Variation of sibilants in three Ladin dialects

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Overview. This paper presents an acoustic study of Ladin, a threatened minority Romance language spoken in Northeastern Italy, with a focus on the sibilants of three dialects (Brach, Cazet, and Moenat) spoken in the Fassa Valley of Trentino. The contributions are threefold. First, it provides up-to-date phonetic data for younger-generation speakers. Second, it reveals the nature of phonetic variation across dialects. Third, Smoothing Spline ANOVA[1] is used in the analysis of fricative spectral envelopes, an innovative application of this method, which provides insight on the nature of the differences amongst sibilants within and across dialects. It thereby exhibits a benefit of using statistical methods in the study of threatened or endangered languages.

Data collection. Previous research has identified two series of voiced and voiceless sibilant fricatives in Fassa dialects (denti-)alveolar and postalveolar. However, it does not show consensus on the nature of the post-alveolar series, which have been variously characterized as palatal(ized) or retroflex[2], [3], [4]. To investigate the nature of these sibilants acoustic recordings of Ladin words, produced in controlled conditions, were acquired in June 2018 in Vigo di Fassa. Four speakers spanning three dialects of Fassa Ladin were recorded: Two speakers of Brach (both F), one speaker of Cazet (F), and one speaker of Moenat (M). The speakers fell within an age range of 18-35. For the purpose of the current study, only words containing voiceless sibilants in our database were used for acoustic analysis, exemplified in (1). We note that these analyses serve as a preliminary study, since the sibilants used for spectral analysis were not controlled for syllable position and neighboring vowel quality.

Analysis and Results. The statistical method Smoothing Spline ANOVA (SSANOVA) has been utilized in phonetic studies for fitting ultrasound trajectories,[5] vowel formants,[6] liquid formants,[7] and fundamental frequency,[8] while this study uses the technique to provide a comparative illustration of the acoustic properties of the sibilants. For each token, a 10-ms window in the middle of the sibilant was selected, and the spectral envelope of the window was extracted. For each dialect, a SSANOVA model was fitted to the extracted spectral envelopes of the sibilants, shown in Figure 1; the interaction plots are shown in Figure 2. Since the post-alveolar series in Moenat was documented as retroflex, the comparison of the post-alveolar in three dialects is given in Figure 3.

Discussion. Within each dialect, the spectral envelope of the alveolar sibilant is significantly different from that of the post-alveolar since only a small portion of overlap can be observed between 5,000 Hz and 10,000 Hz in Figure 1. These results suggest that the two sounds are distinctive. Across dialects, however, the alveolar sibilant in Cazet stands out due to the peak it presents at approximately 7000 Hz (Figure 1b), indicating that it is more retracted compared to its counterparts in Brach and Moenat, and which renders it more similar spectrally to the post-alveolar. The post-alveolar fricative in Cazet shows a plateau between around 3500 Hz and 7000 Hz (Figure 1b). We suggest the possibility that post-alveolar sibilants could have two allophones characterized by two peaks, one at 3500 Hz and the other at around 7000 Hz. The variations could be contextual, which might be related to the syllable position of the post-alveolar or its following vowel. For instance, in words such as *dasc* [daʃ] 'give 2.SG.PRS' versus *scial* [ʃial] 'shawl', the post-alveolar either appears in coda position or in onset position before *i*. These contexts might result in the spectral variations seen in Cazet post-alveolar sibilants. Further, for the post-alveolar series, the noise energy peak in Moenat has lower frequency compared to the other two dialects, shown in Figure 3, which might indicate the backness and retroflex nature of this sound.[9] The results of our study are suggestive that the three Fassa dialects under study have developed post-alveolar sibilants that are each distinct from one

another. This research provides a basis for future in-depth investigation into the properties of sibilants in Ladin.

