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Development of lingual articulations among Cantonese-speaking children

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Introduction

The vocal tract undergoes substantial physical change from early childhood into late childhood, and it is a commonly held belief that many of the speech production issues that appear during the beginning of elementary school are simply a continuation of earlier speech behaviors rather than novel, atypical behaviors. In this paper, we examine the development of lingual articulation as Cantonese-speaking children mature from a young age toward adulthood, with the question as to whether speech production issues during later childhood are indeed a continuation of speech production patterns in early childhood. Developing children may struggle to produce adult-like speech sounds when the proportional sizes of their speech organs differ from those of adults (McGowan, personal communication). To do so, we use ultrasonic tongue imaging to examine the shape of the tongue during the articulation of lingual consonant sounds known to be acoustically interchangeable among younger Cantonese-acquiring children but typically acoustically distinct by elementary-school age (To *et al.*, 2013). The consonantal contrasts of interest are:

- Alveolar stops [t, tʰ] vs. velar stops [k, kʰ] (typically adult-like by age 3;6)
- Alveolar lateral [l] vs. central palatal [j] (typically adult-like by age 4;0)
- Apical affricates [ts, tsʰ] vs. laminal fricative [s] (typically adult-like by age 4;6)

Methodology

In our study, we collected ultrasonic images during these lingual consonants spoken by participants belonging to 3 age categories: 7 younger children (2;6 to 4;6), 8 older children (4;7 to 9;0), and 8 adults (18 or older). The general articulatory ability of each child was assessed using the Hong Kong Cantonese Articulation Test (HKCAT) (Cheung *et al.*, 2006). The HKCAT contains 91 test sounds (48 onsets, 29 vowels, 16 codas) elicited through pictured words and transcribed by researchers with phonetic training. Target words were monosyllables beginning with each sound of interest, followed by the rime [aː] or [ɐm]. There were 9 Cantonese target words in total. Children were prompted to say each item in a picture-naming task, and adults received items prompts in Chinese orthography. Children produced up to 5 repetitions of each item and adults produced 6 iterations of each item. Head-to-probe stabilization was achieved with 3 fully articulating camera/lighting arms: 2 arms provided resting points for talkers' foreheads and 1 arm held the transducer in a fixed position. During scanning, best efforts were made to ensure that each talker's head did not move relative to the probe. Image frames of interest were determined through the acoustic recordings and lingual contours within frames were extracted with EdgeTrak (Li, *et al.*, 2005).

In order to assess the degree of articulatory place contrast within each talker's productions, the angle of maximal constriction along the lingual contour during the production of each sound was measured, where maximal constriction was defined as the point along the contour at which minimum aperture distance to the hard palate contour (as ascertained from video images of water boluses) occurred during the interval of articulatory achievement. Angles were taken from a reference angle of 0°. Examples of this measurement are shown in Figure 1. As a result of this measurement procedure, place contrasts should involve larger angles of constriction for dorsal sounds [k, kʰ] than for coronal sounds [t, tʰ]. Angles were then converted into *z*-scores in order to allow for comparisons between talkers, who possess varying vocal tract shapes and sizes.

Results & Discussion

Data indicate that all adult talkers and most older and younger children produced the target consonant sounds with the expected relative constriction angle. However, 6 out of the 15 children (3 younger, 3 older) frequently articulated alveolar sounds in the dorsal region

(examples in Figure 2). These results correspond relatively well with each child's HKCAT scores. For 5 of these children, both alveolar and velar sounds were produced with a wide degree of variation in terms of where constrictions were formed, suggesting that these children have not yet identified specific locations along the palate where these sounds should be articulated. The remaining talker (CC05: age 5;6) consistently articulated the alveolar stops [t, t^h] nearly identically to the velar stops [k, k^h], despite the fact that the productions of coronal sounds [ts, ts^h, s, l] were articulated with tongue-tip raising toward the dento-alveolar region. This finding indicates that, while younger talkers (below 4;6) may not yet have mastered the contrast between coronal and dorsal articulations, sometimes even executing dorsal and apical raising gestures simultaneously, older children who have persistent articulatory issues, such as CC05, may have settled on consistent, although mismatched, articulations for their consonant productions during early childhood.

