

Tongue Performance in Articulating Mandarin Apical Syllables by Prelingual Deaf Adults Using Ultrasonic Technology: Two Case Studies

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Introduction

Apical syllables in Mandarin, which are formed by sibilants and their corresponding vowels, are notoriously hard both for normal hearing and deaf children. In the past, the apical syllable and its acquisition by deaf children had received decent attention. Nevertheless, there is still no study discussed the articulatory characteristics of producing apical syllables by deaf mutes, especially for cases of deaf adults.

Using the technology of **ultrasound**, the present paper aims at observing the performance of tongue when prelingual deaf adults produce apical syllables, to classify the types of errors, and to clarify the contribution of tongue for the errors in producing apical syllables.

Materials and Methods

Participants Two prelingual deaf college students from Beijing, one male (M) and one female (F), the hearing loss is about 85dB and over 90dB for left and right ear for M, and about 90dB for both ears for F.

Materials 6 apical syllables with 4 tones are divided into two groups (*zi*, *ci*, *si* as *zi* group and *zhi*, *chi*, *shi* as *zhi* group) and selected for analysis.

Data Recording A Terason T3000 ultrasound system with a 8MC3 transducer and its supporting helmet, a Cs5 Microphone with a Roland audio mixer. The sampling frequency of ultrasound is 60 Hz.

Data Processing The audio Signal was judged by 3 linguists and analyzed by Praat. The ultrasonic data was processed by Edgetrak to interpolate 100 X-Y equidistant points from tongue back to tongue tip for each frame. The processed data of each participant were divided into two groups (*zi* group and *zhi* group) for general statistics. Then, according to different research purposes, relevant data were selected and analyzed respectively.

Conclusion

M can not differentiate the two groups, and F has the ability to distinguish the two groups in general.

1. both of them have the problem to produce alveolar syllables as post-alveolar syllables
2. both of them have the tendency to realize the affricates as fricatives.
3. they might build up the divided categories for most of the apical syllables, but because of lacking enough control of their articulators, they could not properly produce those consonants and/or vowels in some specific situations.

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General results

Results of one-Way ANOVA show that, for the male speaker, both of the two sets of syllables are not significantly different at the $p < 0.05$ level; for the female speaker, although the tongue length fails to show any significance, the tongue heights of the two groups are significantly different at the $p < 0.01$ level.

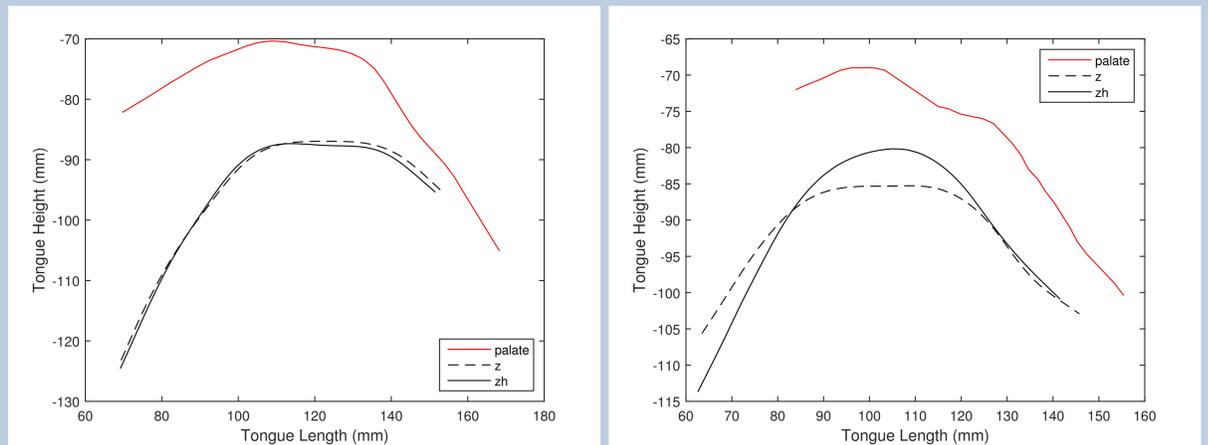


Figure 1: Tongue shapes of the participants (mm)(M:Left; F:right)

The case studies

The male participant

The main difficulty of M is that he cannot distinguish the two sets of syllables. Results of the behavior test indicate that he pronounces 83.3% of alveolar syllables as post-alveolar syllables.

For the alveolar syllables, except for the cases of *ci* under tone 1 and tone 2 which partly keep the sound quality of alveolar, all the syllables left are realized as post-alveolar. Fig. 2 displayed the mean tongue shapes of *ci* under tone 1 and tone 2 at 50% of DurC and 50% of DurV, as well as that of *ci* under tone 3 and tone 4 for the male subject.

