AN ULTRASOUND STUDY ON THE PHONETIC ALLOPHONY OF TYROLEAN /R/

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ABSTRACT

Moving from traditional dialectological literature and inspired by contemporary research on rhotics, in this paper we present preliminary data on the distribution and the articulation of /r/ in Tyrolean, an under-researched South Bavarian dialect. Two speakers produced a comprehensive selection of Tyrolean words containing /r/. They uttered up to five different uvular rhotics: [χ, ʁ, ʁ̞, ρ, ʀ]. We found mild tendencies in the allophonic distribution of the variants, but systematic differences in their lingual configurations: trills are produced steep lowering the tongue tip; vocalizations are markedly lowered and retracted, with the tongue dorsum flat; approximants are retracted.

Keywords: ultrasound tongue imaging; rhotics; Tyrolean.

1. INTRODUCTION

The allophony of /r/ in High German languages is a challenging issue and the many attempts to offer acoustic and/or articulatory descriptions of all attested /r/-variants, as well as to account for their contextual distribution, help shade light on the problematic interface between phonetics and phonology [9, 11]. For this reason, in this paper we present novel UTI data on Tyrolean – an under-researched South Bavarian Dialect – and we discuss the "phonetic allophony" [7] of its uvular rhotics.

According to the traditional dialectological literature, the rhotic system of Tyrolean is characterized by two uvular variants, a fricative and a trill, rarely attested as allophones in the same variety of dialect [4]. Previous articulatory accounts of /r/ in Tyrolean - indeed pertaining almost exclusively to Italian-Tyrolean bilingual speakers - have nonetheless showed a high degree of intra-speaker variation in the uvular realizations of /r/ [10]. According to their study, post-dorsal raising and/or bunching were principal aspects in uvular /r/ realization. Pharyngealization and tip raising were instead secondary articulations held responsible for the appearance of other allophones, namely of uvular approximants or taps, and of vocalized /r/ (see [5] and [7] on the differential role of tongue root retraction and/or tip raising). Building on previous research and moving from acoustic and distributional data we aim at discussing: (1) how many and which variants of uvular /r/ occur in the Tyrolean dialect, and (2) whether or not the variants co-exist in the same phonological system as allophones. Moving from articulatory data, we aim at investigating (3) if the different variants share any articulatory feature, and (4) what primary and secondary (lingual) articulatory correlates of the allophonic variation can be identified.

2. MATERIALS AND METHOD

2.1. Materials

The materials included 80 real Tyrolean words, eliciting /r/ in all possible syllable contexts and positions (onset vs. coda, simple vs. complex, initial vs. medial vs. final) according to an in-depth scrutiny of all available Tyrolean dictionaries. Two Tyrolean mother tongue speakers double-checked the word list in order to verify they were all recognizable and correctly uttered by the participants. In compiling the word list, surrounding vowels (V) were restricted to /a, a:, i, i:, o, o:/; surrounding consonants (C) for /r/ in syllable onset (CRV) and coda (VRC) position were restricted to /t, d, k, g/. For /r/ in coda position words with /r/ + nasal or liquid were also included.

2.2. Participants

Two female native Tyrolean speakers (hereafter identified with MRL and EVK) with no reported speech disorders were recorded. Both participants were aged 33 and were born and living in the area of Meran-Merano, a town in South Tyrol, Northern Italy. Both subjects had command of Standard German and Standard Italian at native-like level.

2.3. Recordings

One recording session for both subjects took place in a soundproof cabin. Real-time synchronized acoustic and ultrasound data were obtained using the Articulate Assistant Advanced (AAA) software package [1] running on a Desktop Workstation. Acoustic recordings were collected by means of a

Sennheiser ME2 microphone connected to a B1 Marantz PMD660. Ultrasonic recordings were captured by means of an Ultrasonix SonicTablet ultrasound imaging system. The tongue contour was tracked using a convex array transducer (Ultrasonix C9-5/10) at 5MHz, stabilized under the participants chin by means of a stabilizing helmet [12]. Ultrasound recordings were collected at a rate of 91Hz and 95Hz with a field of view of 127° and 134° for speaker MRL and EVK, respectively. Audio was sampled at 22050Hz 16-bit mono. The list of words was administered twice to gather at least two repetitions of the same target. Each word was prompted to participants on a 21" monitor.

2.4. Data preparation

The audio material was first exported from AAA to PRAAT [2] and was manually labelled at a segmental level by one of the authors, while another of them double-checked the annotations. All /r/-segments were identified on the basis of the visual inspection of waveform and sonogram. The place of articulation (PoA), the manner of articulation (MoA) and the voicing (±voice) was annotated. Challenging /r/ tokens labelled as "undef" were excluded from the analysis.

