Lingual articulatory evidence of fricative-vowel coarticulation in Japanese devoiced vowels

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Background: Previous acoustic studies have shown effects of a vowel on the preceding fricative (C_1) across languages including Tokyo Japanese. In Tokyo Japanese, however, high vowels (/i/ and /u/) are typically devoiced between voiceless consonants. There is a controversy on whether devoiced vowels are (a) deleted entirely (i.e., there is no vowel-specific supralaryngeal gesture) or (b) merely unphonated (the vocalic gestures are retained). Acoustic studies (e.g., Beckman & Shoji, 1984; Tsuchida, 1994; Whang, 2018) have reported fricative-vowel coarticulation even when the vowel is devoiced, indicating that the devoiced vowel is still present. Articulatory evidence of the following vowel's effects on the lingual articulation of C_1 even when the vowel is devoiced should support this claim. While Shaw and Kawahara's (2018) lingual articulatory study shows that devoiced /u/ in real words is optionally deleted, both Tsuchida (1994) and Whang (2018) report that there is a difference in spectral properties between /ɕi/ and /ɕu/ at the offset of the fricative even when the vowel is devoiced. Spectral differences, however, could have been based on differences in the lip configuration or other sources. Thus, we look at the lingual gestures of /ɕ/ to see whether there are coarticulatory effects of the following vowel. Assuming there are (i.e., the tongue configuration is different between [ɕi] and [ɕu] at the offset of the fricative), this difference would give us further insight into whether devoiced vowels are deleted or merely unphonated.

Hypotheses: We entertain two hypotheses with regard to fricative-vowel coarticulation in devoiced vowels.

1. Devoiced vowels are deleted: In this case, we predict that the tongue configuration should be the same for all productions of [ɕ] in the devoiceable environment since there is no following vowel.
2. Devoiced vowels are still present: Here, we predict the same differences in the lingual articulation between [ɕi̥] and [ɕu̥] as those found between [ɕi] and [ɕu].

Methods: Three native speakers of Tokyo Japanese produced two word-pairs contrasting in the voicing realization of /i/ and /u/ (Table 1). Devoiceable vs. non-devoiceable stimuli were made by the voicing of C_2. All stimuli are nonce words except for /ɕide/, meaning that devoiced /i/ and /u/ were produced in nonce words. Tongue contours were traced from ultrasound frames corresponding to the offset of frication of /ɕ/. The comparison was made via smoothing spline ANOVA (e.g., Davidson, 2006).

Vowel	Devoiceable	Non-devoiceable
/i/	/ɕite/	/ɕide/
/u/	/ɕute/	/ɕude/

Table 1: *Stimulus items*

Results and discussion: The results from one speaker at the offset of /ɕ/ are shown in Figure 1. First, fricative-vowel coarticulation was observed when the vowel was voiced. While the tongue shape looked similar between [ɕi] and [ɕu], the tongue body, particularly the front part of it, was significantly higher when the fricative was followed by /i/ than by /u/ (Figure 1a). The same difference was observed even when the vowel was devoiced: The tongue body was mostly higher for [ɕi̥] than for [ɕu̥] (Figure 1b). For the /ɕi/-pair, the tongue contours mostly overlapped between [ɕi] and [ɕi̥] (Figure 1c). For the /ɕu/-pair, on the other hand, the tongue body was somewhat lower when the

vowel was devoiced (Figure 1d). We also looked at the tongue configuration of /ɕ/ at the onset of the fricative. The results at the onset were comparable to those at the offset.

The findings from this speaker are mostly consistent with the hypothesis that the devoiced vowel is present: Devoiced /i/ and /u/ in nonce words appear to still retain their lingual articulatory gestures, at least for this speaker. However, the lower tongue position for [ɕu̥] than for [ɕu] is actually not predicted by either hypothesis, and thus requires further analysis with more data from all speakers. The effects of the devoiced vowels on the lingual articulation of /ɕ/, including at the onset, will be further discussed when the data from the other speakers are available.
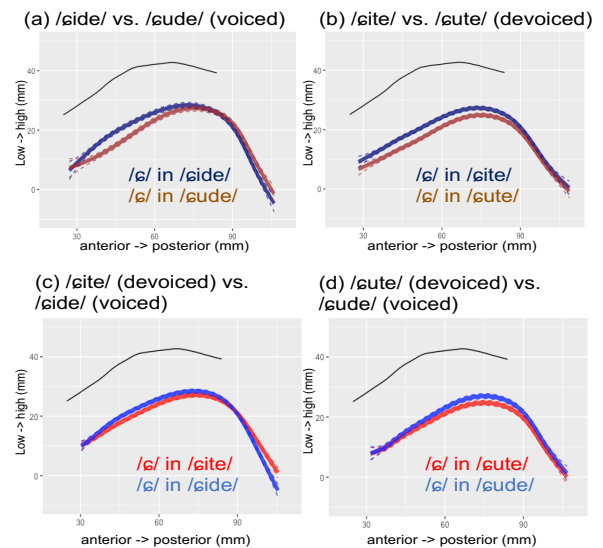
Figures 1: *Smoothing splines (solid) along with 95% Bayesian confidence intervals (dashed) of the tongue contour at the offset of /ɕ/ from one speaker. For (a) and (b), the navy represents when /ɕ/ was followed by /i/ and the brown illustrates /ɕ/ followed by /u/. For (c) and (d), red lines represent when /ɕ/ preceded a devoiced vowel and blue lines represent when /ɕ/ was followed by a voiced one. The black line represents the average palate trace for this speaker.*

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