

# Allophonic variation: An articulatory perspective

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## 1. Introduction

In this paper, we explore the issue of allophonic variation via a quantitative and qualitative analysis of /r/ in Tyrolean -- a South Bavarian Dialect --. The allophony of /r/ in this High German language is a challenging problem and only a few attempts have been done to solve it, usually basing on acoustic and articulatory descriptions of all attested /r/-variants or on their contextual distribution. Interestingly, most previous researches have highlighted a high degree of intraspeaker variation in the uvular realizations of the rhotics [1]. Hence, here we provide novel UTI data on Tyrolean to discuss both the “phonological allophony” -- namely the variation “predictably conditioned by categorically distinct phonological contexts” --, and the “phonetic allophony” -- namely the “cases of predictable contextual differences which exist but which are not thought to be represented by changing the internal phonological content of segments” [2] --.

## 2. Methodology

For the analysis, we employed acoustic and ultrasonic data synchronized using the Articulate Assistant Advanced (AAA) software package [3]. Tongue profiles were captured by means of an Ultrasonix SonicTablet ultrasound imaging system. Tongue contours were tracked using the Ultrasonix C9-5/10 transducer operating at 5MHz. Ultrasound recordings were collected at a rate of about 90Hz with a field of view of about 120°. Acoustic data were recorded by means of a Sennheiser ME2 microphone connected to a B1 Marantz PMD660. Audio was sampled at 22050Hz 16-bit mono.

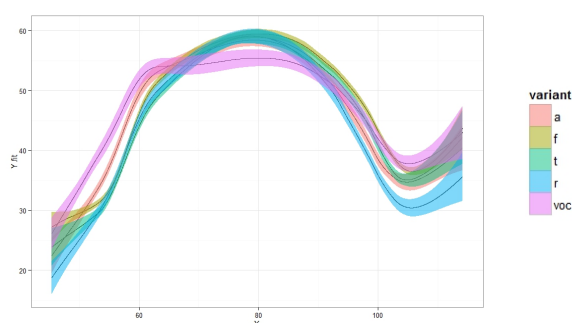
The stimuli included **80 real Tyrolean words**, eliciting /r/ in all possible syllable contexts and positions (onset vs. coda, simple vs. complex, initial vs. medial vs. final) according to an in-depth scrutiny of all available dictionaries of contemporary Tyrolean. In compiling the word list, surrounding vowels (V) were restricted to /a, i, 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 [4].

Five native Tyrolean speakers with no reported speech disorders were recorded. Participants were aged between 25 and 35 and were born and living in the area of Meran. All subjects had command of Tyrolean as well as of Standard German and Standard Italian at native-like level.

## 3. Analysis

The preliminary acoustic-auditory labelling process identifies four possible uvular /r/-variants (trill, tap, fricative and approximant) plus a vocalized variant. The variants are not equally distributed in the sample and do not strictly correlate with the phonetic contexts. However, the following trends emerge: the fricative is the default choice; trills and taps are more likely to occur in onset contexts, the process of r-vocalization is restricted to the coda position. Trends are computed using a multivariate approach to the analysis of data [5].

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 according to [6]. The comparison of /r/-variants profiles irrespective of the phonetic contexts they were in shows that notwithstanding marked allophonic variation in the acoustics, the articulatory patterns are relatively stable (fig. 1).



**Figure 1:** Smoothing splines results for SP1's /r/-variants (colour legend on the left in the following order: a = approximant, f = fricative, t = tap, r = trill, voc = vocalization).

The investigation of extracted tongue profiles shows an overall similarity in tongue shape and position regardless of coarticulatory effects. In particular, the following parameters seem to be contributing to the overall /r/ tongue profiles hence to the allophony.

(1) The degree of dorsal constriction ( $t > f > a > v$ , similarly to what proposed in [8, 9] in regard to the articulatory unity of German /r/);

(2) The peculiar combination of root retraction, tongue blade lowering and tongue dorsum bunching.

Collected data will be used to discuss the phonological vs. phonetic allophony of Tyrolean, and to address the more general question of allophony from the standpoint of articulatory phonetics.

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