(1) Word list (only some examples are listed)

	Brach		Cazet		Moenat	
alveolar	6 words; 28 tokens		10 words; 20 tokens		21 words; 41 tokens	
	das	[da**s**]	das	[da**s**]	asenz	[aˈsɛn**s**]
	ors	[or**s**]	ors	[or**s**]	filz	[fil**s**]
	sauch	[**s**aˈuk]	sauch	[**s**aˈuk]	son	[**s**on]
	soreie	[**s**oˈrɛie]	soreie	[**s**oˈrɛie]	sort	[**s**ɔrt]
post-alveolar	6 words; 25 tokens		8 words; 16 tokens		39 words; 106 tokens	
	dasc	[da**ʃ**]	dasc	[da**ʃ**]	dasc	[da**ʂ**]
	orsc	[or**ʃ**]	orsc	[or**ʃ**]	orsc	[or**ʂ**]
	scial	[**ʃ**al]	scial	[**ʃ**al]	stolz	[**ʂ**tols]
	scigol	[ˈ**ʃ**igol]	scigol	[ˈ**ʃ**igol]	scaji	[ˈ**ʂ**kaʐi]

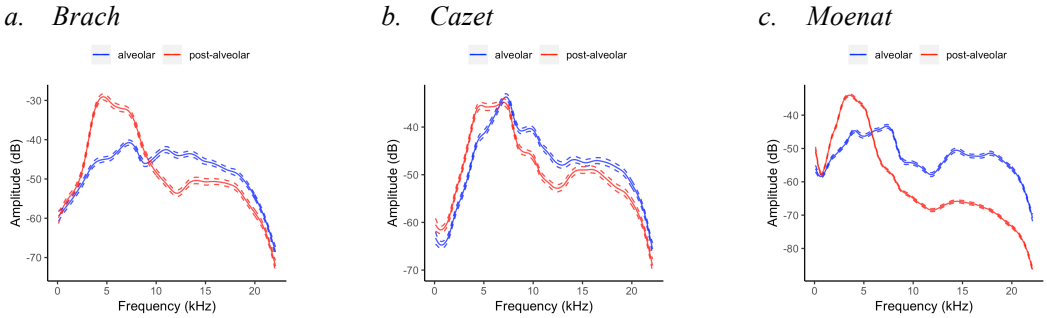

Figure 1. *Spectral information of sibilants in three dialects. The splines were plotted as the solid lines, while the dashed lines indicate the upper and lower boundary of 95% Bayesian confidence interval.*

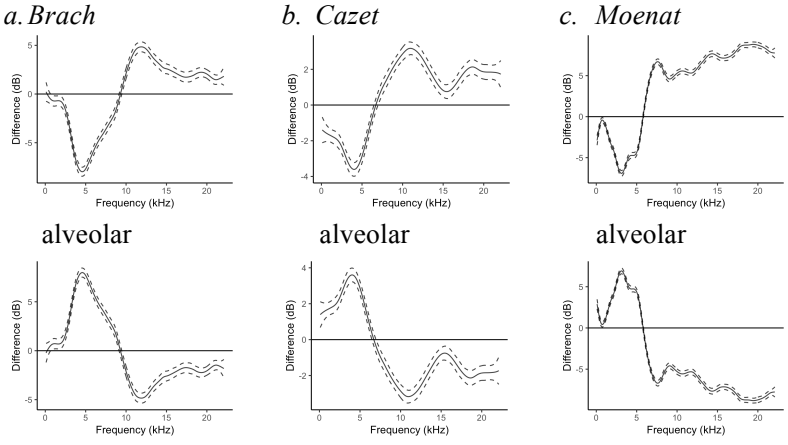

Figure 2. *Interaction effects with Bayesian confidence interval. The dashed lines indicate the upper and lower boundary of 95% Bayesian confidence interval.*

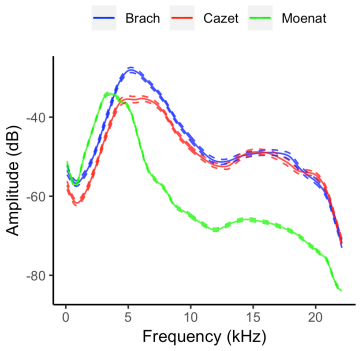

Figure 3. *Post-alveolar sibilant in three dialects. The post-alveolar in Moenat has a peak of lower frequency, indicating longer anterior cavity.*

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