

# Temporal Coordination and Markedness in Moenat Ladin Consonant Clusters

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## 1 Introduction

In this paper we examine the phonotactics of word-initial consonant clusters in Moenat Ladin, both in terms of their phonological markedness and temporal coordination. Word-initial clusters in Moenat Ladin include sibilant-stop, stop-/l/, stop-/r/, and sibilant-stop-/r/. Nevertheless, word-initial sibilant-stop-/l/ clusters are almost entirely unattested. In this work, we probe this issue both experimentally and formally. We hypothesize that the rarity of sibilant-stop-/l/ sequences owes to a cumulative markedness effect that arises from the combination of two kinds of marked structures, involving sibilant-stop and stop-/l/ sequences. Word-initial stop-/l/ sequences have been identified as plausibly more marked than stop-/r/ sequences (Baertsch & Davis 2009). Our investigation centers chiefly on the status of word-initial sibilant-stop sequences in Moenat Ladin, for which we hypothesize that the sibilant is organized external to a syllable onset that begins with the stop. Our hypothesis is probed with an experiment that investigates the temporal coordination of segments, which bears on the organization of elements in syllable structure. In this experiment, we employ a methodology recently developed by Ruthan et al. (2019) and Durvasula et al. (2021) that uses acoustic production data to examine temporal coordination.

We propose a formal account of permissible and non-permissible clusters in Moenat Ladin in the framework of Harmonic Grammar (Legendre et al. 1990, Pater 2009) such that sibilant-stop-/l/ clusters exceed a threshold in contrast to sibilant-stop-/r/ and two-consonant clusters. In this account we employ a null parse model of phonotactics (Albright 2008, 2012, Breiss & Albright 2022) in which a phonotactically non-permissible cluster is modeled as the selection of the null parse, an ineffable form. This account enables the absence of words with word-initial sibilant-stop-/l/ sequences to be derived from the interaction of basic markedness constraints that apply to the components of these sequences.

This paper is organized as follows. In section 2, we outline the relevant word-initial clusters in Moenat Ladin and provide background on their respective markedness. In section 3, we describe the design of our experiment investigating temporal coordination in clusters. In section 4, we discuss the data analysis, and in section 5 we report and discuss the results. In section 6, we present our formal analysis in Harmonic Grammar, and section 7 contains the conclusion.

## 2 Moenat Ladin Clusters

Ladin is a threatened and understudied minority Romance language spoken in the Italian Central-Eastern Alps. Moenat is a variety of Val di Fassa Ladin spoken in the village of Moena in the Trentino province. (Yang et al. 2021). Our focus is on word-initial consonant clusters of Moenat. The data and descriptive generalizations are based on our fieldwork on Moenat phonotactics (Walker & Yang in preparation) with foundation from previous documentation by Heilmann (1955) and two dictionaries, *PODLM (Prontuarie ortografich del ladin moenat dal vocabolario ladino moenese - italiano di Giuseppe Dell'Antonio (1972) 2015)* and *DILF (Dizionario italiano-ladino fassano / Dizionèr talian-ladin fascian 2013)*.

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The consonant clusters with which we are concerned in this study involve sibilants (S), plosive stops (C), and liquids (/l/, /r/). In particular, Moenat clusters include sibilant-stop (SC) sequences (1a), stop-/l/ (Cl) sequences (1b), stop-/r/ (Cr) sequences (1c), and sibilant-stop-/r/ (SCr) sequences (1d).<sup>1</sup> Preconsonantal sibilants in Moenat tend to be post-alveolar and agree in voicing with the following consonant. We represent the post-alveolar sibilants as retroflex, although there is some variation as to whether speakers produce them as retroflex or non-retroflex.

(1) Word-initial consonant clusters in Moenat

a. SC		b. Cl	
[ <u>spu</u> 'dar]	'to spit'	[ 'p <u>l</u> ɔta]	'plate'
[ 'z <u>b</u> iɔfa]	'foam'	[ <u>b</u> lɔk]	'block'
[ <u>s</u> tɪŋf]	'sock'	[ 'k <u>l</u> ampera]	'clip for tree logs'
[ <u>sk</u> als]	'drawer'	[ <u>q</u> lɔ' rjet]	'kiosk, stand'
[ <u>z</u> qo'lar]	'to fly'		
c. Cr		d. SCr	
[ <u>p</u> ra]	'meadow'	[ <u>s</u> prigo'lar]	'to frighten'
[ <u>b</u> ratʂ]	'arm'	[ <u>z</u> bri'on]	'scratch'
[ <u>t</u> ro'ar]	'to throw'	[ <u>s</u> tro'zet]	'sled (for children)'
[ <u>d</u> rɛ]	'sieve (for grains)'	[ 'z <u>d</u> ravia]	'heavy sudden rain'
[ 'k <u>r</u> aʂpe]	'snow shoes'	[ 's <u>k</u> rɪver]	'to write'
[ <u>q</u> rɔs]	'big'	[ <u>z</u> qrizo'lon]	'shiver'

Despite clusters of the kinds shown in (1) being well formed, word-initial sibilant-stop-/l/ (SCl) sequences are exceedingly rare in Moenat. We hypothesize that the rarity of SCl sequences is related to their combination of two types of marked sequences, SC and Cl, which give rise to a cumulative markedness effect.

We further hypothesize that the markedness of SC clusters is connected to their syllabification. Evidence from phonological and phonetic studies of Italian, which is closely related to Ladin, supports an analysis in which a word-initial sibilant in an SC cluster is external to a syllable onset beginning with a plosive stop (Chierchia 1986, Davis 1990, Hermes et al. 2013). A similar scenario is potentially expected for Moenat, and a structure in which a sibilant is not parsed into a syllable is plausibly marked.

