Tongue root position in VC sequences with regard to the phonetic realisation of obstruent voicing: A preliminary study on Hungarian

Gráczi, Tekla Etelka[1,5] – Csapó, Tamás Gábor[2,5] – Deme, Andrea[3,5] – Juhász, Kornélia[4,5] – Markó, Alexandra[3,5]

[1]Hungarian Research Institute for Linguistics,
[2]Budapest University of Technology and Economics, Department of Telecommunications and Media Informatics,
[3]Eötvös Loránd University, Department of Applied Linguistics and Phonetics,
[4] Eötvös Loránd University, Doctoral School of Linguistics, ,
[5]MTA-ELTE "Lendület" Lingual Articulation Research Group
Corresponding author: graczi.tekla.etelka@nytud.hu

Introduction

VOICED FRICATIVES: The simultaneous articulation of the turbulent noise of fricatives and vocal fold vibration has conflicting pressure requirements. Various articulatory gestures may be used to maintain the vocal fold vibration: e.g. lowering the larynx, enlarging the oral cavity, lowering the tongue, tongue root (TR) advancement. TR advancement was found in the voiced compared to the voiceless counterparts segments in various languages (e.g., [1-4]).

TIMING AND COARTICULATION: The (TR) movement for voiced obstruents has been studied in vowel preceding stops [4]. The TR position was advanced in vowels preceding voiced stops compared to vowels preceding their voiceless counterparts.

VOCAL FOLD VIBRATION IN FRICATIVES: The maintenance of vocal fold vibration in voiced fricatives were found to vary not only across speakers [5] but also across languages [6]. The tongue-palate contact measures showed diverse picture with regard to voicing, that may be caused by a variability with voicing: the tongue-palate contact was strongly related to the amount of voicing present in the voiced fricatives in devoicing speakers [5].

QUESTIONS: As the phonetic realization of voicing varies across speakers (for Hungarian see e.g. [7]), and the articulatory gestures may vary with that either as a reason or a consequence of variability in voicing:

❓ The present experiment introduces a pilot study on the timing pattern of TR movement with regard to phonological and phonetic voicing.

➔ Our hypothesis was that speakers whose /z/ realizations tend to maintain voicing throughout the (most of) its duration have larger differences in the fricative and the preceding vowel between /z/ and /s/ than devoicing speakers.

Methods

Speakers: 12 female, monolingual native speakers of Hungarian without any speech or hearing disorder.

Material: 5 sentences started with /izi nɛ/ and 5 with /isi nɛ/. (The rest of the sentences were the same pairwise.) The stimuli of the present pilot study were embedded into another study material [8]. The first syllable bore both sentence accent and word-stress.

Recordings: Tongue contours (TC): in midsagittal orientation, "Micro" ultrasound (US) system (AAA, Articulate Instruments Ltd). Vocal fold activity: D200 EGG (Laryngograph LtD.). Speech signal: head-mounted microphone. The EGG- and US-recordings were time aligned through the two speech signals.

Annotations and measurements: The segmentation: forced alignment [9] & manual correction in Praat [11].

The TCs: traced manually in AAA at each frame along the time course of the /iz/ and /is/ sequences. The voiceless part ratio (ratio of vocal fold vibration to the C duration): automatically labelled & manually corrected in the EGG-signal in Praat [10]. The CoG of the C: automatically, without frequency filtering in Praat [10].

Statistics: Generalised additive (mixed) models (GAMM) (R [11], mgcv [12], itsadug [13] & rticulate [14]. The TCs were analysed separately for each speaker [see 14]. Two models were built: one for the vowel TC in the V and one for the TC in the VC sequence, where the V was set to the 0-0.5 time interval, the C to the 0.5-1 interval.

A basic model and a model with C contrast (with contrast treatment) were compared with $\chi 2$ test: The model with C contrast described the data significantly better in all polar GAMs. (Autocorrelation correction (first order autoregressive model) & knot number setting were carried out.)

Position of the TC points: dependent variable. Factors: smooth of the TC point & the normalized time course in the V or VC sequence, & their interaction (tensor). All the smooths and tensors were included with and without nesting for the difference smooths of the C.

Results

Speaker groups

VOICELESS PART RATIO: Speakers were grouped based on the number of partially devoiced /z/ realizations:

> 25% voiceless part ratio was considered as partially devoiced.

- 0-1: Voicing group: sp01, sp02, sp03, sp04, sp11, sp12,
  - **COG:** Very low CoG across the C duration may mean very weak turbulent noise either due to approximalized realization & low tongue tip position or due to low intraoral pressure.

