subject to the coronal restriction. Notice that there is generally less lenition in the coronal restriction context. There are two surprises. First, the absence of lenition in coronal restriction environments is far from absolute. In fact, in all cases, except with nonleniting clusters, lenition in coronal restriction contexts is well above 50%. The second surprise is that the effect also seems to apply to noncoronal onsets, albeit to a lesser degree.

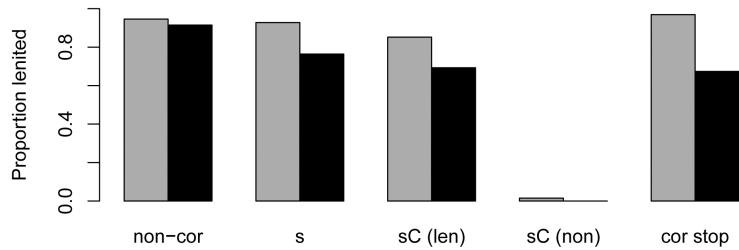


FIGURE 5. Mean rates of lenition for different onset types (noncoronal onsets, [s], leniting *sC* clusters, nonleniting *sC* clusters, and singleton coronal stops) based on whether the trigger is not subject to the coronal restriction (gray) or is (black).

When we test for significance (Table 14), we see a significant main effect of coronal restriction both at 0.05 and at 0.00625. The interaction between coronal restriction and whether the onset is coronal is significant at 0.05, but not at 0.00625.¹⁵ Here the baseline is coronal onsets in unrestricted contexts. These tell us that there is indeed a general

¹⁵ R code: `len ~ cluster * restriction + (1|words) + (1 + cluster * restriction|subjects)`.

effect of the coronal restriction and that this effect may be differential across coronals and noncoronals. That the main effect is driven by the coronals is revealed when we test for the effect of a coronal restriction just within noncoronal onsets (Table 15). It is not significant there at either level.¹⁶ Here the baseline is unrestricted contexts.

	COEFF. EST.	SE	$Pr(> z)$
INTERCEPT	3.751	0.499	0.00000
NONCORONAL	0.169	0.771	0.82648
CORONAL RESTRICTED	-2.390	0.312	0.00000
INTERACTION	1.946	0.732	0.00788

TABLE 14. Mixed-effects logistic regression results for coronal vs. noncoronal onsets by coronal restriction.

	COEFF. EST.	SE	$Pr(> z)$
INTERCEPT	3.584	0.635	0.0000
CORONAL RESTRICTED	0.046	0.694	0.9474

TABLE 15. Mixed-effects logistic regression results for coronal restriction only, with respect to noncoronal onsets.

Let us now consider how robust the effect is as a function of whether the [n] in the trigger is overt—*sean*—or covert—*cha*. Figure 6 shows the relative frequency of lenition as a function of the preceding trigger. The coronal restriction is supposed to apply to the first (*cha*) and fifth (*sean*), but seems hardly applicable to the former. Indeed, if we take *sean* out of the model, there is no longer an effect of the coronal restriction at either level, as seen in Table 16.¹⁷ Here the baseline is coronals in unrestricted environments. If we directly compare *sean* and *cha* there is a significant difference at both 0.05 and 0.00625, as seen in Table 17.¹⁸ Here the baseline is *cha*. These comparisons suggest that the overt status of the coronal nasal is a critical factor.

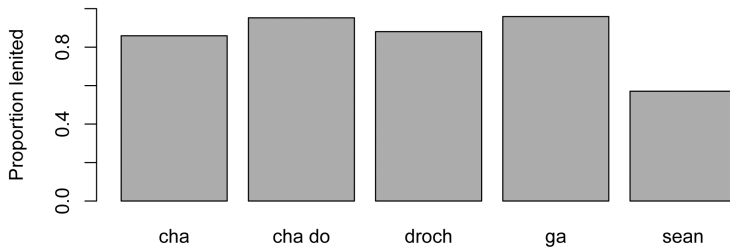


FIGURE 6. Mean rates of lenition for different triggers when the item undergoing lenition begins with a coronal.

	COEFF. EST.	SE	$Pr(> z)$
INTERCEPT	4.303	0.656	0.00000
NONCORONAL	0.139	0.988	0.88812
CORONAL RESTRICTED	-0.884	0.808	0.27419
INTERACTION	-0.905	1.238	0.46468

TABLE 16. Mixed-effects logistic regression results for coronal restriction without *sean*.

	COEFF. EST.	SE	$Pr(> z)$
INTERCEPT	4.03	1.04	0.00011
<i>sean</i>	-3.66	1.04	0.00042

TABLE 17. Mixed-effects logistic regression results for *cha* vs. *sean*.

¹⁶ R code: `len ~ restriction + (1|words) + (1 + restriction|subjects)`.

¹⁷ R code: `len ~ cluster * restriction + (1|words) + (1 + cluster * restriction|subjects)`.

¹⁸ R code: `len ~ context + (1|words) + (1 + context|subjects)`.

That said, there may be an age-related effect here as well. Figure 7 shows lenition rates for *cha* as a function of age. We see lower lenition rates with *cha* scattered among younger speakers. If we put age into the model (as a categorical variable: here ‘young’ (< fifty) vs. ‘old’ (\geq fifty)) and look only at items that begin with coronals, a trend for age and for the interaction between age and the coronal restriction is revealed (Table 18).¹⁹ The baseline here is older speakers with items in unrestricted contexts. This effect may be driven by the forty-five-year-old outlier, however; when this individual is removed, the trend goes away as well. If we use the more stringent adjusted significance level of 0.00625, it would be quite generous to call this a trend.

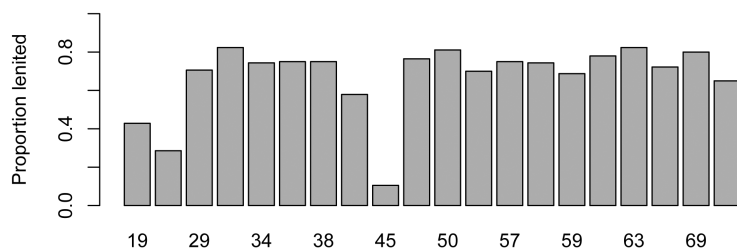


FIGURE 7. Rates of lenition with *cha* as a function of age.