On the markedness of Cl clusters, Baertsch & Davis (2009) have interpreted /l/ as more marked than /r/ in the second position of a syllable onset. In support of this claim, they point to a sound change in which laterals in the second position of an onset cluster of Latin underwent rhotacization in Campidanese, a dialect of Sardinian (Romance, Italy), as illustrated in (2a) (Frigeni 2009: 160 based on Viridis 1978). Rhotics in this context remained (2b), as did laterals in a singleton onset (2c) (Baertsch & Davis 2009: 308).

(2)	Latin	Campidanese	
a.	PLUS	[prus]	'more'
	PLENU	[prenu]	'full'
	CLAMARE	[kramai]	'to call'
b.	PRIMU	[primu]	'first'
	CRAS	[krazi]	'tomorrow'
c.	LONGUS	[lonqu]	'long M.SG'

Also relevant is a diachronic sound change in Italo-Romance that caused lenition of /l/ to /j/ following an obstruent (Maiden 1995, Krämer 2009). This pattern was manifested in varieties of Val di Fassa Ladin in the 19<sup>th</sup> century (Salvi 2016), but words beginning with Cl clusters are nevertheless represented in the lexicon of these varieties in the present day.

<sup>1</sup> This list does not exhaust all the word-initial consonant clusters that are possible in Moenat, but it represents those that are relevant to our investigation. Within clusters of types in (1), /t/ and /d/ are systematically excluded and we did not find any examples of [zd] in word-initial position, except in the sequence [zdr]; however, [zd] may occur intervocally.

If SC and Cl clusters are indeed marked as outlined above, their combination could produce a greater degree of markedness than SC, Cl, Cr, and SCr clusters alone. We note that the rarity of SCl sequences appears to be a static effect in the lexicon. We did not find evidence of synchronic alternations that repair word-initial SCl clusters, such as consonant deletion or vowel insertion.<sup>2</sup> This points to the possibility of a formal account in which a markedness threshold is enforced over the lexicon (e.g. Albright 2008, 2012) to exclude SCl sequences while allowing the other clusters. Before pursuing this approach, we investigate a key prediction about the realization of SC clusters, namely, if word-initial SC clusters in Moenat are structured with an onset-external sibilant, it should be evinced in their temporal coordination. Accordingly, the experiment reported in the next section examines temporal coordination in SC clusters alongside that of SCr and Cl to shed light on the syllabification of word-initial clusters in Moenat.

### 3 Experiment

Whether a prevocalic consonant sequence is a complex onset can be diagnosed by the presence or absence of a C-centering pattern in their temporal organization. Browman & Goldstein (1988, 2000) found that English onset clusters exhibit a *C-centering effect*. In this pattern, the mean of the midpoints of the consonantal gestures, which forms the C-center of the cluster, is temporally aligned with a following anchor, such as the end of the following vowel. In Figure 1a, for instance, if [sp] is a complex onset, the duration between the mean of the temporal midpoints of the consonantal gestures and the end of the vowel gesture is the most stable, which causes a systematic rightward shift of the [p] in [sp] in comparison with a singleton prevocalic [p] to ensure C-center-based alignment. This effect has been observed in a range of languages including Moroccan Arabic (Shaw et al. 2009, 2011), American English (Marin & Pouplier 2010), Georgian (Goldstein et al. 2007), and Italian (Hermes et al. 2013), among others. In Figure 1b, however, when a language disallows a cluster from forming a complex onset, it shows a *right-edge effect* in which the right-edge-to-anchor duration is the most stable. In this scenario, the first consonant in a cluster is external to the syllable onset, and the duration from the center of the rightmost consonant in [sp] to the anchor will most stably resemble the duration from center of singleton [p]. With regard to Moenat, we hypothesize that word-initial SC clusters are structured with an onset-external sibilant, which is consistent with the right-edge-to-anchor stability pattern in Figure 1b.

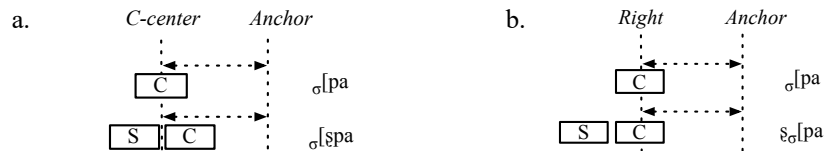


Figure 1. (a) C-center-to-anchor stability pattern and (b) right-edge-to-anchor stability pattern.

Previous studies have primarily used articulatory data to investigate the temporal organization of consonants in syllables. In this study, we use a production experiment with acoustic data instead, since they are more amenable to being acquired in a fieldwork setting. This experiment is the first study of temporal coordination in Ladin clusters. In general, we follow the methodology developed in Ruthan et al. (2019) and Durvasula et al. (2021). These studies support the utility of acoustic techniques in the investigation of the temporal organization of onsets. More details about data analysis and measurements will be introduced in Section 4.

**3.1 Participants** Five native speakers of Moenat were recruited in the experiment. In this paper we report on the data for four of the participants (labeled as S1, S2, S3, and S4, respectively). Analysis of data for the fifth speaker is still in progress. The speakers were in their 20s or early 30s at the time of the

<sup>2</sup> A possible strategy to investigate this issue would be to probe how speakers produce loanwords with initial SCl clusters. However, an interfering factor is that the Ladin-speaking community is proficient in multiple languages, and borrowings are frequently employed without significant adaptation. For example, our primary consultant did not have difficulty producing such forms without adaptation but identified them as borrowings. Whether such words are categorized in a non-native stratum of the lexicon would require further investigation.

experiment. They speak Moenat at home but learned “Standard Ladin” at school, a standardized variety based on another variety of Val di Fassa Ladin. All of the participants are Ladin-Italian bilingual while two of them (S2 and S3) also have good English proficiency.