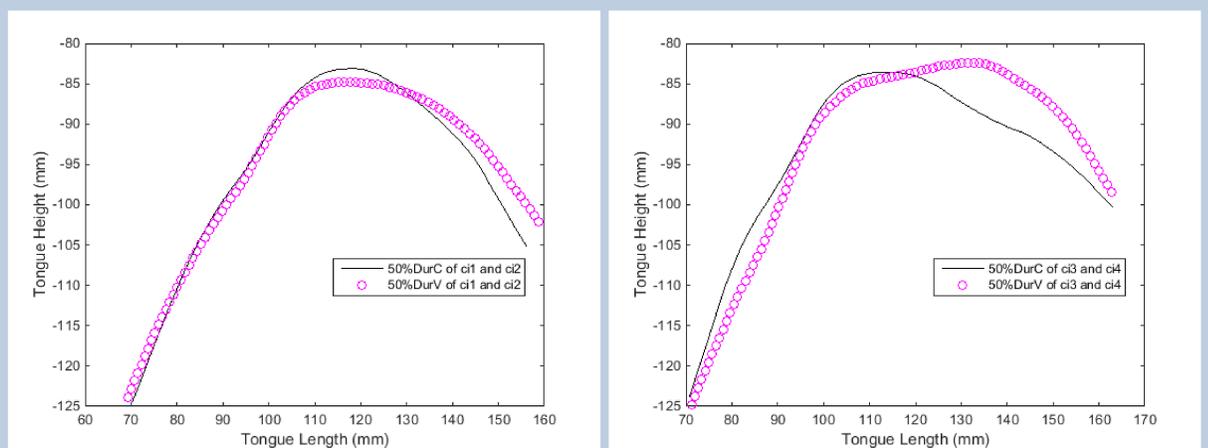


Figure 2: Tongue shapes of *ci* at 50% DurC & 50% DurV (mm)

From Fig. 2, one can see the tongue shape of *ci* experiences limited change from 50% DurC to 50% DurV under tone 1 and tone 2, while the arch of the tongue front is drastically smoothed in that period for *ci* under tone 3 and tone 4. Therefore, it is safe to assume that the tongue performance of the male subject in producing *ci*s is consistent with the result of perception judgement, that he can pronounce the *ci*1 and *ci*2 properly, but could not produce *ci*3 and *ci*4 in a correct way. In these cases, he could not keep the stable tongue shape of *ci*, but gradually changes it into the configuration of *chi*.

The female participant

The major problem for the female participant is not that she could not distinguish the two groups, but that she has the difficulties in properly realizing them, especially for the cases of post-alveolar syllables. Results of perception judgement show that around 58% of post-alveolar vowels are sounded as a transition from *-i* to mid-vowel *e*, and the consonants in these tokens are sounded as a fricative similar as [f].

For the cases of alveolar syllables, besides about 25.3% of tokens being misproduced as post-alveolar syllables, the subject also tends to prolong the alveolar consonant which causes the abnormality of the sound quality. Taken *si* for instance, the mean duration of its consonant under four tones occupy from 57.2% to 67.3% of the duration of the whole syllables.

Fig. 3 demonstrates the average tongue mid-sagittal configurations and their variations at the time of 0%, 25%, 50%, 75% and 100% of the prolonged consonants' articulation, as well as the results of one-way ANOVA for the tongue length and tongue height on the five time points.

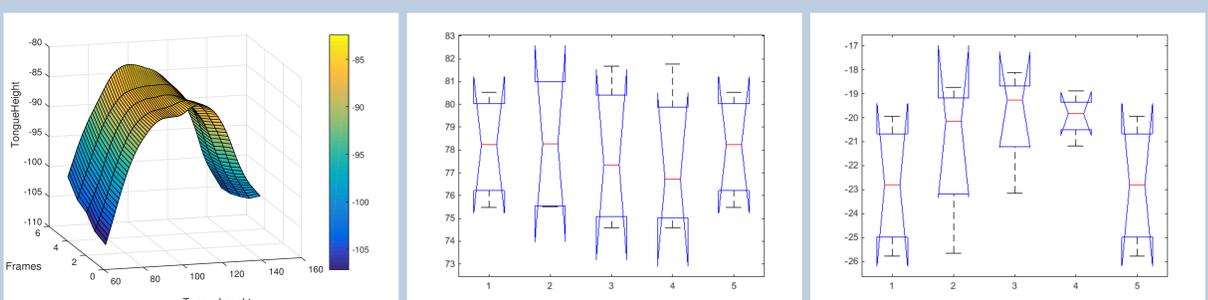


Figure 3: Mean tongue frames and one-way ANOVA results of the prolonged consonants

Taken together, the tongue changes over the production of the prolonged alveolar consonants, might lead to the variations of the sound quality, and consequently cause the abnormality in perception of these alveolar consonants.