Sibilant fronting in Mandarin: An interaction between social and phonological factors

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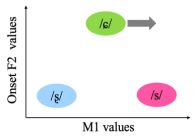
Introduction

- Cross-linguistically, **younger females often produce more fronted sibilants** (higher noise frequency) than males
  - **Mandarin:** Higher noise frequency of /ɕ/ (e.g., Cao, 1987; Li, 2017)
  - **English:** Higher noise frequency of /s/ (e.g., Staurt-smith, 2003)
  - **Korean:** Alveolarization of /tɕa/, /tɕ*a/, /ɕ*i/ (e.g., Kong, 2014)
- Male speakers more often produce non-sibilant (/θ/-like) fronted variants of /s/ (e.g., Kong, 2020; Zhang 2005)
- **Perceptual basis for sibilant fronting**
  - Higher-frequency speech is often associated with smaller body size and further linked to **feminine social personae** (e.g., Gussenhoven, 2016; Munson, 2007; Ohala, 1984)
- **Mandarin sibilants as an informative case**
  - A rich sibilant inventory
    - retroflex /ʂ/, alveopalatal /ɕ/, alveolar /s/
  - Multi-dimensional phonetic cues (e.g., Chiu, 2009; Hauser, 2023; Li, 2008, 2017)
    - Spectral mean frequency (M1)
    - F2 at the vowel onset



- **Vowel context effects on phonetic cues**
  - Rounded back vowels (e.g., /u/) may reduce the spectral space of sibilants (e.g., Hauser, 2023; Jongman et al., 2000), placing pressure on the implementation of socially driven /ɕ/-fronting

Research questions

- How is gendered sibilant production realized in Mandarin, a language with a rich sibilant inventory?
- How does socially motivated variation interact with coarticulatory pressures arising from vowel context?

Methodology

Wordlist reading task

- **Procedure:** randomized wordlist reading task; presented in logographic CHN characters
- **Participants:** 40 college students (20 F, 20 M) from northern China
- **Stimuli:** disyllabic Mandarin words with sibilants in word-initial position (30 items = 3 sibilants * 2 vowels * 5 words)

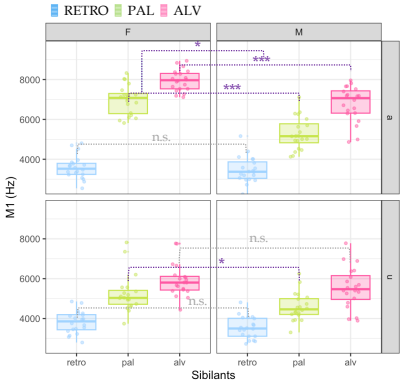
	/ʂ/	/ɕ/	/s/
/a/	/ʂa^{55}fa^{55}/ 沙发 'sofa'	/ɕa^{55}mi^{214}/ 虾米 'small shrimp'	/sa^{55}je^{214}/ 撒野 'act wildly'
/u/	/ʂu^{55}tjɛn^{51}/ 书店 'bookstore'	/ɕu^{55}ɕi^{55}/ 休息 'rest'	/su^{55}tʂou^{55}/ 苏州 'Suzhou city'

Data analysis

- **Spectral mean frequency (M1) of frication noise**
  - 20 ms middle interval of frication noise; multitaper spectral analysis in MATLAB (Blacklock, 2004; Blacklock & Shadle, 2003)
- **F2 values of the following vowels**
  - measured at 20 ms after onset using Praat
- **Linear Discriminant Analysis (LDA) in R**
  - performed separately for each speaker within each vowel context (/a/ and /u/) to quantify **cue weights** of M1 and onset F2 in production (Hauser, 2023); **LDA coefficients** indicate relative M1 and F2 contributions to sibilant categorization within each vowel context

Results

M1 across genders and vowels



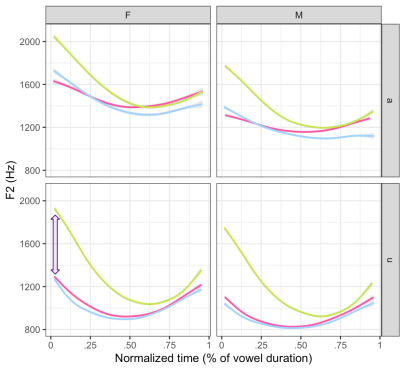
Before the /a/ vowel

- Females show higher M1 for both /ɕ/ (p < .0001) and /s/ (p = 0.0109) than males, especially for /ɕ/
  - aligns with cross-linguistic patterns of femininity-indexing higher-frequency fricatives
  - Parallel /s/-fronting preserves robust /s/-/ɕ/ spectral contrasts

Before the /u/ vowel

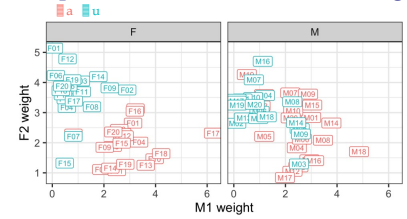
- Higher M1 in female speech is observed only for /ɕ/ (p < .0001)
  - /ɕ/-fronting persists despite contextual constraints

Smoothed F2 trajectories over normalized vowel duration



- Onset F2 separation between /sᵤ/ and /ɕᵤ/ is larger than that between /sₐ/ and /ɕₐ/ (p = .0317)
- This effect is more pronounced in females than in males (p = .0490)
  - females may show a greater increase in reliance on onset F2 in /u/ than males

Speaker-level LDA-derived cue weights for distinguishing /s/-/ɕ/



- Clearer separation between the /a/ and /u/ contexts in females
- Females place greater weight on onset F2 in /u/ than in /a/ (p = .0019), and this increase is significantly larger than that observed in males (p = .0308)

Discussion

Selection of socially motivated phonetic variants

- In Mandarin, gendered variation selectively targets higher-frequency sibilants (/s, ɕ/), consistent with Ohala's (1984) Frequency Code linking higher-frequency cues to perceived smallness, a quality often associated with femininity
- /ɕ/ serves as a stronger index of social meaning than /s/, showing more pronounced and consistent fronting across contexts
  - this prominence may reflect the greater perceptual salience of /ɕ/-fronting
  - when a larger sibilant inventory includes /ɕ/, socially indexed fronting preferentially targets /ɕ/ over /s/ (Polish: Czaplicki et al., 2016)

Adaptation of gendered phonetic variants to contextual variation

- Strong coarticulatory influence of /u/ on sibilants
  - lip rounding and tongue retraction lower M1 and onset F2, masking /s/-fronting
  - /ɕ/ is relatively stable due to its strong coarticulatory resistance (Recasens, 2009)
- **Cue reweighting**: M1 separation is reduced while onset F2 separation increases
- Female speakers show greater cue reweighting, suggesting a stronger tendency to balance social expression with phonological stability

Selected References

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