Articulatory, but not acoustic, target uniformity in Suzhou Chinese

Matthew Faytak faytak@ucla.edu — LSA 2020 Annual Meeting

UCLA

Target uniformity [2, 5]

Phonological content is biased toward similar phonetic implementation across segments

- e.g., feature bundle for [±anterior] sibilant frication tends to be uniformly implemented, for same value of [±anterior]

» **Spectral center of gravity (CoG) correlated**, reflects front cavity length

Unclear which is constrained: acoustic targets or the articulations used to fulfill them

Suzhou Chinese 苏州话

Rich in sibilant sounds, including **fricative vowels** /iʐ/, /yʐ/ and **apical vowels** /ɿ/, [ᶣ]

- Fully, modally **voiced**; light frication appropriate to place [7, 9]
- The vowel series can be thought of as differing in value of [±anterior]
- Vowels contrast for **rounding**, in parallel with high front vowels /i/, /y/

	[+anterior]	[−anterior]
Affricate	ts, ts^h	tɕ, tɕ^h
Fricative	s	ɕ
Vowel, [−rd]	ɿ	iʐ
Vowel, [+rd]	ʮ	yʐ

Phonotactic restrictions:

- Apical/[+ant] vowels always follow [+ant] fricatives
- Fricative/[−ant] vowels follow [−ant] fricatives, but also and a wider variety of onsets

Known **uniformity in articulation** within [±anterior] sets

- Mutually predictable, fricative-like tongue shapes used in each [±ant] series [3, 7]
- Constriction for [−ant] vowels is made non-uniformly by a minority of speakers

Present study

Does uniformity in lingual articulation lead to uniformity in frication acoustics (CoG)?

Goal: Assess relationships among fricative consonants' and fricative/apical vowels' CoG

Hypothesis: Because lingual articulatory uniformity holds, consistent additive effects of voicing, rounding should lower CoG, but correlations in CoG should hold

Materials, method

Participants: 22 speakers (17 F)

Stimuli: CV monosyllables containing both fricative consonants and vowels

- Vowels occurring after fricatives and non-fricative onsets **pooled** in analysis (un-pooled in supplement)

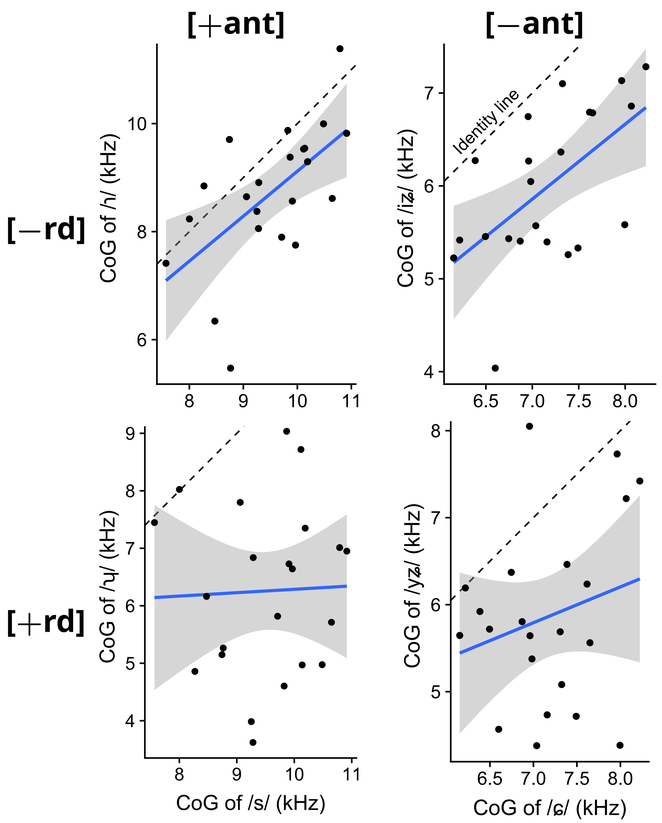
Onset	[+ant] [−rd]	[+ant] [+rd]	[−ant] [−rd]	[−ant] [+rd]
Fric.	丝 sɿ^{44} 'thread'	书 sʮ^{44} 'book'	稀 ɕiʐ^{44} 'rare'	虚 ɕyʐ^{44} 'weak'
Non-fric.	—	—	衣 iʐ^{44} 'garment'	优 yʐ^{44} 'excellent'

Other /s/, /ɕ/: 箫 ɕiæ^{44} 'flute', 沙 su^{44} 'sand', etc.

