Articulatory correlates of morphologically conditioned assimilation: Evidence from ultrasound imaging

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The objective of this paper is to present articulatory data on regressive place assimilation in two-member consonant clusters C_1C_2 in Polish, where C1 is underlyingly dental and C_2 is a palatal. Our study focuses on the following questions: (i) which articulatory parameters are best suited to probe C1 assimilation to palatal sounds, (ii) whether assimilation depends on the morphological composition of clusters and the transparency of the boundary, and (iii) whether lexical frequency and tempo play additional roles. We look at the gradient effects of phonologically and morphologically conditioned assimilation. (i) As palatalization is described as raising and/or fronting towards the hard palate (e.g. [1]), but recent research suggests that tongue root advancement accompanies the effect in the dorsum and plays an important role in palatalization ([2], [3]), we measured the relative fronting and raising of both the tongue dorsum and root (in relation to unassimilated tokens). (ii) We test the hypothesis that the more transparent the morphological boundary, the lower the degree of assimilation in casual speech. It is a well-established fact that morphology has an effect on articulation (e.g. [4], [5]). However, articulatory studies of the effects of morphology on speech production are relatively scarce (e.g. [6], [7], [8], [9]). (iii) Lexical frequency has been shown to have an impact on articulation. We test the assumption that more frequent words have more coarticulation/ gestural overlap than less frequent words ([10], [11]).

We have collected 3D/4D ultrasound data from 8 native speakers of Polish and analyzed it using a custom Matlab toolbox WASL ([12]). The stimuli were words and phrases containing C_1C_2 clusters with C_1 represented by /s z/ and C_2 by /ɕ ʑ tɕ dʑ/. Five types of stimuli were designed depending on the presence and strength of a morpheme boundary within the clusters: (1) intra-morphemic, (2) with a weak morpheme, (3) with a strong morpheme boundary, (4) with a clitic boundary, and (5) spanning a word boundary. The words were repeated twice, once at a normal tempo, and once faster. We have also measured the actual tempo (syllables per second). The test words were controlled for frequency using the plTenTen19 corpus.

Linear mixed effects models with tongue root/body fronting/raising as dependent variables (different correlates of assimilation were tested) and morphological boundary, lexical frequency, subjective tempo, measured tempo, voice and manner as predictors were run. Random by-speaker slopes were included. The best articulatory correlates of assimilation turned out to be tongue body fronting (Fig. 1) and tongue root fronting (Fig. 2). Tongue body raising did not come out as a good correlate of assimilation. For tongue body fronting the differences are statistically significant for: word ~ intra-morphemic ($p<0.001$), word ~ strong boundary ($p<0.001$), word ~ weak boundary ($p<0.001$), and word ~ clitic boundary ($p=0.003$). For tongue root fronting the differences are statistically significant (or statistical tendencies) for: word ~ intra-morphemic ($p=0.02$), word ~ strong boundary ($p=0.03$), word ~ weak boundary ($p=0.06$), intra-morphemic ~ clitic ($p=0.05$) and strong boundary ~ clitic ($p=0.08$). The effect of subjective tempo was significant (Fig 3, $p=0.002$), while the effect of measured tempo was not (Fig. 4). The effects of frequency are being analyzed. The results of the study confirm that consonant assimilation in Polish is morphologically-driven in the sense that word-internal boundaries are significantly more prone to assimilation than word-external boundaries. Although Figures 1 and 2 suggest that various word-internal boundaries differ in strength, data from more participants are necessary to confirm these results. The best articulatory correlates of palatalization are tongue root fronting and tongue body fronting. Higher tempo of speech indeed produces more assimilation, but only when participants are instructed to speak faster.

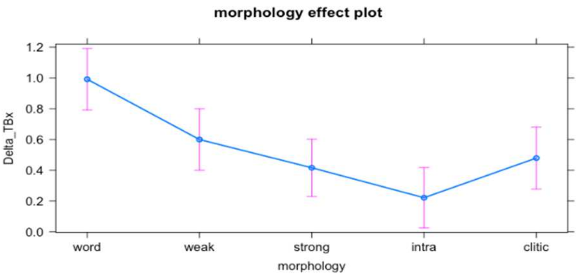

Fig. 1. Effect of morphology on tongue body fronting

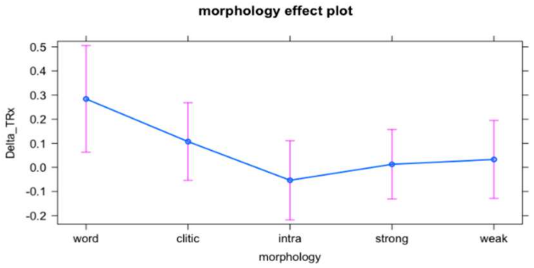

Fig. 2. Effect of morphology on tongue root fronting

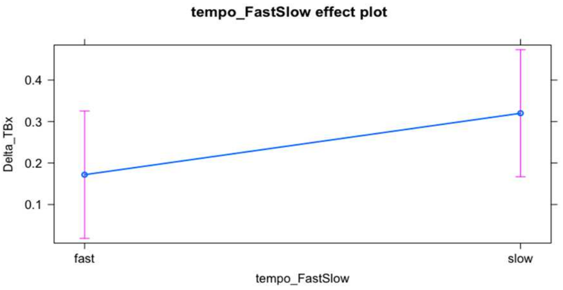

Fig. 3. Effect of subjective tempo on tongue body fronting

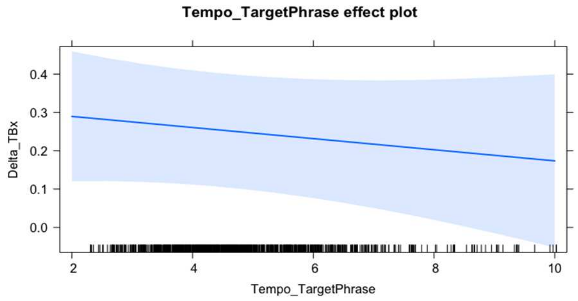

Fig. 4. Effect of measured tempo on tongue body fronting

1. Types of recorded words and phrases
(1) intra-morphemic C_1C_2 (e.g. /sɕ/ *w Odessie* – ‘in Odessa’)
(2) containing a weak morpheme boundary (e.g. /z+tɕ/ *roz+ciągliwa* 'stretchy'),
(3) a strong morpheme boundary (e.g. /z++ɕ/ *roz+siadać* 'sit'),
(4) a clitic boundary (e.g. /z#ɕ/ *bez ziaren* 'without seeds’),
(5) a word boundary (e.g. /s##ɕ/ *włos siwy* 'a grey hair').

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