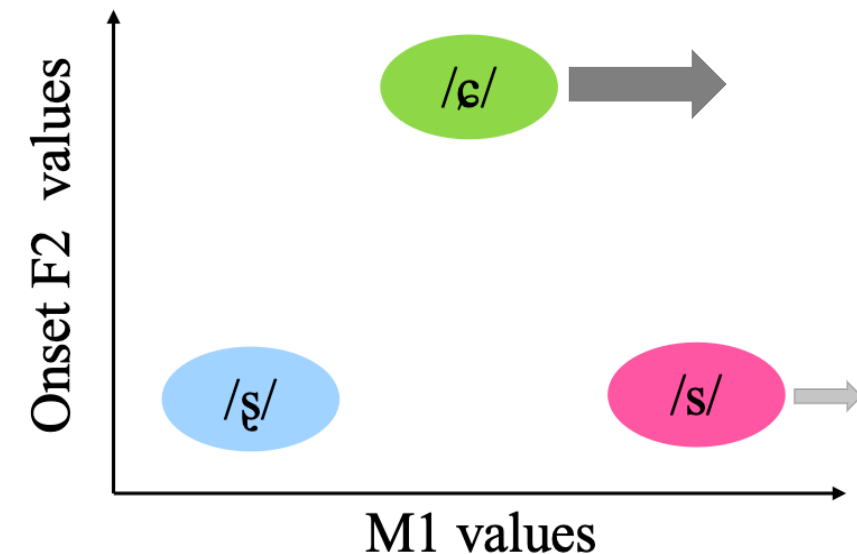


Introduction

- Prosodically strong conditions may heighten the phonetic clarity of segmental contrasts, often resulting in **phonological enhancement** (e.g., Beckman & Edwards, 1994; Cho, 2005; Keating, 1984)
 - Focus-induced strengthening
 - Domain-initial strengthening
- Mandarin sibilants as an informative case**
 - A rich sibilant inventory
 - retroflex /ʂ/, alveopalatal /ɕ/, alveolar /s/
 - Multi-dimensional phonetic cues (e.g., Li, 2017; Hauser, 2023)
 - Spectral mean frequency (M1)
 - F2 at the vowel onset
 - Socially conditioned variation
 - female-associated /ɕ/- and /s/-fronting (higher M1) (Li, 2017; Chen & Lee-Kim, 2025), particularly for /ɕ/, potentially linked to femininity-indexing speech styles (e.g., Cao, 1987)



Research questions

- How does prosodic strengthening driven by focus and boundary strength modulate the realization of Mandarin sibilants?
- How do female speakers navigate socially conditioned sibilant fronting under the contrast demands of prosodic strengthening?

Methodology

Mini-discourse reading task

- Participants:** 30 young speakers (15 F, 15 M) from Northern China
- Procedure:** Target words embedded in carrier sentences within mini-discourses eliciting different prosodic conditions

A: 'XXX' ʂɿ⁵¹ni²¹⁴ɕɛ²¹⁴təmə?

'XXX' — is that the one you wrote? “XXX”是你写的吗?

B: pu³⁵ʂɿ⁵¹. 'XXX' ʂɿ⁵¹wɔ²¹⁴ɕɛ²¹⁴tə.

No. 'XXX' is the one I wrote. 不是。“XXX”是我写的。

- Stimuli:** /sa⁵⁵/ 仨 'three', /ʂa⁵⁵/ 沙 'sand', /ɕa⁵⁵/ 虾 'shrimp'
- Examples with target /ɕa⁵⁵/**

(Underlined: target words; bold: **focused** words)

