'Apical vowels' are not vowels: acoustic and ultrasound evidence from Jixi-Hui Chinese

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Chinese languages are known to have a specific set of segments, termed 'apical vowels' (Lee & Zee 2003, Duanmu 2007, Lee-Kim 2014). In Standard Chinese, they are always homorganic to the preceding coronal fricatives or affricates. Ladefoged and Maddieson (1996: 314) note that they are "*made with the tongue in essentially the same position as in the corresponding fricatives*" and refer to these segments as 'fricative vowels'. Trubetzkoy (1969: 171) describes them as "*a type of vowel with a much lesser degree of aperture and with a much more fronted position of articulation than, for example, i, so that a frictionlike noise resembling a humming is audible in its production*". In this study, we are concerned with the 'apical vowel' in Jixi-Hui-Chinese (JHC), a Chinese language of Hui group spoken in southern Anhui province. We provide evidence from acoustic and ultrasound data that this segment, noted /z/ here, displays phonetic characteristics of a fricative rather than of a vowel.

Method: We collected acoustic data from 10 JHC speakers (5 females and 5 males) and ultrasound tongue imaging data from 7 speakers (3 females and 4 males). A word list was constructed with the following 5 segments [i, a, u, ʉ, z] occupying the rhyme of monosyllabic real words starting with /p_, pʰ_, m_, n_, ts_, tsʰ_, s_/ with different tonal structures. Each word was pronounced within a carrier phrase ([ki˥ ɕɔ˨˩ _ ɕɔ˨˩ sɔ˧ fa˧] 'He writes _ three times'), with 5 repetitions for acoustic recording and 3 repetitions for ultrasound recording. Mid-sagittal data were obtained for the ultrasound experiment, using an *Ultrasound Stabilisation Headset* (Articulate Instruments Ltd. 2008) and the *Articulate Assistant Advanced* software (AAA, V217.03) (Articulate Instruments Ltd. 2012). The acoustic experiment examined (i) the formants of [i, a, u, ʉ, z], (ii) the harmonic-to-noise ratio (HNR) of [i, ʉ] and [z], and (iii) the centre of gravity (COG) of the aspiration phase of [pʰ] onset and the COG of [s] onset. We also visually inspected the acoustic signals and the spectrograms of /z/ in order to provide a qualitative classification of this segment based on the amount of frication noise produced. In this abstract we focus more specifically on the tokens with labial onsets /p_, pʰ_, m_/, assumed to be minimally coarticulatory and we compare them with /s_/ context. The idea is that the acoustic characteristics of /z/ and its tongue shape will be minimally influenced by the onset consonants in the context of labials.

Results: Results from the acoustic experiment show that /z/ is qualitatively different from /i/, but has similar F1 to [u] and similar F2 to [ʉ]. The visual examination of the acoustic signals and spectrograms shows that [z] displays frication noise on more than half of its duration for all speakers. Given that the labial consonants have objectively no frication noise to spread, the noise displayed by apical vowel [z] in this context cannot be considered as the voiced prolongation of the onset consonants (as is argued for apical vowels in Standard Chinese, e.g., Dell 1994, Duanmu 2007). Results from the HNR show that [z] has the lowest values, especially in the first half of the segment, providing additional evidence that this segment contains substantially more noise than [i, ʉ]. As Figure 1 shows, the centre of gravity (COG) of the aspiration phase of /pʰ/ is similar to the COG of onset /s/, while in all other syllables, the COG of /s/ is much higher. This suggests that the articulatory target of /z/ is achieved during the closure phase of /pʰ/, so that the frication noise generated at the oral constriction becomes dominant over the aspiration noise at the glottis. Figure 2 presents representative tongue shape configurations of syllable /pʰz/ from two speakers. It shows that regardless of the articulatory strategies adopted by JHC speakers, the articulatory target for the apical vowel is achieved as early as during the closure phase of the onset consonant /pʰ/. Once the target is achieved, the tongue does not move significantly until the mid-point of the apical vowel. The same phenomenon is observed in /pz, mz/ syllables. This provides evidence that the coronal fricative tongue shape is the canonical articulatory target of the apical vowel in JHC.

Discussion: From a diachronic point of view, /z/ is argued to evolve from /i/ (Zhu 2004). Similar to vowels, /z/ functions as a carrier of prosodic information (it can occupy the nucleus position of a syllable and be a tone-bearing unit). But /z/, as we showed, displays acoustic and articulatory characteristics of a fricative consonant. This mismatch between the phonetic makeup of /z/ and its phonological behavior will be discussed in light of the relevant literature on the vowel/consonant dichotomy and their differing properties.

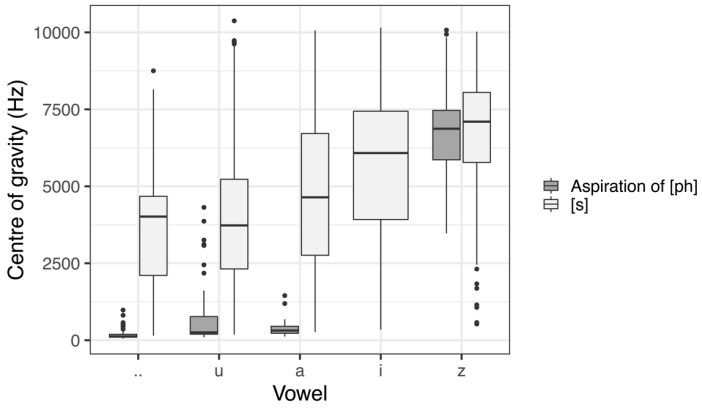

Figure 1 Centre of gravity of the aspiration phase of [p^h] onsets compared to [s] onsets. Data obtained from 10 speakers. [i] vowel only has [s] onset.

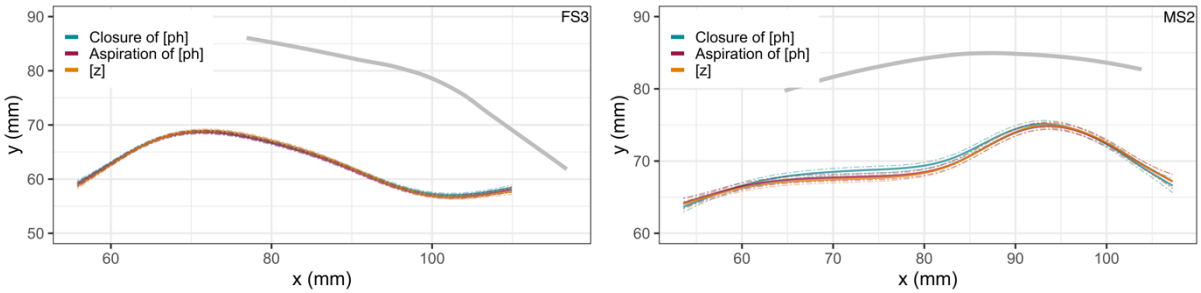

Figure 2 SS ANOVA splines of mid-sagittal ultrasound tongue contours, extracted in x/y values (mm) at the nearest centre image of each segment. The tongue tip is on the right and tongue root on the left. Blue lines represent the nearest centre images of the closure of [p^h], red lines represent the nearest centre images of the aspiration phase of [p^h] and yellow lines represent the nearest centre of nuclei [z]. The splines are presented with 95% Bayesian confidence intervals. The thick grey lines represent the palatal traces obtained with water swallow tasks.

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