	COEFF. EST.	SE	Pr(> z)
INTERCEPT	5.315	0.996	0.00000
NONCORONAL	-1.812	1.083	0.09444
CORONAL RESTRICTED	-0.186	1.053	0.85950
INTERACTION	-1.974	1.186	0.09596

TABLE 18. Mixed-effects logistic regression results for coronal restriction without *sean* and with age (coronal items only).

We conclude that there is indeed a difference between overt and covert triggers and that the coronal restriction is really only operative for overt nasals. That said, the restriction with a covert nasal may be gaining ground with younger speakers.²⁰

To summarize thus far, we have seen the following effects in our behavioral data:

- We saw in Fig. 2 that *sp*, *st*, *sg*, *sm* [sp, st, sk, sm] onsets indeed exhibit less lenition. This is significant (Table 11).
- We saw that younger speakers (under thirty-eight) also lenite significantly less with *sl*, *sr*, *sn* [sl, sr, sn] clusters (Table 13), though this is not in accord with the normative grammatical descriptions.
- We saw in Fig. 5 that (i) the coronal restriction is not categorical, and (ii) that it seems to apply to noncoronals as well. Neither of these is how this is described in the grammars. The overall effect of the coronal restriction is significant (Table 14), but the effect of the coronal restriction with only noncoronals is not (Table 15).
- In Fig. 6 we saw that the coronal restriction seems to have a far greater effect with *sean* than with *cha*. When we take *sean* out of the model, there is no longer an ef-

¹⁹ R code: `len ~ age * restriction + (1 + age|words) + (1 + restriction|subjects)`.

²⁰ It is tempting to hypothesize that this may be a function of the prescriptive rule, that the behavior of younger speakers follows from their being familiar with the grammatical rule that we are examining.

In our coding, we also noticed that some speakers pronounced *sean* as [ʃāw], rather than [ʃawn]. It is possible that the nasal deleted more in precoronal environments, but we cannot say for certain. Our coders were not consistent in noting this detail, and this is a difficult feature to extract from the audio recordings.

fect of the coronal restriction (Table 16), and if we directly compare *sean* and *cha*, there is a significant difference (Table 17). The lack of effect with *cha* is not what the grammars describe.

- By contrast, we saw in Fig. 7 that *cha* had MORE of an effect with younger speakers (under fifty). When we put age into the model as a binary factor, we see a trend for age and an interaction between age and the coronal restriction (Table 18), but this effect goes away when we exclude the forty-five-year-old subject.

Notice that the age effects we have seen are in different directions. In the coronal restriction data, the age trend is that of younger speakers being MORE in accord with the traditional grammatical pattern. The age effect we saw with *sl*, *sr*, *sn* [sl, sr, sn], by contrast, has younger speakers LESS in accord with the traditional pattern.

4. CORPUS ANALYSIS. In this section, we compare our experimental results with corpus data. We use two corpora here.

One corpus of our own making was built from news articles on the BBC Alba website.²¹ This corpus includes news stories collected covering the period from November 24, 2011, to March 10, 2014. Article URLs were obtained from the BBC Alba Twitter feed,²² and the articles themselves were then downloaded from the website. They were then processed to remove extraneous HTML and to normalize coding. The end result is a corpus of 643,808 tokens. We refer to this as the ALBA corpus.

The second corpus was based on an excerpt from the Corpus of Scottish Gaelic from the Digital Archive of Scottish Gaelic.²³ This excerpt is composed of the documents listed in Appendix B. These are all fairly old texts, dating from 1750 to 1918. After stripping out material not in Scottish Gaelic, this corpus has 2,771,612 word tokens. We refer to this as the OLD corpus.

Our assumption is that the distribution of lenition in the language varieties that these corpora embody will be accurately reflected in the spelling of lenition. As noted in §2, we have set aside those lenition patterns not reflected in the orthography. We acknowledge at the outset that the language of these corpora is quite formal compared to what we believe we elicited in the experiment.

Let us first consider the overall distribution of lenition across the different word-onset categories. When comparing with our behavioral data, we consider all of the same categories except the trigger *ga*.²⁴

Figure 8 shows the rate of lenition with all of the experimental triggers (except *ga*) for the different onset types. Compare this with Fig. 2. The rate of lenition with *sl*, *sr*, *sn* [sl, sr, sn] clusters and coronal stops in the ALBA corpus data appears to be extremely low in comparison with the behavioral data. In point of fact, however, the issue with [sl, sr, sn] is not that the rate of lenition with these clusters is low, but that these clusters simply do not occur in the relevant environments in the corpus. Absolute counts for all five onset types are given in Table 19.

As in our behavioral data, *sp*, *st*, *sg*, *sm* [sp, st, sk, sm] exhibit significantly less lenition than the other onsets: $\chi^2(1, N = 16) = 25.219, p < 0.001$. Because of the absence of

²¹ <http://www.bbc.co.uk/naidheachdan>

²² <http://www.twitter.com/bbcnaidheachdan>

²³ These materials were obtained with the very kind permission of Prof. Roibeard Ó Maolalaih, University of Glasgow.

²⁴ As already noted, there are two *ga* morphemes, one that triggers lenition (3SG.M) and one that does not (3SG.F). It would require a great deal of context to disambiguate these in corpora, so we leave them out of our corpus analyses.

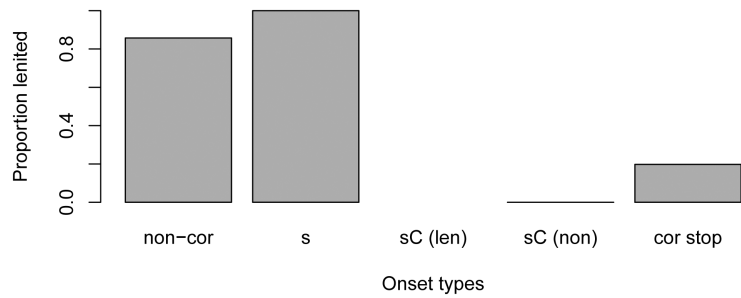


FIGURE 8. Mean rates of lenition in lenition contexts for different onset types in the ALBA corpus.

	LENITED	NOT LENITED
NONCOR	301	50
[s]	69	0
sC (LEN)	0	0
sC (NON)	0	16
COR STOP	54	219

TABLE 19. Counts for lenition rate in lenition contexts for different onset types in the ALBA corpus.

sl, sr, sn [sl, sr, sn] in the relevant environments, we cannot test whether they lenite less than other clusters that should lenite.