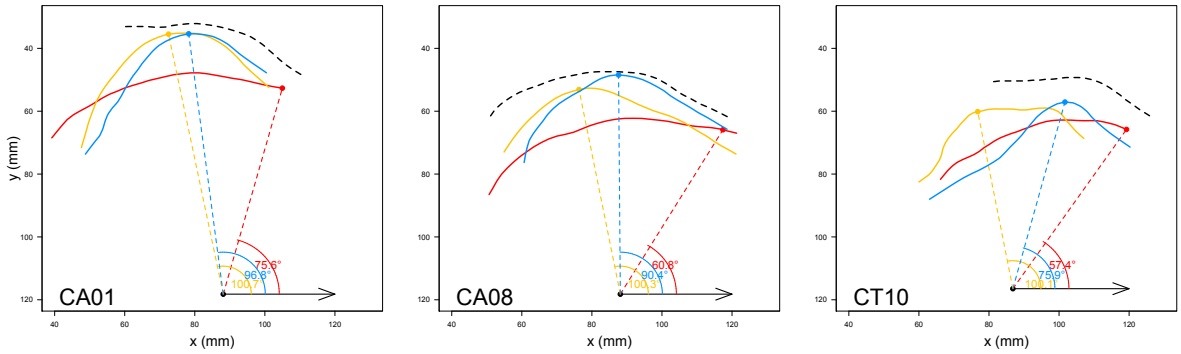

Figure 1. Examples measures of *angle of maximal constriction* for lingual contours during velar [k] (yellow), palatal [j] (blue), and alveolar [t] (red) gestures, as produced by two adult talkers (CA01, CA08) and one younger child (CT10: age 4;4).

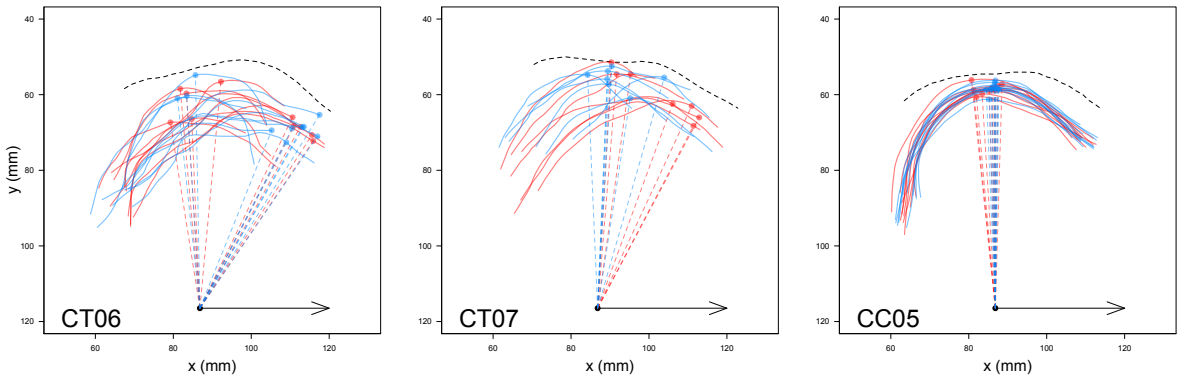

Figure 2. Lingual contours (and constriction angles) from alveolar stops [t, t^h] (red) and velar stops [k, k^h] (blue), produced by child talkers with the lowest three HKCAT scores: CT06 (age 3;10, HKCAT score 56.0%), CT07 (age 3;5, HKCAT score 68.1%), and CC05 (age 5;6, HKCAT score: 74.7%). For the sake of clarity, lingual contours from other target sounds are not pictured.

References

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