

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

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## I. Aim

In this study, we analyze the coarticulation between the **labial onsets and the apical vowel /z/** in Jixi-Hui Chinese (JHC). We seek to prove that this unique segment, particularly well studied in Standard Chinese, has characteristics of **a fricative consonant**.

## II. Background



Jixi-Hui Chinese 绩溪话 (JHC) belongs to Hui 徽 group spoken in southern Anhui 安徽. It has eight monophthong vowels and one apical vowel /i y u ɤ o ɤ ɔ a/+z/ (Zhao, 2003).

It counts for 7.2% of the monosyllabic entries of Jixi dictionary, and can appear in /pz p<sup>h</sup>z mz nz/ in addition to /tsz ts<sup>h</sup>z sz/ syllables.

### ❖ Phonetic characteristics of Apical /z/ in JHC

(Shao & Ridouane, 2018; 2019; 2020)

It contains frication noise even after coronal nasal /n/, the general presence of frication noise is confirmed by Zero-Crossing Rate. Illustrations are from one speaker's [nz<sup>44</sup>] and all male speakers' ZCR data.

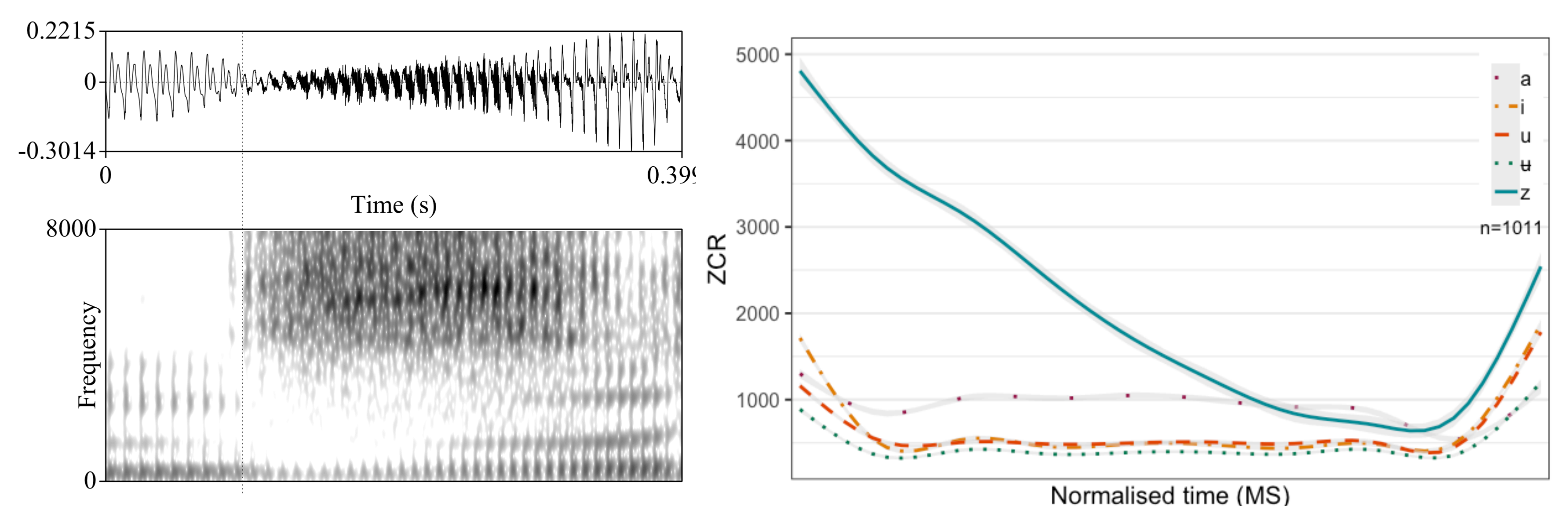
### ❖ Phonological patterning of /z/ in JHC

It is a **distinct phoneme** which can contrast with /i/:

[si<sup>31</sup>] 修 'repair' vs. [sz<sup>31</sup>] 丝 'silk'  
[tsi<sup>31</sup>] 周 'a family name' vs. [tisz<sup>31</sup>] 鸡 'chicken'

It is a tone-bearing unit (TBU), rime of the syllable, and can be subject to tone sandhi:

/sz<sup>31</sup>/ 'west' + /ko<sup>31</sup>/ 'melon' → [sz<sup>33</sup>ko<sup>31</sup>] 西瓜 'watermelon'  
/p<sup>h</sup>z<sup>31</sup>/ 'to comment' + /p<sup>h</sup>iä<sup>44</sup>/ 'judge' → [p<sup>h</sup>z<sup>33</sup>p<sup>h</sup>iä<sup>44</sup>] 批评 'criticize'



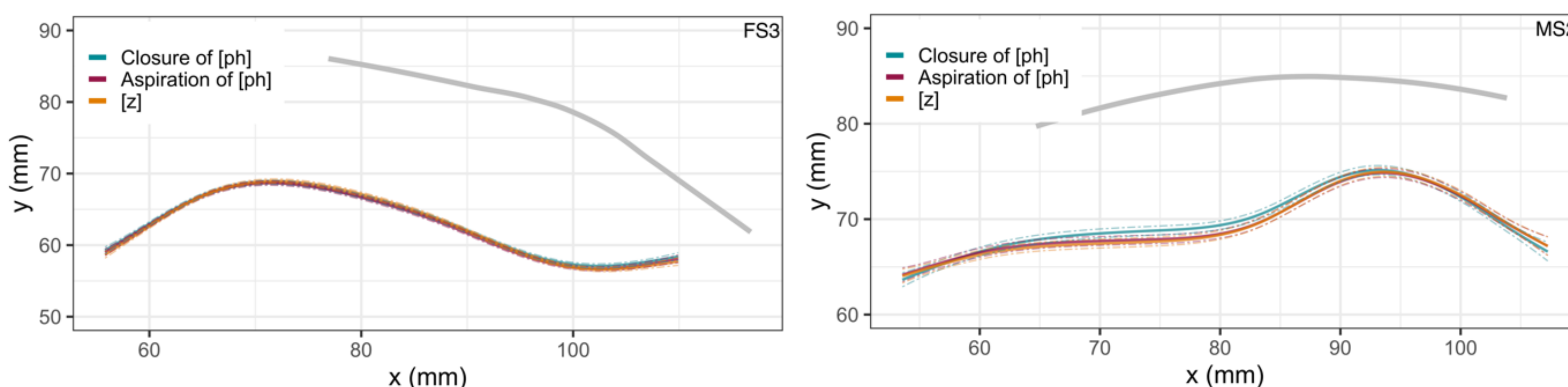
## III. Acoustic and articulatory studies

- Data acquired at Jixi city, in Anhui Province, China with native speakers (10 for acoustic study and 6 for articulatory study)
- Monosyllabic real words with /i a u ɤ z/ as rhymes starting with /p\_ p<sup>h</sup>\_ m\_ n\_ ts\_ ts<sup>h</sup>\_ s\_/ + tone (controlled)
- Produced within a carrier phrase, repeated 5 times and 3 times respectively for acoustic and ultrasonic recordings

### ❖ Articulatory study

Both mid-sagittal and coronal ultrasound data were recorded with an *Ultrasound Stabilisation Headset* (Articulate Instruments Ltd. 2008) and the *Articulate Assistant Advanced* (AAA) (Articulate Instruments Ltd. 2012) software, generalized in SS ANOVA (Davidson, 2006; Gu, 2014).