Spectral center of gravity (CoG) calculated from middle third of target segments, stop-band filtered below 3 kHz

- Wider frequency band than normal [4, 8]
- Fricative vowels have *much* more harmonic energy than voiced fricatives; present in clear formants up to F4

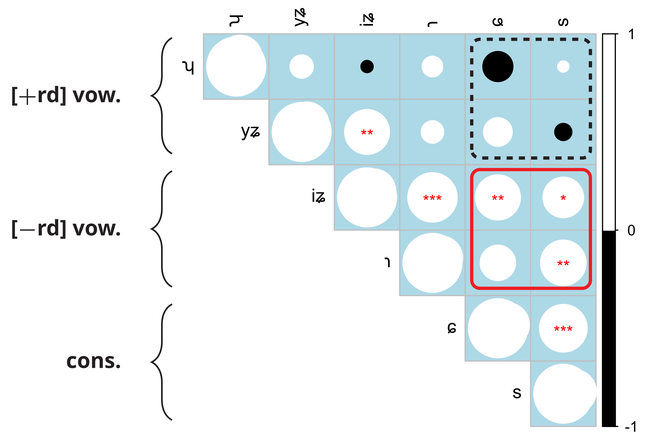
By-talker median CoG



- For **[−round] vowels**, CoG consistently lowered by voicing relative to fricative
- Correlations reach significance

- For **[+round] vowels**, CoG lowered further by rounding by unpredictable amount, particularly for [+ant] vowel
- Correlations fail to reach significance

Correlogram



Rounded vowels: weak correlations with matching [±ant] fricative, do not reach significance

Unrounded vowels: positively and significantly correlated with matching [±ant] fricative

Discussion

Uniform phonetic implementation in acoustics, but **only to a point**

- Unrounded fricative vowels' CoGs correlate with those of appropriate fricatives; does not apply to the rounded fricative vowels
- **Unexpected,** since Sūzhōu Chinese speakers generally use fricative-like **uniform tongue shapes** within [±ant] sets [3]

Working interpretation: speakers are predisposed toward **uniform activity of single articulators**, but this does not necessarily translate into uniformity in acoustics

- Articulatory implementation of tongue shape is constrained; produces uniform acoustics here and in [1]
- Acoustic outcome of uniform tongue shapes with added lip activity (and voicing) is not constrained
- Suggests gradual weakening of uniformity constraint as more co-occurring features are added

Next steps

- Retry with more robust measure of fricative noise source's front cavity resonance, i.e. [6]
- Relate quantitatively to indices of tongue shape illustrated in [3]

Acknowledgements

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PDF with references, supplement

Includes analyses on unfiltered data; data un-pooled by onset type; spectrograms

References

[1] Chodroff, E. (2017). *Structured Variation in Obstruent Production and Perception*. PhD thesis, Johns Hopkins University.

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[6] Koenig, L. L., Shadle, C. H., Preston, J. L., and Mooshammer, C. R. (2013). Toward improved spectral measures of /s/: Results from adolescents. *Journal of Speech, Language, and Hearing Research*, 56(4):1175–1189.

