5aSC7. Structured variation in Suzhou Chinese fricative consonants and vowels

Matthew Faytak — UCLA — faytak@ucla.edu — ASA Spring 2019

Research question

Target **uniformity**: phonological content is implemented phonetically, **in speaker-specific terms**, similarly across segments [1, 2, 5]

- e.g. English, Czech [s, z] [ʃ, ʒ] pairs' spectral centers of gravity correlate strongly [1]
- Or: speakers are predisposed toward uniform implementation of [±anterior] in sibilants

Unclear which is constrained: **acoustic targets** or the **articulations** giving rise to them

The present study: does uniformity in articulation carry through to acoustics?

- Sūzhōu Chinese provides another test case with more feature combinations
- Comparison of spectral properties of **fricative vowels** (including the **apical vowels**), and **fricative consonants**

Suzhou Chinese (苏州话)

Rich in sibilant sounds, including so-called **apical vowels** [ɿ], [ʯ] and **fricative vowels** [iᵡ], [yᵡ]

- Fully, modally **voiced** and have light frication appropriate to place [7, 9]
- Contrast for **rounding** (parallel with /i/, /y/)

	[+anterior]	[−anterior]
Affricate	ts, tsʰ	tɕ, tɕʰ
Fricative	s	ɕ
Vowel, [−rd]	ɿ	iᵡ
Vowel, [+rd]	ʯ	yᵡ

Known case of articulatory uniformity:

- Same fricative-like tongue shapes generally used within each [±ant] series [3]
- In spite of the fact that the constriction for the [−ant] vowels can be made in other ways, and is by a minority of speakers [7]

Goals and predictions

Goal: Assess relationships among fricative consonants' and fricative vowels' spectral centers of gravity (CoG)

- CoG reflects length of cavity anterior to fricative constriction
- **Prediction:** 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

- [+ant] vowels always follow [+ant] fricatives
- [−ant] vowels follow [−ant] fricatives and a wider variety of onsets
- Fricative vowels occurring after fricatives and non-fricatives are **pooled** in analysis

Onset	[+ant]		[−ant]	
	[−rd]	[+rd]	[−rd]	[+rd]
Fric	丝 sɿ[44] 'thread'	书 sʯ[44] 'book'	希 ɕiᵡ[44†] 'rare'	虚 ɕyᵡ[44] 'weak'
Non-fric.	—	—	衣 iᵡ[44] 'garment'	优 yᵡ[44] 'excellent'

Other /s/, /ɕ/: 箫 ɕiæ[44] 'flute', 沙 su[44] 'sand', etc.

† Also with [+ant] onset, e.g. 西 siᵡ[44] 'west'