**3.2 Materials** The materials were prepared by the authors in consultation with a native speaker of Moenat. We designed (near-)minimal sets of target words where each set contains four words (real or nonce) with different onset patterns. The /r/ series sets ( $n = 5$ ), (near-)minimally differ in the word-initial clusters  $Cr \sim C \sim SC \sim SCr$ ,<sup>3</sup> while the /l/ series sets ( $n = 6$ ), (near-)minimally differ in the word-initial clusters  $l \sim Cl \sim C \sim SC$ . To ensure a natural production of clusters, we identified as many real words as possible for Cr, SC, SCr, and Cl clusters. All the nonce words were made to resemble a feminine noun or a conjugated verb, which can be embedded into the frame sentence “*dimo la \_\_\_ Maria!*” (‘say the \_\_\_ Maria!’) or “*dimo ela la \_\_\_ Maria!*” (‘say she \_\_\_ Maria!’). A clitic element (*la* or *ela la*) was included before the target word to reduce the likelihood of a pause between the beginning of the target word and its preceding vowel. The target words are listed in (3); nonce words are underlined. See the appendix for more details.

(3) Target words in the experiment

a. *r-series* ( $Cr \sim C \sim SC \sim SCr$ )

- i. [ˈbrama] ~ [ˈbama] ~ [ˈzbama] ~ [ˈzbrama]
- ii. [ˈprita] ~ [ˈpita] ~ [ˈspita] ~ [ˈsprita]
- iii. [ˈbrata] ~ [ˈbata] ~ [ˈzbata] ~ [ˈzbrata]
- iv. [ˈbrɔtʃa] ~ [ˈbotʃa] ~ [ˈzbotʃa] ~ [ˈzbrɔtʃa]
- v. [ˈbrɔsa] ~ [ˈbɔsa] ~ [ˈzbɔsa] ~ [ˈzbrɔsa]

b. *l-series* ( $l \sim Cl \sim C \sim SC$ )

- i. [ˈlaqa] ~ [ˈblaqa] ~ [ˈbaqa] ~ [ˈzbaqa]
- ii. [ˈlota] ~ [ˈplota] ~ [ˈpota] ~ [ˈspota]
- iii. [ˈlosa] ~ [ˈklosa] ~ [ˈkosa] ~ [ˈskosa]
- iv. [ˈlasa] ~ [ˈglasa] ~ [ˈgasa] ~ [ˈzgasa]
- v. [ˈlata] ~ [ˈblata] ~ [ˈbata] ~ [ˈzbata]
- vi. [ˈlaka] ~ [ˈplaka] ~ [ˈpaka] ~ [ˈspaka]

**3.3 Procedure** The data were acquired in Moena in 2019. The complete list contained 528 randomized sentences (12 repetitions  $\times$  44 target words, embedded in one of the carrier sentences above). The recordings were made onto a laptop computer using a head-mounted Logitech microphone and Praat software (Boersma & Weenink 1992–2022) at a sampling rate of 44,100 Hz.

## 4 Data Analysis

**4.1 Annotation** The audio files were segmented and annotated by trained research assistants. Annotation and segmentation were done with reference to both the spectrogram and waveform, following a set of rubrics. Any tokens that posed difficulty for the research assistants were further examined and annotated by the authors. A total of 43 tokens were excluded due to problems with segmentation, disfluencies in production, or error in pronunciation, yielding 2069 tokens for data analysis.

While the experiments of Durvasula et al. (2021) investigated sibilants and nasals, the current study examines sibilants, plosive stops and liquids. The latter two segment types warrant careful consideration during segmentation. We made use of various acoustic cues to determine the starting and ending points of segments. For vowel segmentation, the same criteria as those in Durvasula et al. (2021:180) were adopted, namely, the appearance and disappearance of strong formant structure and periodic energy in the waveform. For stops, the onset and offset were marked mainly based on formant structure and periodicity of the preceding and following vowel or sonorant (or the offset of high-frequency noise in a sibilant, as in SC(r) words). For rhotic trills, the starting point was determined by the appearance of formant structure associated with the rhotic, as well as an associated change in the waveform. The end of the rhotic was marked at the beginning of formant structure associated with the following vowel. For laterals, the onset was marked based on the appearance of formant structure associated with the lateral, as well as an associated change in the waveform, while the offset was marked at the beginning of formant structure for the following vowel. Finally, the onset and offset of sibilants were mainly identified by the appearance and disappearance of a noisy, high frequency spectrum, assisted by formants of surrounding vowels and reference to waveforms. Two annotated examples are given in Figure 2 (only the first syllable in the target words was annotated).

<sup>3</sup> We also collected data on the comparison of  $r \sim Cr$  but we do not report on it here in the interest of focus.