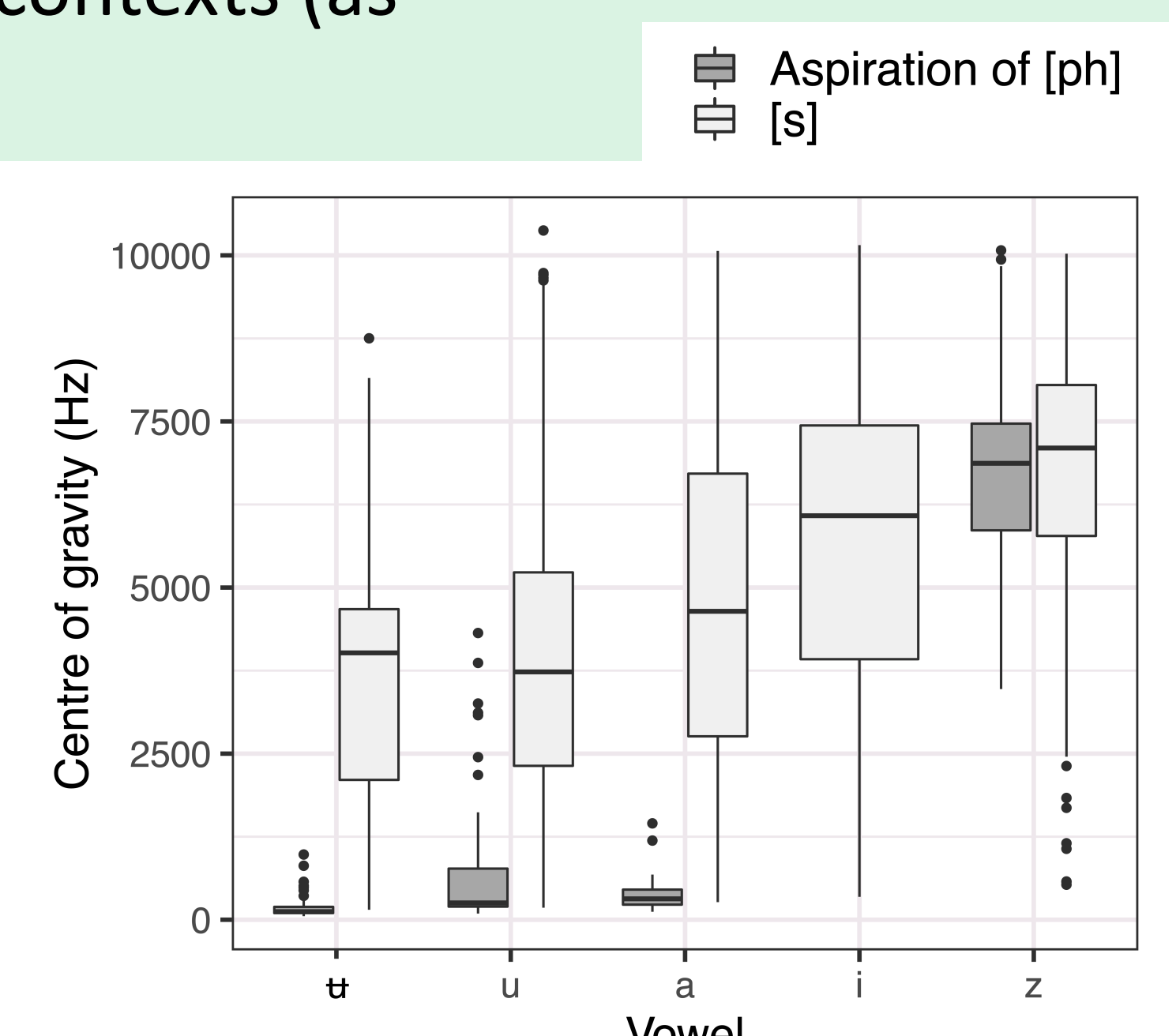
- As **Figure 1** shows, regardless of the articulatory strategies adopted by JHC speakers, the articulatory target for the apical vowel is achieved as early as during the closure phase of the onset consonant /p<sup>h</sup>/.
- Once the target is achieved, the tongue does not move significantly until the mid-point of the apical vowel.
- The same phenomenon is observed also in /pz mz/ syllables and on both mid-sagittal and coronal plane; it is also observed in the two different articulatory strategies.



**Figure 1** 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<sup>h</sup>], red lines represent the nearest centre images of the aspiration phase of [p<sup>h</sup>] 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.

### ❖ Acoustic study

- /z/ is qualitatively different from /i/, but has similar F1 to /u/ and similar F2 to /ɤ/.
- Visual examination of the acoustic signals and spectrograms shows that /z/ displays frication noise on more than half of its duration for all speakers and for all labial onsets.
- 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).
- The acoustic characteristics of /p<sup>h</sup>/ is modified by the /z/ gesture, its aspiration phase has the same centre of gravity as the consonant /s/ in the same contexts (as shown in Figure 2).



**Figure 2** Centre of gravity of the aspiration phase of [p<sup>h</sup>] onsets compared to [s] onsets. Data obtained from 10 speakers. [i] vowel only has [s] onset.

## IV. Conclusion and discussion

- The apical vowel /z/ in JHC displays acoustic and articulatory characteristics of a fricative consonant.
- Its fricative gesture is achieved as early as during the closure phase of the labial onset and has influenced the acoustics of

the labial onset /p<sup>h</sup>/.

- Phonologically, /z/ functions as a carrier of prosodic information.
- This segment provides valuable arguments on the vowel/consonant dichotomy and their differing properties.

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