Interestingly, Fig. 8 also shows that coronal stops in general exhibit proportionally less lenition than singleton noncoronals or [s]. This difference is also significant: $\chi^2(1, N = 273) = 1214.848, p < 0.001$. Recall that we did not see a similar effect in our behavioral data in Fig. 2.

In our experimental data, we saw that younger subjects lenite less with *sl, sr, sn* [sl, sr, sn] clusters, which are not subject to the cluster restriction, suggesting that they are generalizing the cluster restriction to any *sC* cluster. We might therefore expect to find a parallel historical trend in our older corpus in the evolution of this pattern over time. Unfortunately, the relevant clusters are exceedingly rare in the relevant environments at all stages, as shown in Figure 9. Each point in the figure corresponds to a different document from this corpus.

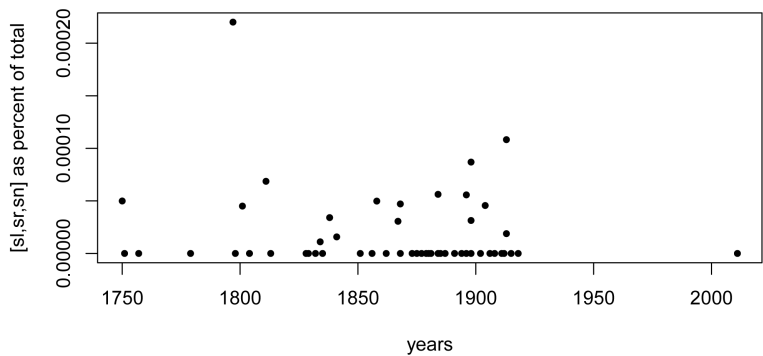


FIGURE 9. Number of occurrences of *sl, sr, sn* [sl, sr, sn] as percentage of total over time.

In our behavioral data, we saw an effect of age and overall lenition. In Fig. 3 we saw that younger speakers lenited less. If we look across the years of the corpus, we see a more complex picture in Figure 10. The data are quite noisy, and we have added a smoothed curve (Loess) to simplify the picture, but lenition seems to increase over the

years. This effect is significant: $b = 0.00152$, $t(42) = 2.63581$, $p < 0.05$, $R^2 = 0.14194$, $F(1,42) = 6.94749$, $p < 0.05$. The R^2 is fairly small, however, so a significant portion of the variation is left unaccounted for. Note that our last data point, for the ALBA corpus in its entirety, shows both a slight drop and a fairly large time break from the previous data point. More data points in this last period would be useful for ascertaining whether there is indeed a fall occurring that would correspond to what we saw in our behavioral data with younger speakers.

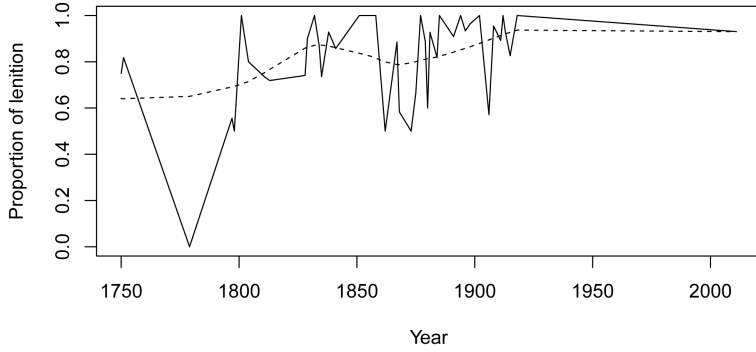


FIGURE 10. Mean rates of lenition by year in the OLD corpus when the coronal restriction does not apply (Loess curve superimposed).

We now turn to the effects of the coronal restriction. Recall that in Fig. 5 we saw that the coronal restriction significantly decreases the rate of lenition for coronals, though we observed a nonsignificant reduction in lenition in all categories. Figure 11 shows the analogous data for the ALBA corpus. The pattern is different. First, as we already saw, there are very few instances of *sl*, *sr*, *sn* [sl, sr, sn] clusters. Second, as with the behavioral data there is an apparent effect with noncoronals. Third, surprisingly, there is virtually no effect of the coronal restriction on [s] onsets. Finally, as expected, there is a huge effect of the coronal restriction on coronal stops.

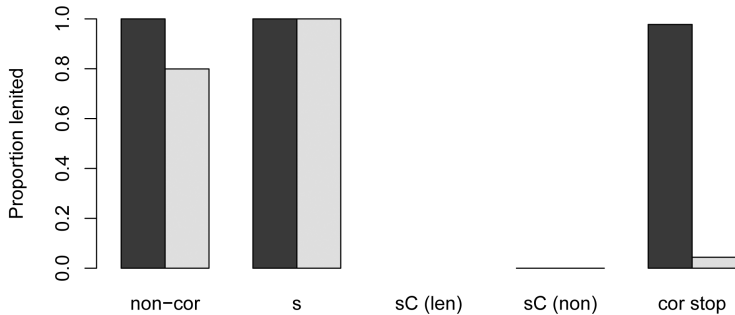


FIGURE 11. Mean rates of lenition for different onset types in the ALBA corpus based on whether the lenition trigger is not subject to the coronal restriction (black), for example, *droch*, or is (gray), for example, *sean*.

We would hope to see how the *s*-cluster facts have changed over time, but there simply are not enough examples of the *s*-clusters to make sense of, so we set them aside. Figure 12 shows the difference in relative proportion of lenition in unrestricted environments vs. coronal restriction environments for the noncoronals vs. coronal stops. Again, the data are noisy, so we have overlain smoothed curves. For the coronal stops, we see occasional dips, but generally a consistent effect of the coronal restriction. For noncoronals, we see

very bumpy data, but a significant increase in the effect of the coronal restriction: $b = 0.00149$, $t(45) = 2.46981$, $p < 0.05$, $R^2 = 0.11937$, $F(1,45) = 6.09994$, $p < 0.05$.