The resulting annotations were imported back into AAA for articulatory analysis. Two of the authors traced the tongue splines for each /r/ token by using the fitting algorithm implemented in AAA with manual correction where needed, while the other of them double-checked the splines.

3. DATA ANALYSIS

3.1. Variants

The rhotics distribution for the two Tyrolean speakers MRL and EVK, according to different phonotactic contexts is presented in Table 1 and Table 2, respectively. The two tables show that both MRL and EVK vocalize rhotics or produce different consonantal allophones. In particular, MRL articulates [χ, ʁ, ʁ̞, ρ, ʀ], while EVK articulates [χ, ʁ, ʁ̞, ρ] with some deletion, too. For both speakers, the uvular fricative is the most recurrent phone in both onset and coda position. Even though none of the two speakers display significant correlation between variants and phonotactic environments, nonetheless the contextual distribution shows some latent regularity. The most relevant tendencies are:

- for both speakers the uvular fricative is the most frequent and the most context-independent variant;
- the uvular approximant seems to be the preferred variant in simple onset position (especially in the intervocalic context);
- /r/-vocalization and deletion occur only in coda position (with vocalization more related to word final position);
- the uvular trill (attested in MRL) occurs only in syllable onset position (both simple and complex onsets).

Table 1: Distribution (%) of MRL's uvular /r/ realizations in onset and coda position according to syllable type and MoA (a = approximant, f = fricative, r = trill, t = tap, voc = vocalization).

	a	**f**	**r**	**t**	**voc**	**sum**
onset	**13**	**52**	**10**	**25**	**-**	**100**
#CRV		82	5	14		
#RV	11	22	67			
CRV		67	2	31		
RV	50	8	8	33		
coda	**15**	**63**	**1**	**7**	**13**	**100**
CVR	50		25		25	
CVR#		75			25	
VR#		100				
VRC					100	
VRC#		100				
VRCL#		100				
VRCN#		100				
VRL	50				50	
VRL#	17	67		17		
VRN#	46			31	23	
total	**14**	**56**	**7**	**18**	**5**	**100**

Table 2: Distribution (%) of EVK's uvular /r/ realizations in onset and coda position according to syllable type and MoA (a = approximant, f = fricative, t = tap, voc = vocalization, del = deletion).

	a	**del**	**f**	**t**	**voc**	**sum**
onset	**18**	**-**	**74**	**8**	**-**	**100**
#CRV			88	13		
#RV	7		93			
CRV	17		81	2		
RV	46		33	21		
coda	**26**	**8**	**45**	**3**	**18**	**100**
CVR	100					
CVR#		13	50		38	
VR#		10	60		30	
VRC		50			50	
VRC#	18		82			
VRCL#			100			
VRCN#			100			
VRL	100					
VRL#	67		33			
VRN#	36	14		14	36	
total	**21**	**3**	**63**	**6**	**7**	**100**

3.2. Articulatory analysis

Fitted splines taken from the acoustic midpoint of each labelled /r/-variant were exported to the AAA's workspace in order to calculate the smoothed tongue contour for each variant in each speaker. The analysis was run in R by computing SSANOVA and Bayesian confidence intervals (using the `ssanova` function in the `gss` package) while comparing /r/-variants profiles irrespective of the phonetic contexts they were in. Notwithstanding the allophonic variation in the acoustics, the articulatory patterns are relatively stable. The visual investigation of extracted tongue profiles shows an overall similarity in tongue shape and position regardless of coarticulatory effects (with the notable exception of /r/ + nasal or liquid). The tongue profiles here presented are similar to those reported by [10] and by [7] for Dutch uvular rhotics, especially the trilled variants of MRL. Smoothed tongue profiles [3] for the imaged part of the tongue of our speakers EVK and MRL are quite similar (Figures 1 and 3)[1]: the tongue body is held convex to the palate; the postero-dorsum is raised; the antero-dorsum and the tongue tip are down (with exception for the aforementioned /r/ + nasal or liquid, especially in MRL).

Figure 1: Smoothing splines results for EVK's /r/-variants (colour legend on the right in the following order: a = approximant, f = fricative, t = tap, voc = vocalization).

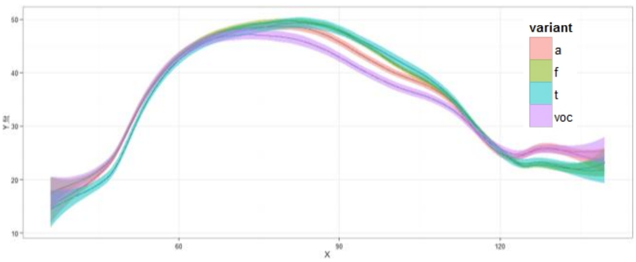
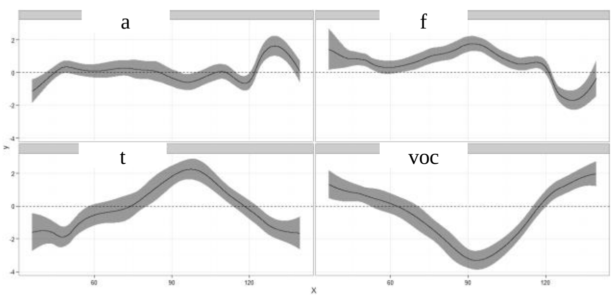


Figure 2: Interaction effects with Bayesian confidence intervals for EVK for approximant (at the top left) and fricative (top right), tap (bottom left) and vocalization (bottom right).