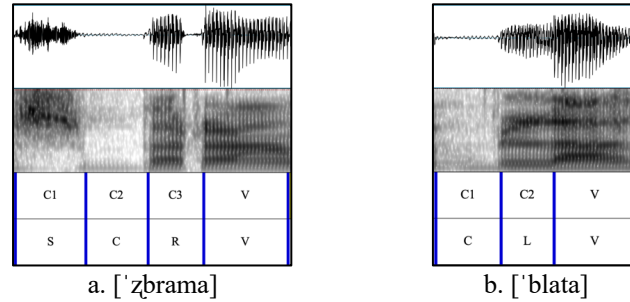


Figure 2. Examples of annotation: (a) for an SCr sequence and (b) for a Cl sequence

**4.2 Measurements** The time points were extracted from the annotated TextGrids with the package *rPraat* (Bořil 2016) in R (R Core Team 2020). The relevant acoustic landmarks in the analysis include the temporal midpoint of each consonant and the end of the following vowel which is referred to as the *anchor*. The C-center of a consonant cluster is calculated by averaging the midpoints of the consonants in the cluster, while the right edge of the cluster is the midpoint of the rightmost consonant. We calculated the duration of two intervals in this analysis, i.e., C-center-to-anchor interval and right-edge-to-anchor interval, illustrated in Figure 3. Note that these intervals are identical in a word with a singleton onset, both being from the center of the single consonant to the anchor.

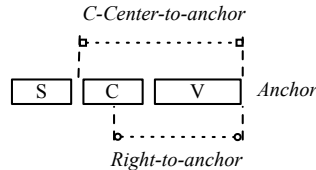


Figure 3. C-center-to-anchor interval and right-edge-to-anchor interval

Based on the measurements, we made three target comparisons for (near-)minimal word pairs with the following types of word-initial consonants: C ~ SC, Cr ~ SCr, and l ~ Cl. For the comparisons that involve singleton ~ two-consonant clusters, if the C-center-to-anchor interval for both types of words in a target pair is the least variable (or has greater stability), that would suggest that the consonant cluster exhibits a C-center effect and can be viewed as a complex onset. If instead the right-edge-to-anchor interval of both types of words in a target pair is least variable, the initial consonant in the prevocalic cluster can be treated as onset-external. In the comparison Cr ~ SCr, where there is a three-consonant cluster, the Cr sequence can be treated as a unit. This point will be elaborated in the following paragraph.

Among the comparisons, C ~ SC and Cr ~ SCr are designed to determine if a word-initial sibilant is external to the onset, while the pair l ~ Cl helps evaluate the status of a stop and lateral liquid in a prevocalic cluster. For Cr ~ SCr pairs, we treated Cr as a unit, similar to a single segment, for which the midpoint was calculated as the C-center of Cr. We then compared the C-center-to-anchor interval of Cr words (Figure 4a) with two C-center-to-anchor intervals for SCr (Figure 4b-c). One interval is from the C-center of all three consonants in  $S_1C_2r_3$  (Figure 4b), while the other is from the C-center of  $C_2r_3$  in  $S_1C_2r_3$  (Figure 4c). The alignment in Figure 4b is what is expected if the sibilant forms the beginning of an SCr onset, while that shown in Figure 4c is what is expected if the sibilant is external to a Cr onset. If a word-initial sibilant is onset-external in an SCr sequence, there should be less variation in the latter comparison, namely, between the C-center-to-anchor of Cr (Figure 4a) and the  $C_2r_3$  C-center-to-anchor of  $S_1C_2r_3$  (Figure 4c).

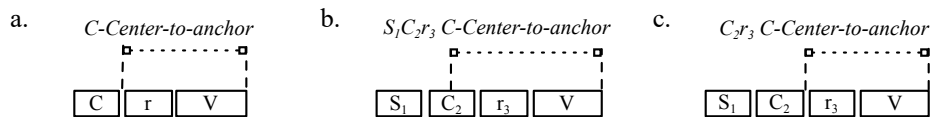


Figure 4. Comparisons between Cr and SCr words

To evaluate which interval has less variance, we calculated the Relativized Standard Deviation (RSD) of the C-center-to-anchor duration and the right-edge-to-anchor duration for each target pair, using the formula in (4) (e.g. for ['paka] ~ ['ʃpaka], the RSD of this pair was calculated with 12 repetitions across 4 speakers).

(4)

$$\text{RSD} = \frac{100 \times \text{standard deviation}}{\text{mean}}$$

The utility of RSD in the study of temporal coordination has been supported by various authors (e.g. Shaw et al. 2009, 2011, Ruthan et al. 2019, Durvasula et al. 2021). This method gives an unbiased measure for a set of durations in comparison with an uncorrected measure such as standard deviation or variance, since longer durations (C-center-to-anchor compared to right-edge-to-anchor) inherently have larger variance. Therefore, an interval with a smaller RSD suggests less difference and greater stability, which relates to a pattern of temporal coordination. Readers are referred to Durvasula et al. (2021) for more detailed rationale of this method.

## 5 Results and Discussion

We first present the results of word-initial C ~ SC and Cr ~ SCr comparisons, followed by l ~ Cl. All the plots and analyses were performed in R (R Core Team 2020).

Figure 5 shows the comparison of durations between SC words and words with a singleton stop onset. The results are pooled across sets and speakers. We observe that the right-edge-to-anchor interval is more stable for word-initial singleton consonants and clusters than the C-center-to-anchor interval. In addition, the RSD values of the right-edge-to-anchor interval are smaller, which indicates greater stability in comparison to the C-center-to-anchor interval, as shown in Figure 6. The results suggest an onset-external status for a word-initial sibilant in an SC cluster in Moenat.

