

# Coarticulatory effects on lingual articulations in the production of Cantonese syllable-final oral stops

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## Introduction

Previous studies have determined that the inaudibly-released syllable-final oral stops [p<sup>7</sup> t<sup>7</sup> k<sup>7</sup>] of Cantonese are primarily cued by spectral formant transitions into stop closure during the preceding vowel (Ciocca et al., 1994; Khouw & Ciocca, 2006). However, younger speakers are reported to have a tendency to either merge the alveolar and velar codas [t<sup>7</sup>] and [k<sup>7</sup>] or produce a full glottal closure in lieu of or immediately preceding the coda gesture (Zee, 1999; Law et al., 2001), potentially leading to perceptual confusions between alveolar and velar stop place. While prior perceptual work has attributed this phenomenon to the phonological loss of a coronal-dorsal coda place contrast in younger speakers, articulatory investigations of the loss of [t<sup>7</sup>]-[k<sup>7</sup>] contrasts for this segment of the population are lacking. The goal of this study is to understand whether young-adult speakers consistently produce lingual gestures that correspond to the coda stops [t<sup>7</sup>] and [k<sup>7</sup>] and whether there are strong anticipatory coarticulatory influences that could mask the acoustic cues to coda place according to the place of the following consonantal gesture.

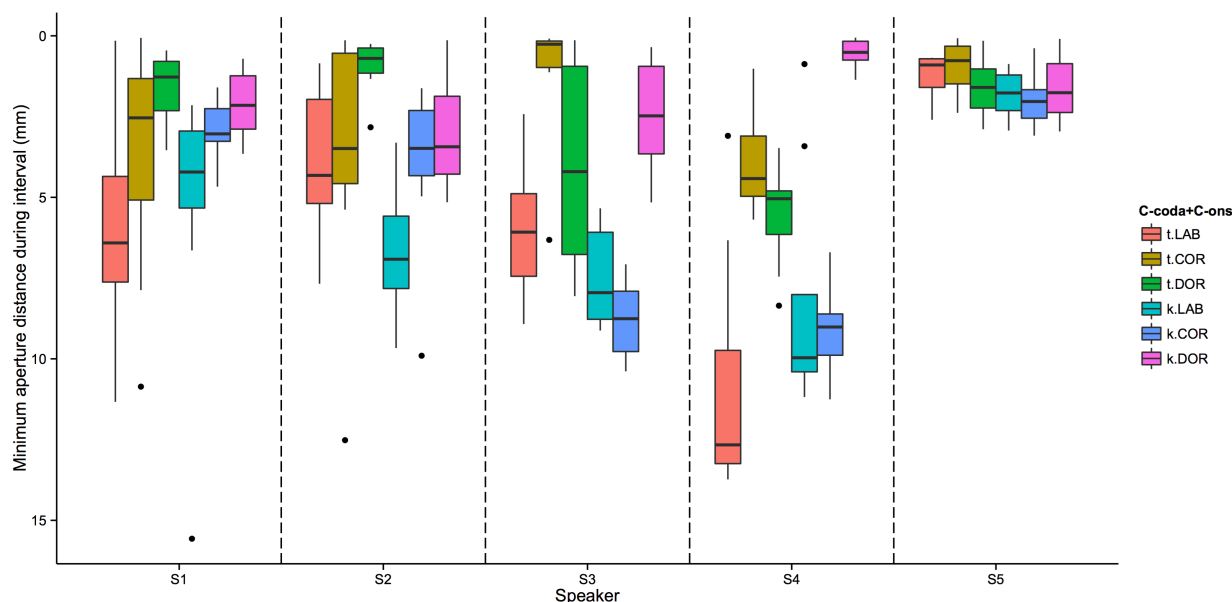
## Methodology

In this study, ultrasonic tongue imaging was used to examine the lingual dynamics during the production of coda stops [t<sup>7</sup>, k<sup>7</sup>] in 24 Cantonese disyllabic words. These target words were selected such that the initial syllables containing the coda stops were one of 4 morphemes (發 [fa:t<sup>3</sup>], 法 [fa:t<sup>3</sup>], 白 [pa:k<sup>2</sup>], and 拍 [p<sup>h</sup>a:k<sup>3</sup>]) and the second syllables contained onset consonants with labial, coronal, and dorsal place of articulation, e.g. [fa:t<sup>3</sup>men<sup>21</sup>] vs. [fa:t<sup>3</sup>ta:t<sup>2</sup>] vs. [fa:t<sup>3</sup>kok<sup>3</sup>] and [pa:k<sup>2</sup>pa:m<sup>25</sup>] vs. [pa:k<sup>2</sup>teu<sup>25</sup>] vs. [pa:k<sup>2</sup>kap<sup>25</sup>]. Ultrasonic images of the productions of 5 native speakers of the Hong Kong variety of Cantonese were collected using a Telemed ClarUs machine at a frame rate of 60 fps and sequences of ultrasonic frames were extracted during the interval [...V<sub>1</sub>C<sub>1</sub>.C<sub>2</sub>V<sub>2</sub>...] within each target item, as determined from the synchronized acoustic signal. Splines corresponding to lingual contours in each frame within the intervals of interest were traced and extracted in EdgeTrak (Li et al., 2005), as well as contours of the palate. To assess the achievement of syllable-final stop gestures, minimum values of distance between the tongue contour and coronal and dorsal regions of the palate ("aperture") during C<sub>1</sub>-C<sub>2</sub> closure were calculated at each frame time. For each talker, minimum aperture distances corresponding to the coda gesture were compared in a linear mixed-effects model with fixed effects of *articulator* (tongue tip, tongue dorsum) and *place context* (labial, coronal, dorsal) and the random effect of *item*.

