

From a Two-way Contrast to a Three-way Contrast: Voiceless Sibilant Fricative Production by Children in a Canadian Mandarin-English Bilingual Program

Lujia Yang¹, Karen Pollock¹, Youran Lin¹, Benjamin V. Tucker² and Fangfang Li³

¹*Department of Communication Sciences and Disorders, University of Alberta (Canada),* ²*Department of Communication Sciences and Disorders, Northern Arizona University (USA),* ³*Psychology Department, University of Lethbridge (Canada)*

According to the revised Speech Learning Model (SLM-r) [1] and the Perceptual Assimilation Model (PAM) [2,3], learning a new sound system with more complex contrasts than the learner's first language can be challenging and is influenced by learner's language exposure. While previous research on language exposure and speech learning has primarily focused on adult speakers, studies on the speech production of children learning a socially non-dominant language are limited. Voiceless sibilant fricatives, considered typologically uncommon sounds [4], are interesting targets for cross-language comparison. In Mandarin, voiceless sibilant fricatives build a three-way contrast (alveolar /s/, alveolo-palatal /ç/, and retroflex /ʂ/), while in English, they form a two-way contrast (alveolar /s/ and postalveolar /ʃ/) [5,6]. The goal of this study is to investigate the influence of language background and exposure on children's acquisition and retention of sound contrasts in two languages.

Speech data was collected from Mandarin heritage language (HL) speakers and Mandarin second language (L2) speakers studying in a Canadian Mandarin-English bilingual program. Eighty-two children in grades one, three, and five (aged 5;11 – 10;10 [years;months]) as well as 12 Mandarin teachers participated in a picture-naming task. Stimuli are Mandarin and English words containing voiceless sibilant fricatives in different contexts. Participants' speech productions were recorded and analyzed using both transcription and acoustic methods to assess the influence of language background and grade level on children's productions. Acoustic analysis focused on the Centre of Gravity (CoG) and the F2 onset of the following vowel. Linear mixed-effect regression was used for data analysis.

Both groups of children achieved high accuracy rates in producing English fricatives /s/ and /ʃ/ regardless of grade level. For Mandarin production, HL and L2 children in higher grade levels generally achieved higher accuracy rates compared to those in lower grades, though the difference was not significant. HL children achieved higher accuracy rates than L2 learners, with their productions resembling teachers' production more closely (Figure 1). Mandarin retroflex /ʂ/ posed a challenge for both groups, often assimilated to English [ʃ]. Alveolo-palatal /ç/ was particularly challenging for L2 learners, with [ʃ] or [s] as the most likely replacements. Acoustic analyses of children's Mandarin production showed that irrespective of grade level and language background, CoG for each sibilant was significantly different. However, significant differences in F2 onset were only observed in the production of Mandarin heritage speakers in all grade levels. In L2 speakers' correct productions, the difference in F2 onset for each sound was not significant in grade one. However, they were more likely to produce the three-way contrast in higher grade levels (Figures 2 & 3).

The findings support the SLM-r and PAM, showing a dynamic interplay between language exposure and speech production. Grade level did not have a significant impact on accuracy rate, whereas language background did. In the English-dominant society, children exhibited comparable proficiency in producing English voiceless sibilant fricatives. Nevertheless, HL speakers outperformed Mandarin L2 learners in achieving a clearer three-way contrast since grade one. HL speakers were better able to keep the two speech systems distinct and were less susceptible to interference patterns. Conversely, limited Mandarin exposure at home posed challenges for L2 speakers in developing a three-way contrast from a two-way contrast. However, despite being more likely to be influenced by English, L2 speakers in higher grades, with increased exposure to Mandarin at school, demonstrated the potential to develop a clearer three-way contrast in producing Mandarin voiceless sibilant fricatives.

Keywords: fricative, Mandarin, English, bilingual children, speech, SLM-r

References:

- [1] Flege, J. E., Aoyama, K., & Bohn, O.-S. (2021). The Revised Speech Learning Model (SLM-r) Applied. *Second Language Speech Learning (Issue May)*. <https://doi.org/10.1017/9781108886901.003>
- [2] Best, C. T. (1994). The emergence of native-language phonological influences in infants: A perceptual assimilation model. *The Development of Speech Perception: The Transition from Speech Sounds to Spoken Words*, 167(224), 233–277.
- [3] Best, C. T., McRoberts, G. W., & Goodell, E. (2001). Discrimination of non-native consonants contrasts varying in perceptual assimilation to the listener’s native phonological system. *Journal of the Acoustical Society of America*, 109(2), 775–794.
- [4] Goh, H. L., Woon, F. T., Moisk, S. R., & Styles, S. J. (2022). Contrastive alveolar/retroflex phonemes in Singapore Mandarin bilinguals: Comprehension rates for articulations in different accents, and acoustic analysis of productions.
- [5] Li, F., & Munson, B. (2016). The Development of Voiceless Sibilant Fricatives in Putonghua-Speaking Children. *Journal of Speech, Language, and Hearing Research*, 59(4), 699–712. https://doi.org/10.1044/2016_JSLHR-S-14-0142
- [6] Nissen, S. L., & Fox, R. A. (2005). Acoustic and spectral characteristics of young children’s fricative productions: A developmental perspective. *Journal of the Acoustical Society of America*, 118(4), 2570–2578.

Figure 1. Accuracy rates in producing Mandarin voiceless sibilant fricatives (left) and English voiceless sibilant fricatives(right) by Heritage Speakers and L2 Learners. The dotted line represents the accuracy rates of teachers' productions.

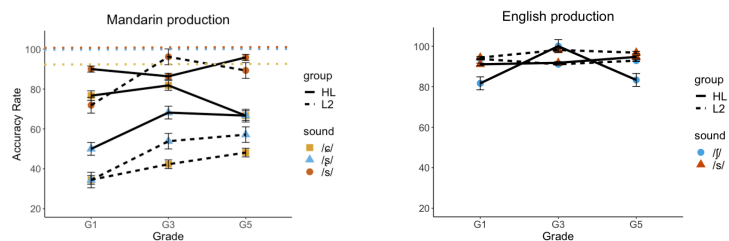


Figure 2. F2 onset plotted against the Centre of Gravity for teacher, heritage speakers, and L2 learners, with filled markers representing correct production and unfilled markers representing incorrect production. (top panel: Mandarin production; bottom panel: English production)

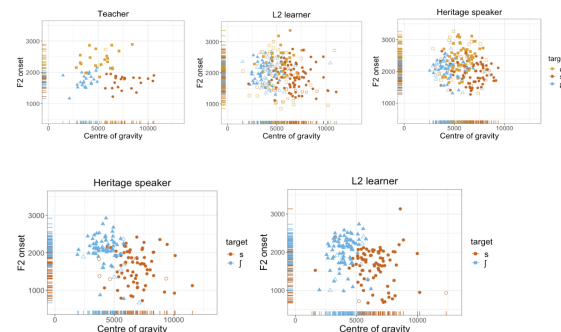


Figure 3. F2 onset plotted against the Centre of Gravity for heritage speakers (HS) and L2 learners (L2) studying in grade one (G1), grade three (G3), and grade five (G5) with filled markers representing correct production and unfilled markers representing incorrect production. (right: Mandarin production; left: English production)