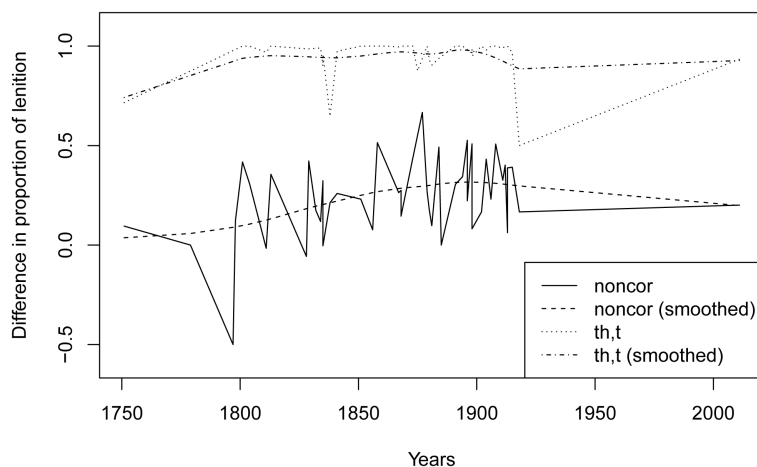


FIGURE 12. Difference in proportion of lenition for different onset types in terms of whether the environment is unrestricted or subject to the coronal restriction (Loess curves superimposed).

Finally, to the extent that there are data, we see a more categorical effect of the coronal restriction on coronals in the historical period, albeit with occasional dips. This is at odds with what we saw with our behavioral data, where we consistently saw a less-than-categorical effect of the coronal restriction. It may be that we are in another dip. Alternatively, it may be that the system is undergoing a fundamental change. Finally, this may be a function of written vs. spoken register, with the coronal restriction applying virtually categorically in the written register, but less categorically in the spoken register that our experiment tapped into.

We saw with our experimental data that the coronal restriction was essentially restricted to overt nasals, as in *sean*, rather than covert nasals, as in *cha* (Fig. 6). We plot the same percentages for the ALBA corpus in Figure 13. Remarkably, we see that lenition with coronals after *cha* is quite low. It is tempting to compare this with *sean*, but there simply are no examples of *sean* before a coronal in the corpus. The pattern with *cha* is in contrast to our behavioral data where lenition with *cha* was fairly high.

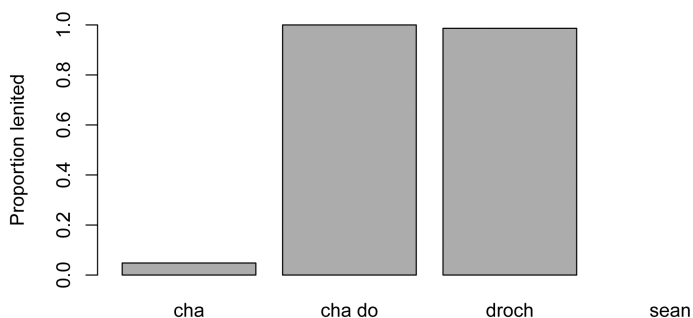


FIGURE 13. Mean rates of lenition for different triggers when the item undergoing lenition begins with a coronal in the ALBA corpus.

If we look at the rate of lenition after *cha* over the years, given in Figure 14, we see the usual variation, but no trend upward or downward: $b = -0.00008$, $t(42) = -0.17243$,

$p = 0.86393$, $R^2 = 0.00071$, $F(1,42) = 0.02973$, $p = 0.86393$. (Again, we have superimposed a Loess curve to show the general pattern.)

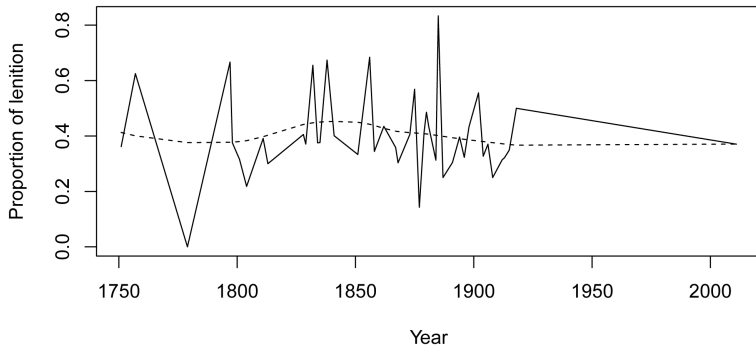


FIGURE 14. Mean rates of lenition by year in both corpora for *cha* (Loess curve superimposed).

To summarize, we have found the following in our corpus data:

1. There were generally insufficient instances of *sl*, *sr*, *sn* [sl, sr, sn] occurring in relevant contexts to make useful comparisons involving these onsets.
2. In conformity with our behavioral results, we saw that *sp*, *st*, *sg*, *sm* [sp, st, sk, sm] exhibit significantly less lenition than other onsets. (As noted just above, there are insufficient numbers of [sl, sr, sn] clusters to determine how they fare.)
3. We saw that while the coronal restriction was far from absolute in our behavioral data, it exhibited a more, though certainly not completely, categorical pattern in the corpus data.
4. In Fig. 10, we saw a general (and significant) pattern of increasing lenition, and then a drop in the ALBA corpus.
5. In Fig. 11 we saw the effects of the coronal restriction on different onset categories. As expected, *sp*, *st*, *sg*, *sm* [sp, st, sk, sm] show no effect. Surprisingly, [s] lenites virtually always and shows no effect. We see a huge effect with coronal stops and a small but steadily increasing effect with noncoronals.
6. We saw that the coronal restriction applies to *cha* in the corpora.
7. Finally, in Fig. 14, we saw that the rate of lenition for *cha* does not change in a significant way over the years in both the OLD and ALBA corpora.

5. GENERAL DISCUSSION. We saw that the *sp*, *st*, *sg*, *sm* [sp, st, sk, sm] clusters exhibited less lenition than other clusters in both the behavioral data and the corpus data. This is consistent with grammatical description. This suggests that the prohibition against leniting these is in full force in the modern language, both for spoken and written registers.

We saw in the corpus data, however, that *sl*, *sr*, *sn* [sl, sr, sn] clusters occur very infrequently in the relevant lenition contexts. In the behavioral data, we saw that younger speakers lenited less with [sl, sr, sn], which suggests that [sl, sr, sn] clusters are being treated as less lenitable, assimilating to the *sp*, *st*, *sg*, *sm* [sp, st, sk, sm] class. That [sl, sr, sn] should be assimilated to the [sp, st, sk, sm] category seems fairly natural: a restriction against leniting [s] in clusters is a simpler generalization than one that precludes lenition of [s] in only certain clusters. The cluster restriction is thus becoming more general.