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

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

Results

By-talker median CoGs

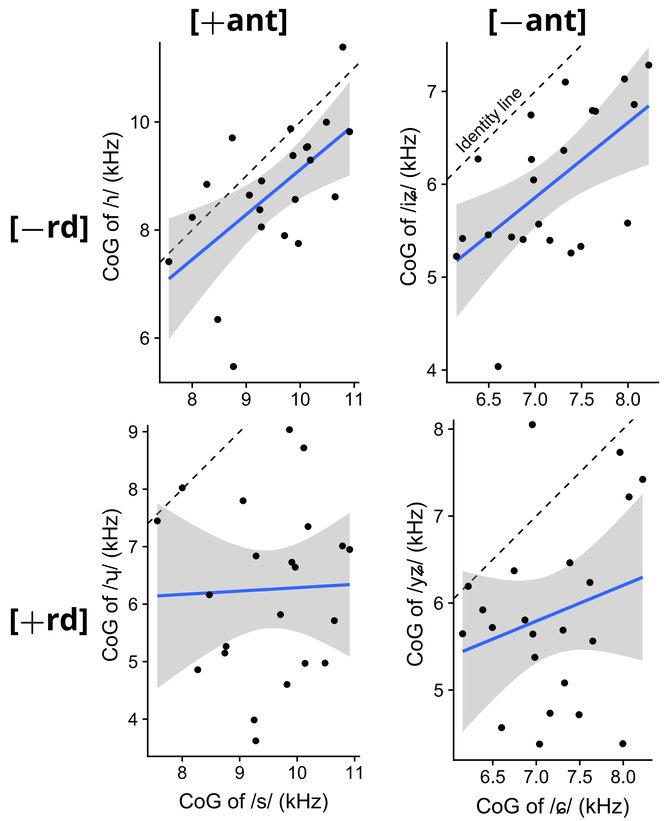
→ → →

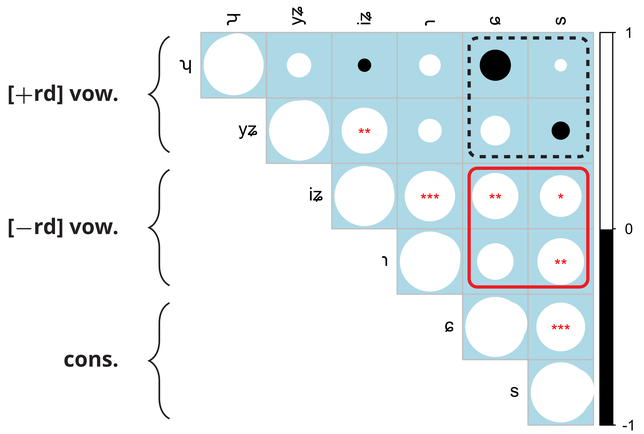
- CoG lowered by voicing; consistent effect
- CoG lowered further by rounding; much less consistency in effect, particularly for [+ant]
- Simple lm smooths added to visualize trends in data

Correlogram

↓ ↓ ↓

- Unrounded vowels' correlations with same-place consonants are significant and strong (r = 0.4–0.6)
- Rounded vowels' correlations with same-place consonants less consistent; fail to reach significance





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:** 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

Thanks to Eleanor Chodroff and Pat Keating for useful discussion; and Chen Zhongmin 陈忠敏 and Wang Feifan 王非凡 for logistical help. Data collection supported by ASA Stetson Scholarship in Phonetics and Speech Science.

PDF with references, supplement

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

References

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

[2] Chodroff, E. and Wilson, C. (2017). Structure in talker-specific phonetic realization: Covariation of stop consonant VOT in American English. *Journal of Phonetics*, 61:30–47.

[3] Faytak, M. (2019). Uniform phonetic implementation and the sūzhōu chinese fricative vowels. ms.

[4] Jongman, A., Wayland, R., and Wong, S. (2000). Acoustic characteristics of english fricatives. *The Journal of the Acoustical Society of America*, 108(3):1252–1263.

[5] Keating, P. (2003). Phonetic and other influences on voicing contrasts. In *Proceedings of ICPhS 15*, pages 375–378.

[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.

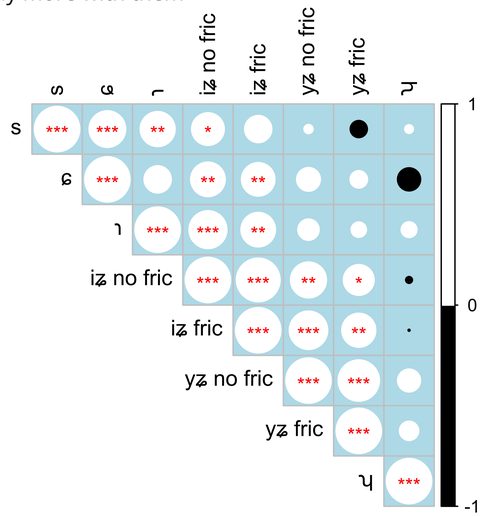
[7] Ling, F. (2009). *A phonetic study of the vowel system in Suzhou Chinese*. PhD thesis, City University of Hong Kong.

[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].

What if /iʑ/, /yʑ/ are split by onset type?

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
- /ɕ/ 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