EVK presents mild allophonic variation in the root and the dorsum of the tongue: vocalizations are sensibly lower and retracted (see the interaction effects plot in Figure 2); taps are higher and forward, mostly overlapping with fricatives. In the pre-dorsum there is a dip (more evident in the approximant and the r-vocalization), hint of secondary articulation.

Allophonic variation is more evident in MRL: vocalizations are markedly lowered and retracted with the tongue dorsum flat; approximants are retracted; trills are produced steep lowering the tongue tip, in a more circle-like shape.

Figure 3: Smoothing splines results for MRL's /r/-variants (colour legend on the left in the following order: a = approximant, f = fricative, t = tap, r = trill, voc = vocalization).

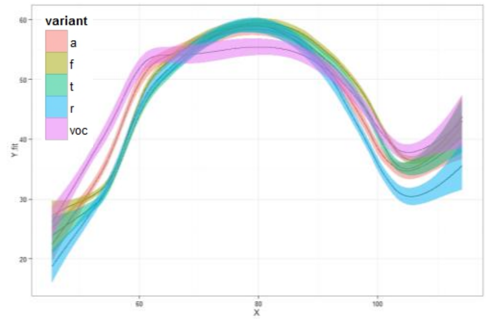
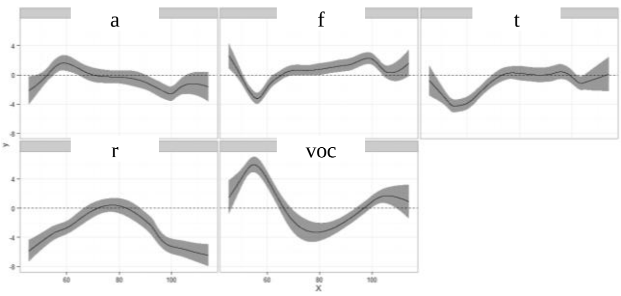


Figure 4: Interaction effects with Bayesian confidence intervals for MRL for approximant, fricative and tap (at the top, from left to right), trill and vocalization (at the bottom).



4. DISCUSSION

In this paper, a quantitative analysis of a small set of articulatory data on the allophonic variation of /r/ in Tyrolean was presented. The main aim of the study was to explore the possible sources of allophonic variation of /r/ in Tyrolean by providing a preliminary account of the corresponding lingual configurations.

The preliminary acoustic-auditory labelling process identified five possible /r/-variants (dorso-uvular trill, tap, fricative and approximant, plus a more vocalized variant). If we consider the variables Speaker and Phonetic contexts, we must observe that the variants are not equally distributed in the sample.

With reference to the former factor (Speaker), two slightly different subsystems can be noticed, namely a "trilled" vs. a "non-trilled" dialect variety. Possible implications due to the number (and quality) of variants on the allophonic system should be accounted for and carefully considered, as they might influence the articulatory space – and therefore the phonetic allophony.

Concerning the distribution of /r/ according to phonetic contexts, the following trends were identified: the fricative variant is the default choice; trills and taps are more likely to occur in onset contexts, while the process of r-vocalization is restricted to the coda position.

The ultrasound investigation only partly confirms this broad classification, as other parameters seem to be contributing to the overall /r/ tongue profiles. Two different subsystems emerge:

- that of EVK, where the variation can be accounted for by the degree of dorsal constriction: t > f > a > v (according to the proposal of articulatory unity of German uvular /r/ put forward by Schiller [6]);
- that of MRL, where /r/-variants can be characterized as a combination of (roughly defined) parameters of the kind reported in Table 3.

Table 3: Possible combination of articulatory tongue parameters characterizing /r/-variants.

	Trill, Tap	Fricative	Approx., Voc.
Tongue Root retraction	-	-	+
Tongue Tip/Blade lowering	+	-	-
Dorsal raising/bunching	+	+	-

Once more, articulatory data does not only provide complementary evidence to acoustic analysis, but reveals important descriptive details that are themselves theoretically significant. Of relevance to us is the problematic interface between phonetics and phonology, and notably the mirroring of acoustic allophony in the articulation.

5. ACKNOWLEDGEMENTS

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[1] High resolution images are available on the web by clicking on the images.