In our behavioral data, we saw that the coronal restriction is not categorical and seems to extend to noncoronals. We saw similar effects in our corpus data. By contrast,

in the ALBA corpus, we saw that [s] exhibited no effect of the coronal restriction. The status of [s] thus differs between the corpus and behavioral data. We conclude that this is a register difference. In the conversational style we explicitly elicited in the experiment, [s] is treated as a coronal. In the more formal register of news reporting, [s] is treated as a noncoronal (for purposes of the coronal restriction). We have characterized this as treating [s] as a noncoronal, but a more natural way of expressing it is that the coronal restriction is becoming limited to coronal stops. In this regard, the coronal restriction is becoming less general.

In our behavioral data, we saw that while the coronal restriction is in place for *sean*, it is not significantly present for *cha*. In the corpus data, we saw a robust effect of the coronal restriction for *cha*, but insufficient tokens of *sean* to draw any conclusions about it. We saw also that the lack of effect with *cha* in our behavioral data was intertwined with age: younger speakers apply the coronal restriction with *cha* more than older speakers. Our analysis is that the covert nasal of *cha* generally does not invoke the coronal restriction in the spoken register, but, as reflected by the behavior of younger speakers, it is starting to now. In particular, younger speakers are more likely to be taught the restrictions in school, so perhaps that age effect might be due to the fact that the prescriptive rule is drilled into them. This accounts for why older speakers, who have not been schooled in the prescriptive rules, are at odds with grammatical description, younger speakers, and the corpus data.

That the covert nasal should not invoke the coronal restriction in the spoken register is quite reasonable. Presumably, in that register, the synchronic relationship between *cha* and *chan* is lost and a more transparent version of the coronal restriction is developing, one that requires the nasal to be overt. That this is being undone with younger speakers who do enforce the coronal restriction with *cha* seems to be evidence of hypercorrection, that younger speakers are being influenced by the more formal register than older speakers. We did not test our speakers for literacy in Scottish Gaelic, but it might be reasonable to suppose that younger speakers are generally more literate in Scottish Gaelic.

The upshot is that the traditional phonological restrictions are in flux, with different patterns emerging as a function of age and register. We see evidence of the restrictions becoming more general in some ways, less general in others, and more transparent for some. These developments suggest that the phonological restrictions on lenition remain an active part of the grammatical system of Scottish Gaelic and that any analysis of lenition must also account for those restrictions.

This is quite relevant for grammatical analyses of mutation. Consider, for example, Stewart (2004), who argues for separate stems corresponding to lenited and unlenited forms. A similar approach is taken by Green (2006). This kind of approach cannot capture phonological generalizations like the coronal and cluster restrictions above and must treat them instead as morphologically governed diacritic mutation classes.

This can be opposed to approaches like that of Pyatt (1997), where the assignment and form of mutation is directly governed by phonological generalizations. In her case, these fall into a category she characterizes as PHONOLOGICAL ADJUSTMENT RULES, but our general result is not that these generalizations must be formalized as rules or that they must appear in a distinct block; it is simply that they are productive and must be in the grammar somewhere.

Another hybrid approach that addresses our concern is that of Hannahs (2013). Hannahs treats mutation in Welsh by extending the theory of morphological relationships

developed by Bybee (1985, 1988). The machinery is different from what is usually used to capture phonological generalizations, but the key issue is whether it can be used to describe productive phonological relationships. Hannahs uses it in this way.

While it is certainly a fair and appropriate observation that lenition, and mutation generally in the Celtic languages, is governed by morphosyntactic generalizations, our results suggest that we need to be careful not to throw the phonological baby out with the bathwater. If we want to treat the assignment of mutation as morphosyntactic, we still need that assignment to be tempered by productive phonological generalizations like the cluster and coronal restrictions.

6. PRODUCTIVITY. Our analysis implies that the phonological constraints on lenition are productive. To examine that claim, we must ask what it means for a constraint to be productive. A very common interpretation is to say that some piece of phonology is productive if it extends to novel items. See, for example, Hayes 2009 and Albright & Hayes 2011. In our case, what this would mean is that the phonological restrictions on lenition extend to novel items—that is, that lenition is blocked in novel items when the restrictions are met, just as it is blocked in nonnovel items.

Our study was not designed to test this specific question, but coincidentally, our task included a fair number of items that are borrowed from English. This allows us to test the productivity of constraints on lenition. If the constraints are productive, we would expect them to apply to these borrowed items, just as they apply to nonborrowed items. The words that are arguably borrowed are given in Table 20.

SCOTTISH GAELIC	ENGLISH
danns	dance
sàbh	saw
sèine	chain
saighdear	soldier
sgi	ski
sgoil	school
smoc	smoke
stamp	stamp
tidsear	teacher

TABLE 20. Borrowed words among our items.

Some of these borrowings are fairly recent, and some are probably only apparent. What is important is not their true etymological status, but whether speakers construe them as borrowed. If they do, then these words constitute a test of the productivity of the phonological restrictions.

The borrowed items are not distributed evenly across all conditions, so it is not possible to test statistically whether they behave the same as nonborrowed items. For example, there are no instances of *sl*, *sr*, *sn* [sl, sr, sn] among the items, nor are there any examples of (singleton) noncoronals. That said, we can look at some of the mean rates of lenition to get a sense of the behavior of borrowed items. Means relevant to the cluster restriction are given in Table 21. Note that lenition rates are roughly comparable overall, with hugely reduced lenition for nonleniting clusters for both nonborrowed and borrowed items.

The same pattern obtains for the coronal restriction. Relevant means are given in Table 22. Notice how there are similar reductions in the rate of lenition when the coro-

	NOT BORROWED	BORROWED
NONCOR	0.95	N/A
[s]	0.94	0.90
sC (LEN)	0.85	N/A
sC (NON)	0.01	0.02
COR STOP	0.98	0.94

TABLE 21. Mean lenition rates for nonborrowed and borrowed items with respect to the cluster restriction.

	NOT BORROWED		BORROWED	
	NOT AFTER [n]	AFTER [n]	NOT AFTER [n]	AFTER [n]
NONCOR	0.95	0.91	N/A	N/A
[s]	0.94	0.79	0.90	0.71
sC (LEN)	0.85	0.69	N/A	N/A
sC (NON)	0.01	0.00	0.02	0.00
COR STOP	0.98	0.68	0.94	0.65

TABLE 22. Mean lenition rates for borrowed and nonborrowed items with respect to the coronal restriction.

nal restriction is in play for both [s] and coronal stops. The behavior of borrowed words, insofar as they can be seen as analogs to novel words, supports treating the coronal restriction and the cluster restriction as productive aspects of the grammar of Scottish Gaelic.