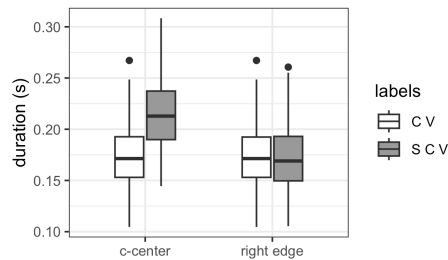


Figure 5. Durations for the C-center-to-anchor interval and right-edge-to-anchor interval for C ~ SC comparison

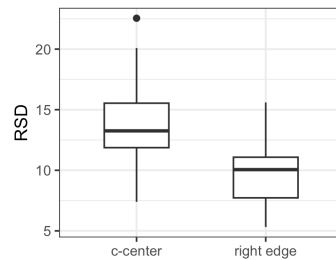


Figure 6. Overall RSDs for each interval

We further examined the words starting with SCr to investigate whether this cluster is also structured with an onset-external sibilant. The experiments of Durvasula et al. (2021) did not examine three-consonant clusters. For our analysis, we modified their general approach and treated Cr in the Cr ~ SCr comparison as a single unit in this scenario, as illustrated in Figure 4. Similar to our findings for SC clusters, Figure 7 suggests that a C<sub>2</sub>r<sub>3</sub> C-center-to-anchor interval (labeled as <S>Cr) is more stable in comparison to the C-center of a word-initial Cr sequence than the interval from the C-center of SCr in comparison to word-initial Cr. Additionally, the former interval also shows smaller RSD values in Figure 8. Thus, this comparison further supports an onset-external status for word-initial sibilants in Moenat.

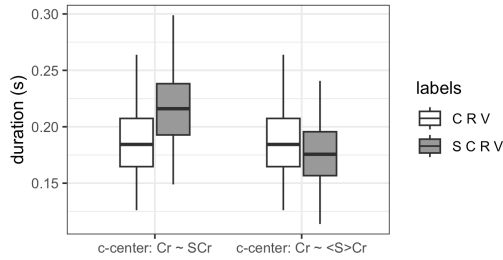


Figure 7. Durations for the C-center-to-anchor interval of Cr, S<sub>1</sub>C<sub>2</sub>r<sub>3</sub>, and C<sub>2</sub>r<sub>3</sub> (labeled as <S>Cr)

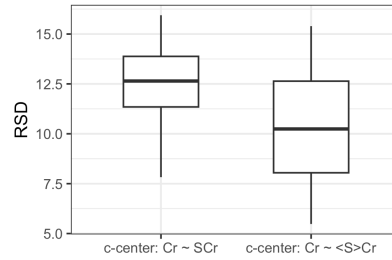


Figure 8. Overall RSDs for each interval: the C-center-to-anchor intervals for Cr ~ S<sub>1</sub>C<sub>2</sub>r<sub>3</sub>, and Cr ~ C<sub>2</sub>r<sub>3</sub>

The results for word-initial CI clusters show variation between speakers. After inspecting the results of each participant, we observed that the productions of S1 and S2 have a more stable right-edge-to-anchor interval. The raw durations of the right-edge-to-anchor interval are the least variable, as shown in Figure 9, and the RSDs of this interval are smaller, as shown in Figure 10. Nevertheless, Figure 11 and Figure 12 suggest that S3 and S4 demonstrate a C-center effect for CI clusters. This is more obvious in Figure 12, where the RSDs of the C-center-to-anchor interval are smaller. These results indicate a greater stability of the C-center-to-anchor interval for these speakers.

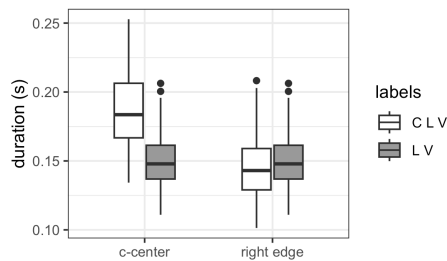


Figure 9. Durations for the C-center-to-anchor interval and right-edge-to-anchor interval for l ~ CI comparison (S1 and S2)

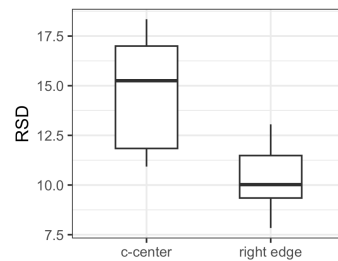


Figure 10. Overall RSDs for each interval (S1 and S2)

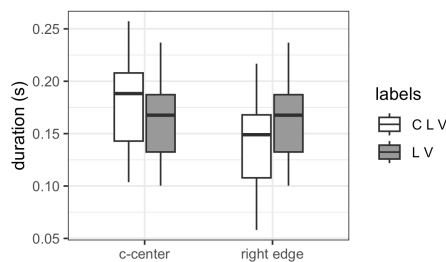


Figure 11. Durations for the C-center-to-anchor interval and right-edge-to-anchor interval for l ~ CI comparison (S3 and S4)

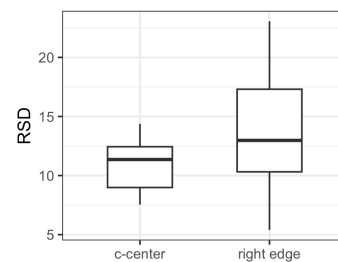


Figure 12. Overall RSDs for each interval (S3 and S4)

To summarize, the pooled temporal alignment results suggest that word-initial S is external in both SC and SCr clusters, based on a right-edge effect. We further examined individual speakers and found that each participant shows a clear right-edge effect for SC, while for the SCr sequences, most participants (3/4) showed a right-edge effect. For word-initial CI clusters we found differences across participants, with CI sequences syllabified as an onset by at least some participants (S3 and S4).

The variable results for CI suggest that SC(r) differs from CI in the potential for onset-hood, though we remain cautious about this conclusion based on the number of speakers investigated and limitations of the methodology. Because the target word in frame sentences is always preceded by [la], it is possible that the right-edge effects found for SC clusters could be due to syllabification of the sibilant in the coda of the preceding word. Nevertheless, if cross-word syllabification indeed occurred, we would not expect to find any C-center effect for CI cluster. The C-center effects for CI observed in some speakers thus suggest that the right-edge effect found in SC(r) clusters is indicative of a preference for the word-initial sibilant to be organized external to the syllable.

