

Prosodic position effects on Cantonese vowels: ultrasound evidence for initial strengthening and final reduction in disyllabic words

¹ Chu Yan Ho, ¹ Yijing He, ¹ Wai-Sum Lee

¹City University of Hong Kong

Introduction: Within-word syllable position has been shown to affect vowel realization in a number of languages. In Korean [2] and Creek [3], vowels in word-initial syllables tend to be produced with more peripheral acoustic targets, whereas vowels in word-final syllables show varying degrees of centralization/reduction. These asymmetries suggest a systematic tendency for initial syllables to be more strongly realized than final syllables within the word. This pattern is consistent with the phenomenon of prosodic strengthening at larger prosodic edges, where domain-initial positions are associated with strengthened vowel realization relative to medial or final positions [1]. One possibility is that within-word positional asymmetries reflect a similar strengthening effect at the left edge of the word. Acoustic evidence from Cantonese is consistent with this view. Previous work showed that long vowels in disyllabic Cantonese words are more peripheral in initial syllables, while vowels in final syllables are lower and more centralized, particularly for mid vowels (see Fig. 1) [4]. The present study asks whether these acoustic asymmetries are reflected in tongue articulation. Using ultrasound tongue imaging, we examine tongue contour differences between initial and final syllables across seven Cantonese vowels.

Methodology: The same wordlist from [4], which includes seven Cantonese long vowels, /i y u ε œ ɔ a/, in meaningful CV.CV disyllabic words were in the experiment. 7 native Cantonese speakers (5F2M, aged 20-23) were asked to repeat the wordlist 5 times. Stimuli were recorded using Articulate Assistant Advanced with a stabilizing headset. Ultrasound tongue contours were automatically tracked with DeepLabCut. For each vowel, tongue contour data were analyzed using a generalized additive mixed model (GAMM) implemented in *mgcv* in R. Radial distance was modelled as a function of angular position, with syllable position (initial vs final) entered as a parametric predictor and separate smooths of angular position fit for each position. To account for repeated observations and between-speaker variability, the model included random effects for speaker and individual contour trajectory.

Results and Discussion: Figure 2 shows pooled GAMM predictions of tongue contours for seven Cantonese vowels across speakers. Overall, the effect of within-word syllable position (initial a vs. final b) is expressed mainly as subtle vertical shifts in tongue contour, and the magnitude of this effect varies by vowel category. The high front unrounded vowel /i/ shows minimal initial-final separation, with near-overlapping trajectories. In contrast, the high rounded vowels /y/ and /u/ show a clearer positional effect: initial-syllable productions are generally higher than final-syllable productions, consistent with greater articulatory displacement in initial position and mild undershoot in final position. This pattern contrasts with the acoustic findings in [5] which shows marginal positional difference for /y/ and /u/. The mismatch suggests that even when acoustic differences are limited, systematic differences in tongue contour may persist. One possible interpretation is that high vowels occupy acoustically stable regions of the vowel space, such that comparable articulatory variation yields only limited acoustic change. Mid vowels /ε/ and /œ/ show positional asymmetries that are broadly consistent with the acoustic results in [5], with initial syllables exhibiting relatively higher and more anterior tongue configurations than final syllables, especially for /œ/. For /ɔ/, positional differences are comparatively limited, again in line with the acoustic results. The low vowel /a/ shows the smallest difference; inspection of individual speakers further suggests that this effect is also the least consistent across speakers. Taken together, these results suggest that within-word positional strengthening in Cantonese is most clearly expressed in the high rounded and mid vowels, while /a/ shows relatively weak and variable effects.

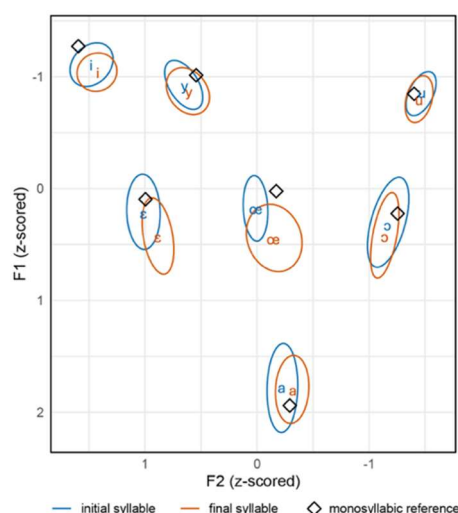


Fig. 1. Positions in the z-scored F1/F2 plane for the Cantonese long vowels in the initial (blue) and final (orange) syllable, reconstructed from [4]

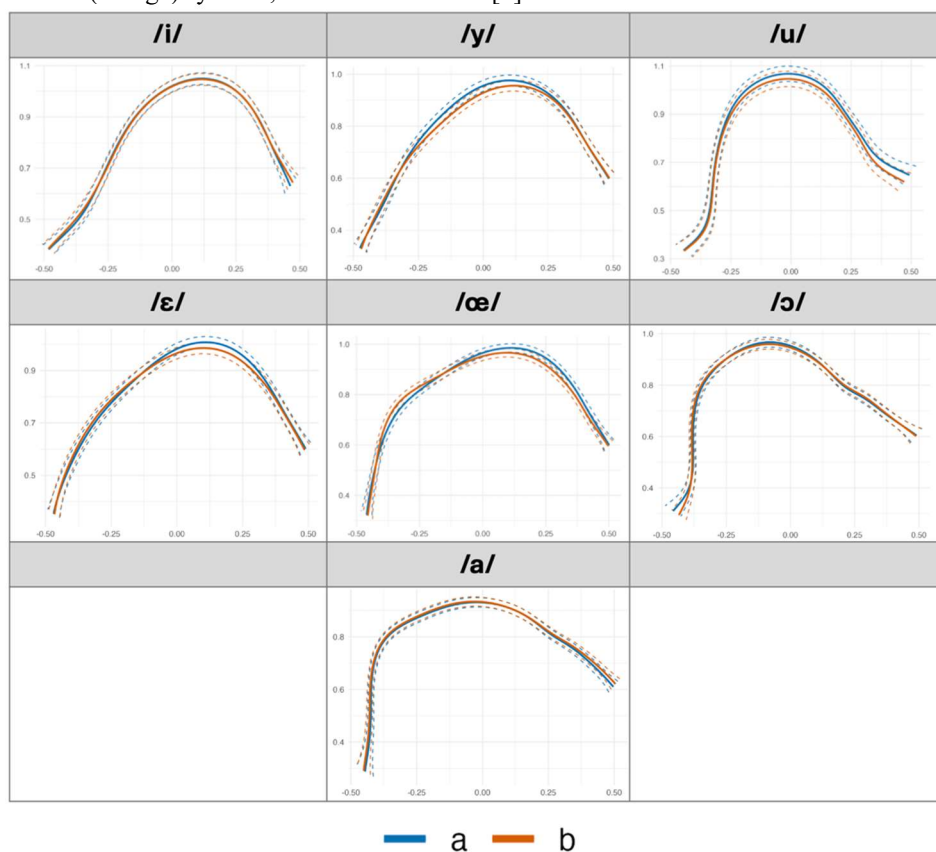


Fig. 2. By-vowel mean tongue contours with 95% confidence intervals (dashed lines) for the initial (blue) and final (orange) syllables, estimated from separate GAMMs across speakers

References

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