Another way to evaluate the productivity of the constraints is to see whether they tolerate exceptions at all in other contexts. If not, that suggests they are productive. To test this we look for potential counterexamples to the constraints anywhere in the language. Let us first consider the cluster constraint. We focus our counts on the ALBA corpus, as this is our best measure of the distribution of these patterns in the modern language. Recall that this corpus contains 643,808 words. If we use a regular expression (sh[ptg]) to look for potential violations of the cluster constraint, there are only three and they are clear borrowed words: *ashgill*, *scottishpower*, *ashton*. In these cases, the sequence *sh* is clearly being interpreted as English [ʃ], rather than Gaelic [h]. We conclude that the cluster restriction is robust and exceptionless in the modern language.

For the coronal restriction, we search for any instance of *nth*, *ndh*, or *nsh*. This returns thirty-nine hits. Most of the hits are borrowed items, but three items are not. One is the item *aindheoin* ‘reluctance’ [anʲɔ̃n], where the spelling does not reflect the pronunciation. Another is the related expression *a dh’aindeoin* ‘nevertheless’ [aʲanʲɔ̃n], where again the spelling does not reflect the pronunciation. Finally, there is the item *taisbeandh*. This appears to be a misspelling of the word *taisbeanadh* ‘show’ [taʃbənʊ]. We conclude that the coronal restriction is also robust and exceptionless in our modern corpus data.

7. CONCLUSION. In conclusion, we have presented data from behavioral and corpus investigations that bear on the phonological restrictions on lenition in Scottish Gaelic.

One restriction is that *sp*, *st*, *sg*, *sm* [sp, st, sk, sm] clusters do not undergo lenition. We have seen that this restriction is being generalized and *sl*, *sr*, *sn* [sl, sr, sn] clusters now exhibit less lenition as well.

The other restriction is that mutation triggers ending in an overt or covert coronal nasal do not trigger lenition of a following coronal. We saw several developments here. First, we saw that older speakers fail to invoke the coronal restriction after *cha*, suggesting that there is an older informal pattern whereby *cha* is not treated as ending in a coronal nasal for purposes of the coronal restriction. The second effect we saw was that the coronal restriction seems to be becoming limited to coronal stops. We also saw a nonsignificant effect whereby coronals lenite less in all environments.

The cluster restriction appears to be changing to a simpler system where any *s*-cluster resists lenition. One might take this as evidence that the phonology is precarious, but the opposite conclusion would seem more appropriate. The precise phonological condition is changing, but it is changing to ANOTHER phonological condition.

The coronal restriction seems to be subject to several points of variation. First, it shows signs of losing sensitivity to the environment and becoming a constraint against leniting coronals generally. If so, we have the same situation as with the cluster generalization: one phonological restriction is being traded in for another. The other dimension of variation is whether the coronal nasal in the trigger is overt. We have seen that some speakers do not enforce the coronal restriction when the coronal is covert, for example, with *cha*. Again, the phonological nature of the constraint is unaltered. For such speakers, the constraint is simply more transparent: the relevant nasals must be visible on the surface. Finally, we saw that for some speakers the coronal restriction is becoming limited to stops. Again, while the constraint is in flux, it seems to be shifting to another phonological constraint.

Finally, we directly assessed the productivity of the restrictions by looking at the behavior of borrowed items in our experimental data and the distribution of potential exceptions in our modern corpus data. Both analyses point to the continued productivity of the restrictions.

The important conclusion is that phonological restrictions still apply. Even though the lenition pattern is changing, it is not changing to something less phonological. Rather, it is changing to something that is phonological in a different way. Any analysis of lenition in Scottish Gaelic must therefore accommodate the fact that lenition is subject to productive phonological restrictions.

APPENDIX A: EXPERIMENTAL ITEMS

Here the relevant item is italicized and given in its normative form; that is, lenition below is based on grammatical descriptions. (Lenited forms always have *h* as the second letter.) Items are coded for each of the following:

- **Part of speech:** Is it a noun or verb?
 - **Coronal restriction:** Does it end in an overt or covert coronal nasal?
 - **Onset cluster:** Is it a lenitable onset cluster? If so, is it covertly or overtly so? The proportion of lenition responses for each item is given in parentheses.
1. They did not *swim*.—*Cha do shnàmh iad.*
(verb, overt leniting coronal cluster onset) (0.95)
 2. She wants an old *herring/salmon*.—*Tha i ag iarraidh sean sgadan.*
(noun, overt coronal-restriction, nonleniting onset cluster) (0)
 3. The bad *school* is cold.—*Tha an droch sgoil fuar.*
(noun, nonleniting onset cluster) (0)
 4. This is old *milk*.—*Tha seo sean bhainne.*
(noun, overt coronal-restriction) (0.87)
 5. He got a bad *inheritance*.—*Fhuair e droch dhileab.*
(noun, leniting coronal onset) (0.92)
 6. She did not *saw* the tree.—*Cha do shàbh i a' chraobh.*
(verb, leniting coronal onset) (0.95)
 7. She sees an old *man*.—*Tha i a' faicinn sean duine.*
(noun, overt coronal-restriction) (0.28)
 8. She has a bad *shell*.—*Tha droch shlige aice.*
(noun, overt leniting coronal cluster onset) (0.85)
 9. She didn't *pour* it.—*Cha do dhòirt i.*
(verb, leniting coronal onset) (1)
 10. The old *hunter* died.—*Mharbh an sean sealgair.*
(noun, overt coronal-restriction, leniting coronal onset) (0.65)