    The "Voicing" group was devided into "Fricative" and "Approximant" groups.
    - **Approx. group: sp02, sp04, sp11, sp12**
    - **Voic. group: sp01, sp03**
- 2-3: **Sometimes devoicing group : sp05, sp07, sp08**
- 4-5: **Devoicing group: sp06, sp09, sp10**

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Results (cont.)

Tongue contour differences

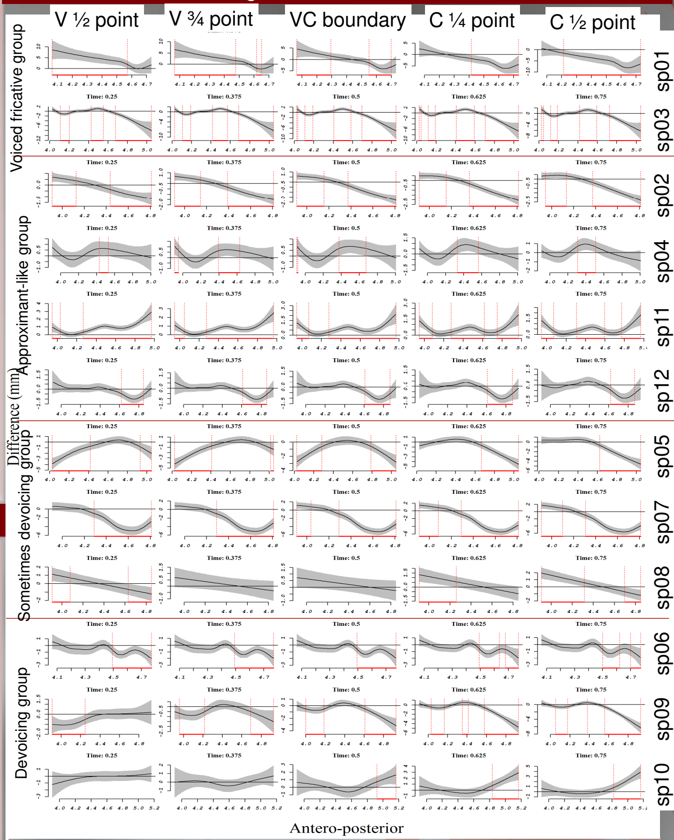

Figure: Estimated difference and its 95% confidence interval of the Tcs by the GAMM on the VC sequence. Red lines show the parts where the TCs show significant difference. Positive difference means higher values in /iz/ realizations.

Expected difference in TR position: more anterior TR in /z/ ⇨ lower value of the posterior TC points ⇨ significant negative difference at the posterior TC points.

Approximant group (sp02, sp04, sp11, sp12): 2 speakers had no (sp11) or opposite (sp04) difference in TR position between the fricatives.

Voicing, fricative group (sp01, sp03): In one speaker (sp01) the expected TR position difference appeared only during the C duration.

Sometimes devoicing group (sp05, sp07, sp08): The TR position difference was very variable in 1 speaker's (sp08) pronunciation – It was detectable during the vowel production but disapeared towards the C. The difference in the TR position was only small dung the V, but increased during the C in sp05.

Devoicing group (sp06, sp09, sp10): The difference in the TR was opposite of the expecte in 1 speaker (sp10).

Conclusions

The TR was advanced already during the V and maintained during the C in 6 out of the 12 speakers. TR was advanced only during the C in 3 speakers.

No difference was found in 2 speakers, and no difference in 1 speaker. 2 speakers belonged to the group with approximant-like realizations, 1 to the devoicing group.

→ Approximant-like realizations (low CoG, i.e. low frication) throughout the C may appear due to relatively large cross-sectional area at the stricture or due to low intra-oral pressure. In the first case it might be a maneuver for vocal fold vibration maintanance. Two explanations may arise: 1) The speaker does not advance the TR thus she needs to keep the tongue tip lower to maintain voicing. OR 2) The speaker tends to pronounce more approximant-like /z/s to maintain voicing, and thus she does not need to advance the TR.

→ In tha case of the devoicing speaker the devoicing may be a conqequence of the non-advanced TR. In the case of the partially devoicing speakers the results might hint to variability in TR position that may be in connection with the variability of devoicing in their speech.

Future work:

Further articulatory maneuvers can also appear that contribute to the maintanance of voicing.

Also the features of the consonant and the phonetic context have to be considered.

The analysis of the TR advancement timing needs also the statistical analysis of selected points of the TR.

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