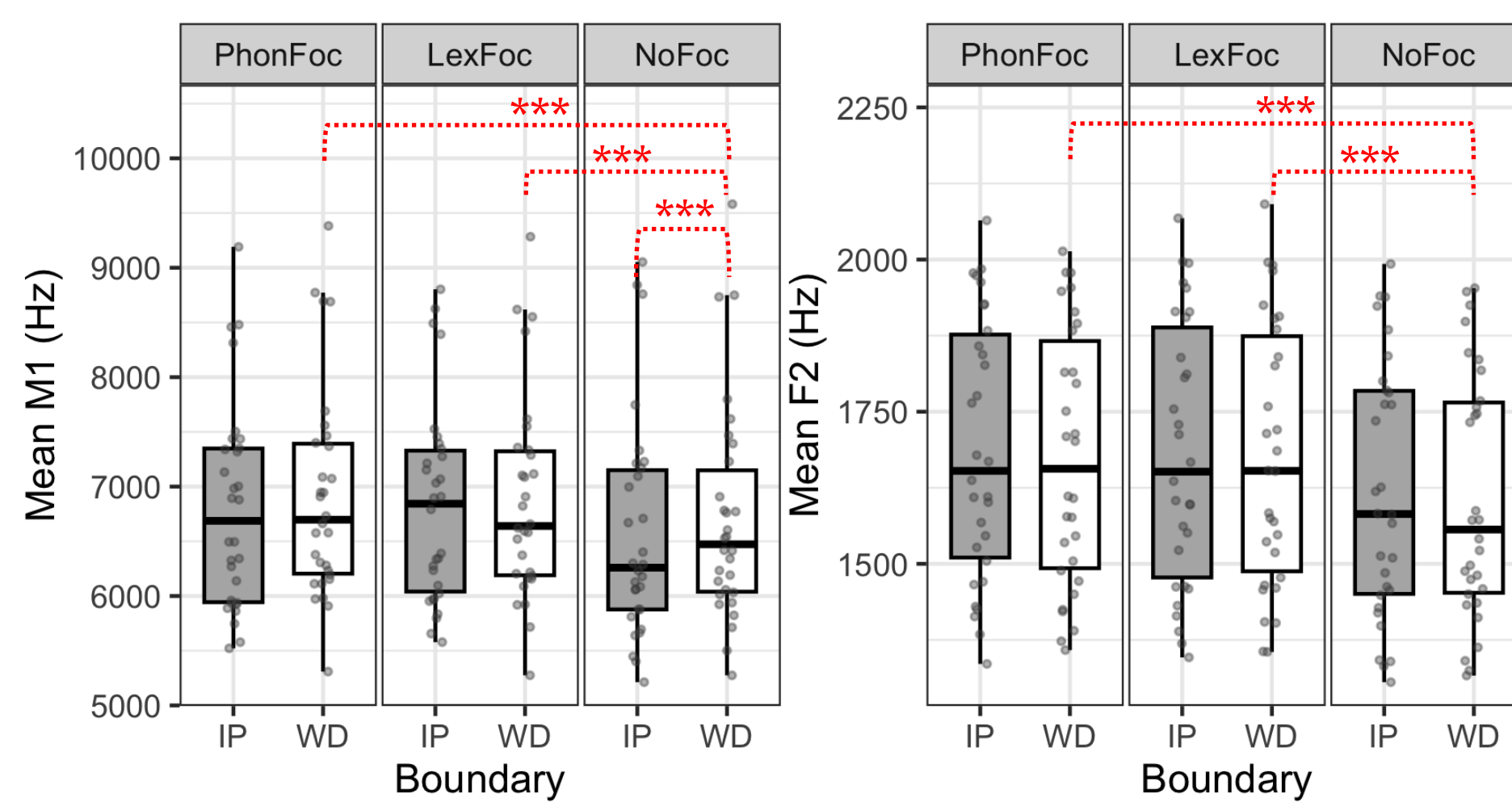
Boundary	Focus	Prompts	Targets
IP-initial	No Foc	ɕa ⁵⁵ ta ⁵¹ tɕɛ ²¹⁴	ɕa ⁵⁵ ta ⁵¹ kɿ ⁵⁵
	Lexical Foc (semantic neighbor)	y ³⁵ ta ⁵¹ kɿ ⁵⁵ (fish)	ɕa ⁵⁵ ta ⁵¹ kɿ ⁵⁵ (shrimp)
	Phonological Foc (/s/ or /ʂ/ prompt)	sa ⁵⁵ /ʂa ⁵⁵ ta ⁵¹ kɿ ⁵⁵	ɕa ⁵⁵ ta ⁵¹ kɿ ⁵⁵
Word-initial (IP-medial)	Target preceded by [ta ²¹⁴ lɔ] 'hit' 打了 ; identical to IP-initial otherwise.		