11. He has a bad *nose*.—Tha droch *shròn* aige/air.
(noun, covert leniting coronal cluster onset) (0.92)
12. She sees an old *barn*.—Tha i a' faicinn sean *sabhal*.
(noun, overt coronal-restriction, leniting coronal onset) (0.64)
13. He will not *swim*.—Cha *snàmh* e.
(verb, covert coronal-restriction, overt leniting coronal cluster onset) (0.96)
14. They did not *look*.—Cha do *sheall* iad.
(verb, leniting coronal onset) (0.92)
15. He has an old *shell*.—Tha sean *slige* aige.
(noun, overt coronal-restriction, overt leniting coronal cluster onset) (0.77)
16. They will not *clean* today.—Cha *ghlan* iad an-diugh.
(verb, covert coronal-restriction) (0.83)
17. This is bad *business*.—Tha seo droch *ghnothach*.
(noun) (0.73)
18. He did not *pluck* this.—Cha do *spiol* e seo.
(verb, nonleniting onset cluster) (0)
19. The tall boy will not *climb*.—Cha *sreap* am balach àrd.
(verb, covert coronal-restriction, covert leniting coronal cluster onset) (0.62)
20. She did not *feed* it.—Cha do *bhiath* i e.
(verb) (1)
21. They will not *look* at the man.—Cha *seall* iad air an duine.
(verb, covert coronal-restriction, leniting coronal onset) (0.83)
22. He did not *write*.—Cha do *sgriobh* e.
(verb, nonleniting onset cluster) (0)
23. He will not *teach*.—Cha *teagaisg* e.
(verb, covert coronal-restriction, leniting coronal onset) (0.92)
24. He likes the bad *barn*.—Is toigh leis an droch *shabhal*.
(noun, leniting coronal onset) (0.84)
25. The girl will not *pour* it.—Cha *dòirt* an nighean e.
(verb, covert coronal-restriction, leniting coronal onset) (0.92)
26. He doesn't want bad *milk*.—Chan eil e ag iarraidh droch *bhainne*.
(noun) (0.92)
27. The big man *teaches* him.—Tha an duine mòr ga *theagasg*.
(verb, leniting coronal onset) (1)
28. That is old *business*.—Tha sin sean *ghnothach*.
(noun, overt coronal-restriction) (0.81)
29. She will not *write* a letter.—Cha *sgriobh* i litir.
(verb, covert coronal-restriction, nonleniting onset cluster) (0)
30. The old *school* is nice.—Tha an sean *sgoil* snog.
(noun, overt coronal-restriction, nonleniting onset cluster) (0)
31. She did not *climb*.—Cha do *shreap* i.
(verb, covert leniting coronal cluster onset) (0.92)
32. He is a bad *hunter*.—Is e droch *shealgair*.
(noun, leniting coronal onset) (0.96)
33. He sees a bad *man*.—Tha e a' faicinn droch *dhuine*.
(noun, leniting coronal onset) (1)
34. He will not *saw* the tree.—Cha *sàbh* e a' chraobh.
(verb, covert coronal-restriction, leniting coronal onset)
35. He wants a bad *herring/salmon*.—Tha e ag iarraidh droch *sgadan*.
(noun, nonleniting onset cluster) (0)
36. She will not *pluck* that.—Cha *spiol* i sin.
(verb, covert coronal-restriction, nonleniting onset cluster) (0)
37. That's an old *inheritance*.—'S e sean *dileab* a tha sin.
(noun, overt coronal-restriction, leniting coronal onset) (0.69)
38. He will not *feed* them.—Cha *bhiath* e iad.
(verb, covert coronal-restriction) (0.95)
39. They did not *clean*.—Cha do *ghlan* iad.
(verb) (0.96)

40. He sees an old *nose*.—Tha e faicinn sean *sròn*.
(noun, overt coronal-restriction, covert leniting coronal cluster onset) (0.81)
41. She will not *dive*.—Cha dàibh i.
(verb, covert coronal-restriction, leniting coronal onset) (0.86)
42. She sees the old *dog*.—Tha i a' faicinn an sean *chù*.
(noun, overt coronal-restriction) (0.96)
43. She did not *marry*.—Cha do phòs i.
(verb) (1)
44. That's a bad *cod*.—'S e droch *thros*g a tha sin.
(noun, leniting coronal onset) (0.96)
45. The old *stamp* is good.—Tha an sean *stamp* math.
(noun, overt coronal-restriction, nonleniting onset cluster) (0)
46. They did not *stand* there.—Cha do *sheas* iad an-sin.
(verb, leniting coronal onset) (1)
47. She will not *believe* that story.—Cha *chreid* i an t-sgeulachd sin.
(verb, covert coronal-restriction, nonleniting onset cluster) (0.96)
48. The bad *teacher* is tall.—Tha an droch *thidsear* àrd.
(noun, leniting coronal onset) (0.88)
49. He will not *dirty* this.—Cha *salaich* e seo.
(verb, covert coronal-restriction, leniting coronal onset) (0.92)
50. She sees an old *thrush*.—Tha i a' faicinn sean *smeòrach*.
(noun, overt coronal-restriction, nonleniting onset cluster) (0)
51. They will not *stand*.—Cha *seas* iad.
(verb, covert coronal-restriction, leniting coronal onset) (0.92)
52. He saw a bad *thrush*.—Chunnaic e droch *smeòrach*.
(noun, nonleniting onset cluster) (0.04)
53. The old *teacher* is tall.—Tha an sean *tidsear* àrd.
(noun, overt coronal-restriction, leniting coronal onset) (0.42)
54. He tied a bad *knot*.—Cheangail e droch *shnaidhm*.
(noun, overt leniting coronal cluster onset) (0.68)
55. They did not *dirty* that.—Cha do *shalaich* iad sin.
(verb, leniting coronal onset) (1)
56. Look at the bad *chain*.—Sheall air an droch *shèine*.
(noun, leniting coronal onset) (0.77)
57. The water will not *flow*.—Cha *sruth* an uisge.
(verb, covert coronal-restriction, covert leniting coronal cluster onset) (0.67)
58. Here is the old *chain*.—Seo an sean *sèine*.
(noun, overt coronal-restriction, leniting coronal onset)
59. She will not *smoke*.—Cha *smoc* i.
(verb, covert coronal-restriction, nonleniting onset cluster) (0)
60. He sees the bad *cupboard*.—Tha e a' faicinn an droch *phreas*.
(noun) (0.96)
61. That was old *snow*.—Bha sin sean *sneachd*.
(noun, overt coronal-restriction, overt leniting coronal cluster onset) (0.35)
62. They will not *dance*.—Cha *danns* iad.
(verb, covert coronal-restriction, leniting coronal onset) (0.88)
63. He wants a bad *stamp*.—Tha e ag iarraidh droch *stamp*.
(noun, nonleniting onset cluster) (0.077)
64. She talks with an old *soldier*.—Tha i a bruidhinn le sean *saighdear*.
(noun, overt coronal-restriction, leniting coronal onset) (0.69)
65. She did not *smoke* a cigarette.—Cha do *smoc* i toiteag.
(verb, nonleniting onset cluster) (0)
66. He is a bad *soldier*.—Is e droch *shaighdear*.
(noun, leniting coronal onset) (0.96)
67. He did not *believe*.—Cha do *chreid* e.
(verb) (1)
68. Give me an old *cod*.—Thoir dhomh sean *tros*g.
(noun, overt coronal-restriction, leniting coronal onset) (0.48)