## Results & Discussion

The data reveal that the 5 speakers' productions fell into three general categories of articulatory patterns: gestural preservation (S5), gestural reduction or partial loss (S1 and S2), and near-complete loss (S3 and S4). In the preservation pattern, lingual articulations consistently achieved full stop closures near the end of the first vowel, regardless of articulator and place context. In the reduction/partial loss pattern, lingual articulations were greatly reduced in labial contexts but involved strong effects of tongue-tip to tongue-dorsum coproduction in lingual-lingual sequences (t+DORSAL and k+CORONAL). For talkers exhibiting nearly complete loss of the syllable-final stop articulations, movements of the tongue during the C<sub>1</sub>-C<sub>2</sub> closure interval corresponded strongly to the place of the following onset consonant only, with little evidence of lingual coproduction behaviors. Differences in speech rate are also observed and could be the source of gestural timing variation between speakers. The articulation of Cantonese syllable-final stops were varied – not only between

talkers but also before syllables differing in onset place—and this variability even occurred within the same morpheme (Chinese character) in different contexts. The results of this study provide a richer picture as to whether and how the inaudibly-released, syllable-final, lingual oral stops in Cantonese are produced by young-adult talkers.



**Figure 1. Boxplot of minimum aperture distances during the C<sub>1</sub>-C<sub>2</sub> closure interval for codas [t] and [k] (C<sub>1</sub>) in labial, coronal, and dorsal onset (C<sub>2</sub>) contexts, grouped by speaker.**

## References

- Ciocca, V., Wong, L., & So, L. 1994. An acoustic analysis of unreleased stop consonants in word final positions. *Proceedings of the International Conference on Spoken Language Processing, Yokohama*, vol. 21, 1131-1134.
- Khouw, E. & Ciocca, V. 2006. An acoustic and perceptual study of final stops produced by profoundly hearing impaired adolescents. *Journal of Speech, Language, and Hearing Research*, **49**, 172-185.
- Law, S.-P., Fung, R. S.-Y., & Bauer, R. 2001. Perception and production of Cantonese consonant endings. *Asia Pacific Journal of Speech, Language and Hearing*, **6**, 179-195.
- Li, M., Kambhamettu, C., & Stone, M. 2005. Automatic contour tracking in ultrasound images. *Clinical Linguistics and Phonetics*, **19**(6-7), 545-554.
- Zee, E. 1999. Change and variation in the syllable-initial and syllable-final consonants in Hong Kong Cantonese. *Journal of Cantonese Linguistics*, **27**, 120-167