Data analysis

- Spectral mean frequency (M1) of frication noise**
 - 20 ms middle interval of frication noise; multitaper spectral analysis in MATLAB
- F2 values of the following vowels**
 - measured at 20 ms after vowel onset using Praat

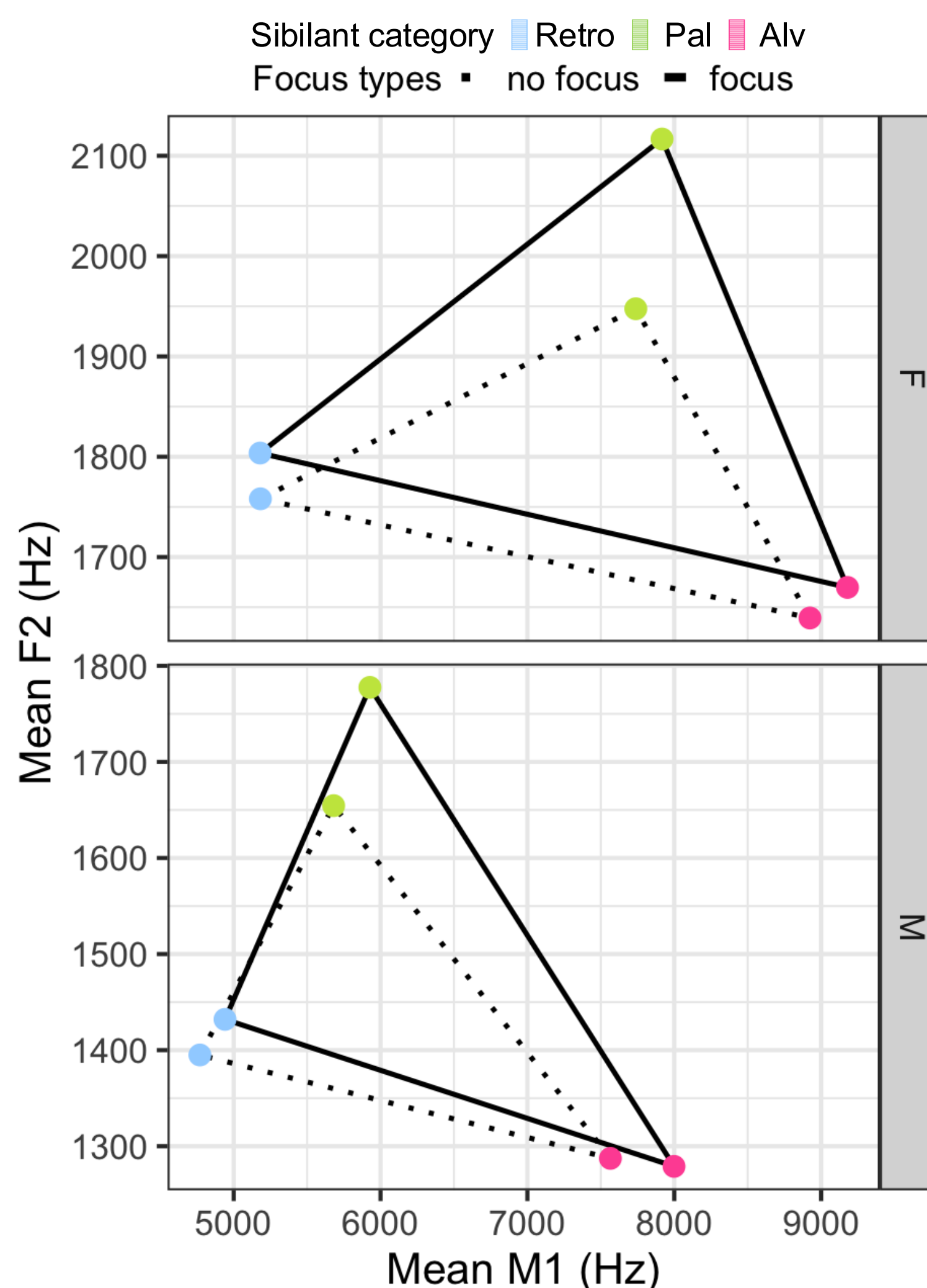
Results

Spectral variation across focus and prosodic boundary types



- Robust focus effects**
 - Higher M1 and onset F2 under focus
- Limited boundary effects**
 - Lower M1 in the IP-initial position only in the no-focus condition

Focus effects on M1 and F2 across sibilants and gender groups



F2 results

- Higher F2 for /ɕ/ and /ʂ/ under focus, especially for /ɕ/** (focus:sibilant: $p < .0001$)
- Greater F2 increase for /ɕ/ in female than in male speakers (focus:gender: $p = .0431$)

M1 results

- Higher M1 for /ɕ/ and /s/ under focus**
- Persistent fronting in female speech:** higher M1 for /ɕ/ and /s/ in female relative to male speech, especially for /ɕ/, regardless of focus condition
 - No differentiation between lexical and phonological focus; **robust /ɕ/-fronting even with overt /s/ prompt**
 - deep integration of fronted variants into female phonological representations

Discussion

Robust focus-induced enhancement of place contrast

- Prosodic strengthening in Mandarin sibilants is largely focus-driven**, with comparatively limited boundary effects.
- Focus effects support place-contrast enhancement** (e.g., Chuang & Fon, 2010), rather than uniform strengthening across categories (e.g., Chang & Shih, 2015).
 - the effects are selective, targeting each sibilant's feature-defining dimensions (M1 for /ɕ/ & /s/; F2 for /ɕ/ & /ʂ/)
- /ɕ/ bears the primary burden of contrast enhancement**, as it shows increases in both M1 and F2, with particularly strong focus-induced F2 enhancement

Functional differentiation of acoustic cues in female speech

- Female speakers appear to navigate social and contrastive demands by assigning distinct functions to M1 and F2**