69. She did not *dance*.—Cha do *dhanns* i.
(verb, leniting coronal onset) (1)
70. They will not *ski*.—Cha *sgì* iad.
(verb, covert coronal-restriction, nonleniting onset cluster) (0)
71. This is bad *snow*.—Is sin droch *shneachd*.
(noun, overt leniting coronal cluster onset) (0.81)
72. The water did not *flow*.—Cha do *shruth* an uisge.
(verb, covert leniting coronal cluster onset) (0.78)
73. She *pulls* him.—Tha i ga *shlaodadh*.
(verb, overt leniting coronal cluster onset) (0.91)
74. He will not *marry*.—Cha *phòs* e.
(verb, covert coronal-restriction) (1)
75. He did not *dive*.—Cha do *dhàibh* e.
(verb, leniting coronal onset) (1)
76. Look at the old *knot*.—Sheall air an t-sean *snaidhm*.
(noun, overt coronal-restriction, overt leniting coronal cluster onset) (0.48)
77. He sees the bad *dog*.—Tha e a' faicinn an droch *chù*.
(noun) (1)
78. He will not *pull* the car.—Cha *slaod* e an car.
(verb, covert coronal-restriction, overt leniting coronal cluster onset) (0.92)
79. He did not *ski*.—Cha do *sgì* e.
(noun, nonleniting onset cluster) (0)
80. He sees the old *cupboard*.—Tha e a' faicinn an sean *phreas*.
(noun, overt coronal-restriction) (0.92)

APPENDIX B: EXCERPT FROM THE CORPUS OF SCOTTISH GAELIC

- #64: Dùn-Àluinn, 1912; 51,986 words
- #65: Gosg Gaidhlig, 1915; 85,264 words, prose
- #68: An t-Ogha Mor, 1913; 56,323 words
- #69: Aig Tigh na Beinne, 1911; 77,442 words
- #70: Oiteagan O'n Iar, 1908; 33,071 words
- #71: Dain agus Orain, 1918; 6,627 words, poems and songs
- #72: Lochran an Anma, 1906; 22,436 words
- #75: Saor Mharsantachd; 1,982 words
- #76: Na Baird Leathanach, 1898; 43,182 words, poetry
- #77: Leabhar na Ceilidh, 1898; 65,909 words, stories and poetry
- #78: Leabhar nan Gleann, 1898; 71,116 words, fiction and nonfiction
- #79: An t-Urramach Iain Mac-Rath, 1894; 20,051 words
- #80a: Dain Iain Ghobha vol. 1, 1896; 49,214 words, poetry
- #80b: Dain Iain Ghobha vol. 2, 1896; 49,214 words, poetry
- #82: Dan Spioradail, 1885; 50,584 words
- #83: Dain agus Orain Ghaidhlig, 1891; 2,639 words, poems and songs
- #86: Marbh-rainn air daoine urramach diadhaidh, 1887; 3,085 words
- #89: Croft Cultivation, 1885; 3,263 words, nonfiction
- #90: Poems, 1884; 19,168 words, poetry
- #92: Gaelic Proverbs, 1881; 140,954 words, proverbs
- #93: Laithean Ceisde, 1880; 16,800 words
- #94: Poems and Songs, 1880; 34,042 words, poetry
- #95: An t-Oranaiche, 1879; 106,023 words, songs
- #97: Ordo Missæ; 8,157 words
- #98: Orain ann sa Ghailig, 1875; 7,592 words, songs
- #99: Gaelic Songs, 1880; 10,090 words, songs
- #100: Am Filidh Gaidhealach or the Highland Minstrel, 1873; 22,251 words, songs
- #104: An Duainaire, 1868; 31,366 words, songs and poems
- #105: Gaelic Hymns, 1868; 26,439 words, hymns
- #108: Caraid nan Gaidheal, 1867; 243,479 words
- #109: Spiritual Songs in Gaelic & English, 1862; 25,906 words, songs
- #113: Gaelic Astronomy, 1856(?); 28,813 words, nonfiction

- #115: Orain, 1851; 10,272 words
- #118: Marbhrainn; 49,257 words
- #119: Laoidhean Spioradail, 1857; 3,336 words
- #121: Eachdraidh a' Phrionnsa, 1854; 76,883 words
- #125: Sar-obair nam Bard Gaelach or the Beauties of Gaelic Poetry, 1841; 219,007 words, poetry
- #128: An Teachdaire Ùr Gàidhealach, 1835; 129,772 words
- #129: An Cath Spioradail, 1835; 53,608 words
- #130: Leabhar nan Cnoc, 1834; 98,827 words
- #131: Daoine air an Comhairleachadh an Aghaidh bhi Deanamh Croin Orra Fein-Searmoin, 1832; 17,865 words
- #135: Co'Chruinneachadh, 1828; 87,937 words
- #140: Laoidhean Bean Torra Dhamh, 1902; 5,737 words, hymns
- #141: Comhchruinneacha do dh'Orain Taghta, 1813; 69,148 words
- #143: Orain Nuadh Ghaeleach, 1811; 38,434 words
- #145: Searmona, 1804; 80,475 words
- #146: Orain Ghaelach, 1801; 29,113 words
- #149: A New Gaelic Song Book, 1798; 14,253 words, songs
- #166: Leabhar Ceasnuighe Aithleasughte, 1779; 15,544 words
- #167: Orain le Rob Donn (Songs and Poems in the Gaelic Language); 72,136 words, songs and poems
- #169: An Saighdear Criosduidh, 1797; 9,606 words
- #172: Spiritual Songs of Dugald Buchanan, 1913; 30,582 words, songs
- #179: Gairm an De Mhoir; 66,800 words
- #181: Metrical Reliques, 1851; 65,551 words, poetry
- #194: Regimen Sanitatis, 1911; 35,923 words, nonfiction
- #196: Hints for the Use of Highland Tenants, 1838; 60,048 words, nonfiction
- #199: Am Fear-Ciuil, 1904; 49,244 words, stories, poems, songs

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