## 6 Analysis in Harmonic Grammar

Our experiment suggests that a word-initial sibilant in an SC cluster in Moenat is external to a syllable onset beginning with the following plosive stop. This finding is consistent with the hypothesis introduced in section 2 that the lack of SCl clusters in Moenat arises through avoidance of the combined markedness of a syllable-external sibilant and a CI onset. We propose to account for this pattern as a threshold effect in Harmonic Grammar (HG; Legendre et al. 1990, Pater 2009), emerging from the interaction of basic constraints. We employ a null parse model of phonotactics in HG (Albright 2008, 2012, Breiss & Albright 2022, and citations therein). In this approach, a form that is phonotactically unacceptable is modeled as selection of the null parse, represented by [Ø], corresponding to a candidate in which the form is not produced (Prince & Smolensky 2004). This model is applicable to static phonotactic restrictions that hold of the lexicon, which is consistent with our observations about the rarity of word-initial SCl clusters in Moenat.

For our analysis, we assume the four constraints in (5).  $*_o[SC]$ , in (5a), penalizes an SC cluster in a syllable onset (Coetzee 2004, 2008).<sup>4</sup> A tautosyllabic SC cluster is marked on the basis of violating the Sonority Sequencing Principle (Clements 1990). In Moenat this constraint drives a sibilant in an SC cluster to be external to the syllable onset. However, the onset-external organization of the sibilant violates PARSE-SEG, in (5b).<sup>5</sup>  $*_o[CI]$ , in (5c), prohibits a CI cluster in a syllable onset. This constraint encodes that a CI onset is more marked than Cr, as discussed in section 2, but it can nonetheless be violated in Moenat words. Finally MPARSE assigns a violation to a null output (Prince & Smolensky 2004). A null output incurs a violation of the MPARSE constraint only; it satisfies all other constraints (Wolf & McCarthy 2009).

### (5) Constraints

- a.  $*_o[SC]$ : Assign a violation to each sibilant-stop sequence in a syllable onset.
- b. PARSE-SEG: Assign a violation to each segment that is not parsed into a syllable.
- c.  $*_o[CI]$ : Assign a violation to each tautosyllabic stop-lateral sequence.
- d. MPARSE: Assign a violation to a null output.

In the null parse model of phonotactics that we implement here, the weight assigned to MPARSE serves as a threshold on well-formedness in the lexicon. Any candidate with a harmony score that is lower than the weight of MPARSE will not be permissible in the lexicon. In that case, the null output will be favored. In this approach, faithfulness does not enter into the competition for phonotactic acceptability, rather only candidates that faithfully preserve the input string are evaluated. Accordingly, the non-null candidates that we consider in relation to the constraints in (5a-c) differ in their syllabification, but they do not include deletion, epenthesis or featural changes.<sup>6</sup>

The basic structure of the analysis is that PARSE-SEG and  $*_o[CI]$  each have a lesser weight than MPARSE so that forms with an onset-external sibilant or a CI onset are permissible. On the other hand, the combined weight of PARSE-SEG and  $*_o[CI]$  exceeds the threshold of the weight of MPARSE, causing a word-initial  $S_o[CI]$  cluster to be excluded in favor of the null parse. In other words, the cumulative markedness penalty incurred

<sup>4</sup> Coetzee's version of this constraint applies to any tautosyllabic SC sequence, not only those in onsets.

<sup>5</sup> An onset-external sibilant might be integrated into a higher level of prosodic structure, such as the prosodic word (see Goad 2011), though this detail remains an open issue for Moenat.

<sup>6</sup> See Breiss & Albright (2022) for discussion on drawing a distinction between modeling of phonotactic acceptability judgments using MPARSE while modeling alternations that involve changes to strings with a competition that employs faithfulness constraints.



by a candidate that violates PARSE-SEG and  $*_{\sigma}[\text{Cl}]$  falls beyond the boundary of phonotactic acceptability. We demonstrate these weighting relations and further details in what follows.

We assume the following constraint weights for our analysis:  $w(\text{MPARSE}) = 8$ ,  $w(*_{\sigma}[\text{SC}]) = 6$ ,  $w(\text{PARSE-SEG}) = 5$ ,  $w(*_{\sigma}[\text{Cl}]) = 4$ . For this account, the constraint weights and weighting relations were worked out by hand. The particular weights assigned are consistent with the pattern characterized in categorical terms but they are not crucial provided that the established weighting relations are respected.<sup>7</sup>

We start with the constraint weighting relations needed to obtain the appropriate syllabification for an SC cluster in which the sibilant is external to the syllable onset. Two weighting relations are relevant. First,  $w(\text{MPARSE}) > w(\text{PARSE-SEG})$  is required to favor the winner over the null output. This is shown in (6) for the word [ʃkals] ‘drawer’. The winner, in (6a), violates PARSE-SEG to earn a harmony score of  $-5$ , while the null output, in (6b) has a lower harmony score ( $H = -8$ ) due to its violation of MPARSE. Second,  $w(*_{\sigma}[\text{SC}]) > w(\text{PARSE-SEG})$  is required. This is seen by comparing the winner in (6a) ( $H = -5$ ) with the loser in (6c) ( $H = -6$ ). The winner violates PARSE-SEG, while (6c) parses the sibilant into the syllable onset with the following stop, earning a violation of higher-weighted  $*_{\sigma}[\text{SC}]$ .