 - M1 encodes social meaning through fronting, which is unaffected by prosodic strengthening
 - F2 primarily serves contrastive purposes, showing especially strong focus-induced enhancement for /ɕ/

References

Beckman, M., & Edwards, J. (1994). Articulatory evidence for differentiating stress categories. *Papers in Laboratory Phonology III: Phonological Structure and Phonetic Form*; Cao, Y. (1987). 北京话tɕ组声母的前化现象[The fronting phenomenon of the /tɕ/ class sounds in Beijing Mandarin]. *语言教学与研究*[Language teaching and research]; Chang, Y. H. S., & Shih, C. (2015). Place contrast enhancement: The case of the alveolar and retroflex sibilant production in two dialects of Mandarin. *Journal of Phonetics*; Chen, Z., & Lee-Kim, S. I. (2025). Sibilant fronting in Mandarin: An interaction between social and phonological factors. *2025 Spring Joint Conference of the Korean Society of Phonetic Sciences*; Cho, T. (2005). Prosodic strengthening and featural enhancement: evidence from acoustic and articulatory realizations of /a, i/ in English. *JASA*; Chuang, Y. Y., & Fon, J. (2010). The effect of prosodic prominence on the realizations of voiceless dental and retroflex sibilants in Taiwan Mandarin spontaneous speech. *Proceedings of Speech Prosody*; Hauser, I. (2023). Differential cue weighting in Mandarin sibilant production. *Language and Speech*; Keating, P. (1984). Phonetic and Phonological Representation of Stop Consonant Voicing. *Language*; Li, F. (2017). The development of gender-specific patterns in the production of voiceless sibilant fricatives in Mandarin Chinese. *Linguistics*.

This work was supported by the Ministry of Education of the Republic of Korea and the National Research Foundation of Korea (NRF) under Grants [No. NRF-2021S1A5C2A02086884, PI: Prof. Cho], and by the Yonsei University Research Fund of 2026 (2026-22-0217).