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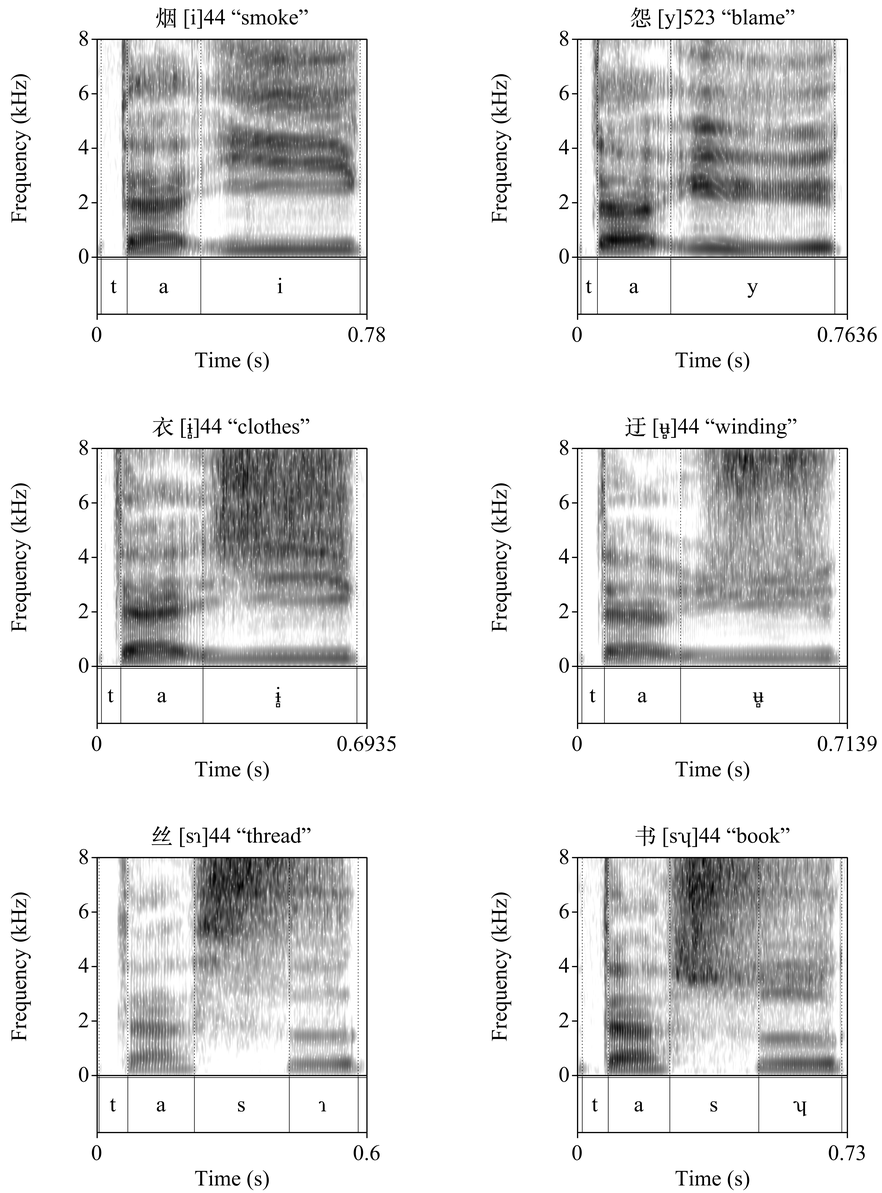
[8] Silbert, N. and de Jong, K. (2008). Focus, prosodic context, and phonological feature specification: Patterns of variation in fricative production. *The Journal of the Acoustical Society of America*, 123(5):2769–2779.

[9] Wang, P. (2011). 苏州方言研究 *[Research on the Sūzhōu dialect]*. 中华书局 [Zhonghua Book Company].

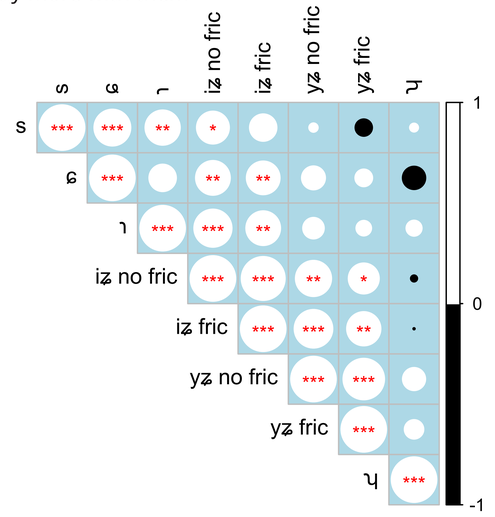
Spectrogram examples

Note: fricative vowel symbols differ from rest of poster. [i̝] = [iʐ], [ʉ̝] = [yʑ]



What if /iʐ/, /yʑ/ are not pooled across onset types?

As one might expect: vowels that immediately follow fricative onsets correlate slightly more with them



What if the data aren’t filtered?

CoG of whole spectrum yields different results

- /s/ does not correlate with any apical vowels
- /ʂ/ does not correlate with unrounded vowels; correlates with rounded vowels
- Fricative and apical vowels more extensively correlate with themselves
- Filtering to a lower frequency (2 kHz) yields intermediate results