(6) S in a word-initial SCV sequence is onset-external

$w(\text{MPARSE}) > w(\text{PARSE-SEG})$  (a ~ b)

$w(*_{\sigma}[\text{SC}]) > w(\text{PARSE-SEG})$  (a ~ c)

/ʃkals/	Weight:	MPARSE	$*_{\sigma}[\text{SC}]$	PARSE-SEG	$H$
a. $\sigma_{\sigma}[\text{kals}]$		8	6	-1	-5
b. $\emptyset$		-1			-8
c. $\sigma[\text{ʃkals}]$			-1		-6

Next we turn to the syllabification of Cl sequences with illustration in (7) with the word [blɔk] ‘block’. The constraint weights we examine here are applicable to our finding that a Cl sequence can form a complex onset for at least some speakers. The first weighting relation is  $w(\text{MPARSE}) > w(*_{\sigma}[\text{Cl}])$ . The winning output in (7a) syllabifies the cluster into an onset, violating  $*_{\sigma}[\text{Cl}]$  ( $H = -4$ ). This candidate has a higher harmony score than the null parse in (7b) ( $H = -8$ ). A comparison of the winner with another loser (7c) supports the weighting relation  $w(\text{PARSE-SEG}) > w(*_{\sigma}[\text{Cl}])$ . Candidate (7c) forms a simple onset and locates the stop outside of the syllable. This incurs a violation of PARSE-SEG, which earns a lower harmony score ( $H = -5$ ) than (7a).

(7) Cl can be syllabified into a complex onset

$w(\text{MPARSE}) > w(*_{\sigma}[\text{Cl}])$  (a ~ b)

$w(\text{PARSE-SEG}) > w(*_{\sigma}[\text{Cl}])$  (a ~ c)

/blɔk/	Weight:	MPARSE	PARSE-SEG	$*_{\sigma}[\text{Cl}]$	$H$
a. $\sigma_{\sigma}[\text{blɔk}]$		8	5	-1	-4
b. $\emptyset$		-1			-8
c. $b_{\sigma}[\text{lɔk}]$			-1		-5

The tableau in (8) shows how these assigned constraint weights will select the null output when a word begins with an SCl sequence. Schematic forms are considered in this tableau. The null output, in (8a), incurs a violation of MPARSE only, earning a harmony score of  $-8$ . The losing candidate in (8b), which forms a Cl onset and has an onset-external sibilant, violates both PARSE-SEG and  $*_{\sigma}[\text{Cl}]$ , resulting in a harmony score of  $-9$ , which is lower than that of the winner. This supports a weighting relation in which the weight of PARSE-SEG plus the weight of  $*_{\sigma}[\text{Cl}]$  is greater than that of MPARSE. The loser in (8c) syllabifies the three consonants together into a complex onset, violating both  $*_{\sigma}[\text{SC}]$  and  $*_{\sigma}[\text{Cl}]$  for a harmony score of  $-10$ . This comparison supports a weighting relation in which the combined weights of  $\sigma[\text{SC}]$  and  $*_{\sigma}[\text{Cl}]$  exceed that of MPARSE. Finally, (8d) forms a simple onset with the lateral and places both the sibilant and stop outside of the syllable.

<sup>7</sup> In future work, a probabilistic MaxEnt model could be used to fit gradience in the lexicon (e.g. Goldwater & Johnson 2003, Hayes & Wilson 2008); however, this awaits a Moenat lexicon over which gradience can be examined.

This candidate violates PARSE-SEG twice, for a losing harmony score of  $-10$ . This loser supports a weighting relation such that  $2*w(\text{PARSE-SEG}) > w(\text{MPARSE})$ .

(8) Word-initial SCl is not permitted

$$w(\text{PARSE-SEG}) + w(*_{\sigma}[\text{Cl}]) > w(\text{MPARSE}) \quad (\text{a} \sim \text{b})$$

$$w(*_{\sigma}[\text{SC}]) + w(*_{\sigma}[\text{Cl}]) > w(\text{MPARSE}) \quad (\text{a} \sim \text{c})$$

$$2*w(\text{PARSE-SEG}) > w(\text{MPARSE}) \quad (\text{a} \sim \text{d})$$

/SCIV/ Weight:	MPARSE 8	* <sub>σ</sub> [SC 6	PARSE-SEG 5	* <sub>σ</sub> [Cl 4	<i>H</i>
☞ a. Ø	-1				-8
b. S <sub>σ</sub> [CIV]			-1	-1	-9
c. σ[SCIV]		-1		-1	-10
d. SC <sub>σ</sub> [IV]			-2		-10

The tableau in (9) for the word [zbrɪ'on] ‘scratch’ illustrates how these weights predict a word-initial SCr sequence to be acceptable. The evaluation here is parallel to that for a word-initial SC sequence, as in (6). The winning output, in (9a) has an onset-external sibilant ( $H = -5$ ).<sup>8</sup> Lower harmony scores are earned by each of the losers, for the null parse, in (9b) ( $H = -8$ ), and the syllabification of the sibilant in the onset, in (9c) ( $H = -6$ ).

(9) A word-initial SCr sequence is permissible

/zbrion/ Weight:	MPARSE 8	* <sub>σ</sub> [SC 6	PARSE-SEG 5	* <sub>σ</sub> [Cl 4	<i>H</i>
☞ a. z <sub>σ</sub> [bri...]			-1		-5
b. Ø	-1				-8
c. σ[zbrɪ...]		-1			-6

To summarize, in the formal account that we propose here, the absence of word-initial SCl clusters in Moenat comes about through the combined force of PARSE-SEG and \*<sub>σ</sub>[Cl. This outcome is implemented as a threshold effect represented by the weight of MPARSE, while allowing permissible SC and Cl clusters to fall below the threshold. We note that the weighting relations proposed here make two further predictions about the phonotactics of Moenat, namely, that a word with a word-initial SC cluster will not also contain a word-medial Cl onset, nor will a word with a word-initial Cl cluster contain a word-medial SC onset or unparsed sibilant. To the best of our knowledge, these predictions are borne out.<sup>9</sup>

## 7 Conclusion

In this paper we have contributed new experimental data on the temporal coordination of consonants in Moenat Ladin, an understudied minority Romance variety. The findings of this study suggest that word-initial sibilants before a stop are organized external to the syllable onset, which begins with the stop. Building on this evidence, we have proposed an analysis of the phonotactics of word-initial clusters in Moenat in which SCl sequences are excluded because they exceed a markedness threshold deployed in HG, while the relevant permissible two-consonant clusters and SCr clusters do not exceed the threshold.

While we have made some progress on these issues, many questions and paths remain open for future work. With respect to the experiment reported here, it will be important to probe the data further with statistical analyses, which we have planned. In addition, a primary area for further analysis involves the differences in temporal coordination that we found across some of our participants, especially for Cl clusters,

<sup>8</sup> Candidates (9a) and (9c) will presumably violate a general constraint such as \*COMPLEXONSET. This constraint would have to have a very low weight so as not to favor the null output or to drive an onset-external stop for a Cl cluster. We have left this aside for simplicity.

<sup>9</sup> We examined these predictions based on searches in *PODLM* and *DILF* together with the phonotactic description of Moenat in Walker & Yang (in preparation).

but also for SCr sequences. As we noted above, because the word preceding the target word in the carrier phrase was vowel-final, it is possible that the first consonant in a word-initial cluster could have been syllabified into the coda of the preceding syllable. It is also possible that different participants employed this strategy to different extents. We plan to look into this issue in further analysis of the data, starting by examining any effects on the duration of the preceding vowel.

In another vein, it would be valuable to undertake a systematic quantitative study of the frequency of phonemes and types of consonant clusters in the lexicon. We have not yet been able to perform a frequency study because we do not have a sufficiently complete lexicon of Moenat available to us. We therefore cannot rule out frequency as a factor in the rarity of SCl sequences in Moenat. Nevertheless, our acoustic experiment contributes insight on the temporal organization and syllabification of SC sequences in Moenat, which are factors that could come into play in shaping the frequency and acceptability of clusters with these sequences.

### Appendix: Target words in the experiment

Word	Transcription	Gloss	Word	Transcription	Gloss
<i>l-series</i>			<i>spaca</i>	[ˈʃpaka]	nonce
<i>laga</i>	[ˈlaɣa]	nonce	<i>r-series</i>		
<i>blaga</i>	[ˈblaɣa]	‘arrogant person’	<i>brama</i>	[ˈbrama]	‘sour cream’
<i>baga</i>	[ˈbaɣa]	nonce	<i>bama</i>	[ˈbama]	nonce
<i>sbava</i>	[ˈzɓava]	‘slobber, drool (noun)’	<i>sbama</i>	[ˈzɓama]	nonce
<i>lòta</i>	[ˈlòta]	nonce	<i>sbrama</i>	[ˈzɓrama]	‘to remove sour cream from milk. 3SG/PL’
<i>plota</i>	[ˈplòta]	‘stone, concrete slab’			
<i>pòta</i>	[ˈpòta]	nonce			
<i>spona</i>	[ˈʃpɔna]	‘bed, wagon train’	<i>prita</i>	[ˈprita]	nonce
<i>lòssa</i>	[ˈlòsa]	nonce	<i>pita</i>	[ˈpita]	‘hen’
<i>clòssa</i>	[ˈklòsa]	nonce	<i>spita</i>	[ˈʃpita]	nonce
<i>còssa</i>	[ˈkòsa]	nonce	<i>sprita</i>	[ˈʃprita]	nonce
<i>scòza</i>	[ˈʃkòsa]	nonce	<i>brata</i>	[ˈbrata]	nonce
<i>lassa</i>	[ˈlasa]	nonce	<i>bata</i>	[ˈbata]	‘cotton wool’
<i>glassa</i>	[ˈɣlasa]	‘icing (for food)’	<i>sbata</i>	[ˈzɓata]	nonce
<i>gàssa</i>	[ˈɣasa]	nonce	<i>sbrata</i>	[ˈzɓrata]	nonce
<i>sgassa</i>	[ˈzɣasa]	nonce	<i>bròcia</i>	[ˈbrɔtʃa]	‘nail’
<i>lata</i>	[ˈlata]	nonce	<i>bòcia</i>	[ˈbɔtʃa]	nonce
<i>blata</i>	[ˈblata]	nonce	<i>sbòcia</i>	[ˈzɓɔtʃa]	‘female friend’
<i>bata</i>	[ˈbata]	‘cotton wool’	<i>sbròcia</i>	[ˈzɓrɔtʃa]	nonce
<i>sbata</i>	[ˈzɓata]	nonce	<i>brossa</i>	[ˈbrosa]	nonce
<i>laca</i>	[ˈlaka]	‘lacquer, paint’	<i>bossa</i>	[ˈbosa]	‘kiss 3SG.PRS’
<i>plata</i>	[ˈplaka]	‘calm down 3SG.PRS’	<i>sboza</i>	[ˈzɓosa]	nonce
<i>paca</i>	[ˈpaka]	‘blow (noun)’	<i>sbroza</i>	[ˈzɓrosa]	nonce

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