

Post-stop F0 in Mandarin–English bilinguals: Production–imitation asymmetries under tonal constraint

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Introduction: Pitch perturbation following stop consonants is a robust cross-linguistic phenomenon [1]: vowels after voiceless aspirated stops tend to show raised F0, whereas those after voiced stops show lowered F0. A cross-linguistic large corpus study [2] reported that this effect is weaker in tone languages than in pitch-accent or stress languages, likely because tonal systems constrain post-consonantal F0 variation. Mandarin, however, shows inconsistent patterns. Xu and Xu [3] found higher tone-onset F0 following unaspirated than aspirated stops, contrary to typological expectations, whereas Cao and Zhang [4] reported aspiration-induced F0 raising. Guo and Kwon [5] further demonstrated that perturbation is tone-dependent, reversing between high- and low-initial tones. Extending beyond L1 production, Lo [6] showed that Mandarin-English bilinguals constrain perturbation in Mandarin but enhance it in English, suggesting language-specific phonetic implementation. Following this line of work, the present study examines how post-stop F0 is implemented and imitated across language contexts by Mandarin speakers in L1 Mandarin and L2 English across sonorant, voiceless unaspirated, voiceless aspirated, and voiced categories.

Method: Two groups of native Mandarin speakers with English as an L2 were recruited for two tasks: a production experiment (7F, 3M; mean age = 22) and an imitation experiment (7F, 3M; mean age = 21). In the production task, Mandarin and English wordlists were constructed to parallel each other in prosodic and laryngeal structure. Stimuli were counterbalanced by Tones and Manner. For Mandarin (L1), tones included high-level T1 and falling T4. For English (L2), stressed initial bisyllabic words approximated T1 (e.g., copy) and stressed monosyllabic words approximated T4 (e.g., cop). Manner categories included sonorant, voiceless aspirated, voiceless unaspirated stops in Mandarin, and sonorant, voiceless aspirated and voiced stops in English. The imitation task used the same stimulus design, with post-consonantal F0 resynthesized into three levels, High, Normal and Low, following [7]. Participants read written stimuli displayed on the screen at a natural pace in the production task and were instructed to imitate the model tokens as closely as possible in the imitation task. Both tasks were conducted using Gorilla.

Results: Participants' productions of the target syllables were manually annotated in Praat. F0 was extracted from the first 20% of the vowel following the target consonants to assess pitch perturbation, using the STRAIGHT algorithm implemented in VoiceSauce [8]. F0 values were converted to semitones and z-scored within participant for subsequent statistical analyses [9]. Linear mixed-effects modeling showed that post-aspirated stops yielded higher F0 than post-unaspirated and sonorant stops across tones and language contexts, with the effect slightly stronger for contour T4 than level T1. Consistent with Lo [6], the perturbation effect was more pronounced in L2 English than in L1 Mandarin (Fig. 1), suggesting language-specific phonetic implementation. However, this larger phonetic implementation in L2 English was not mirrored in the imitated data. While both language contexts showed systematic imitation of manipulated post-stop F0 in the Normal and Low conditions (Fig. 2), only the L1 Mandarin context showed consistently higher post-aspirated F0 than the other manners, again stronger in T4 than in T1 (Fig. 3). These findings indicate that production of post-stop F0 is constrained by the L1 tonal system, whereas imitation shows greater sensitivity to pitch differences in L1 than in L2. This pattern highlights the role of language-specific tonal structure in shaping both production and perception.

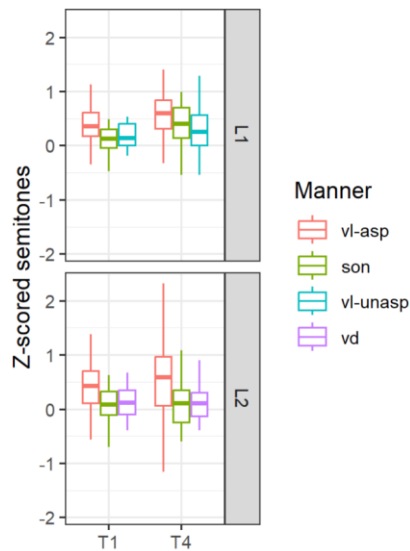


Fig. 1. Z-scored semitone values from the production task, plotted by tone (x-axis) and manner (legend), and faceted by language context.

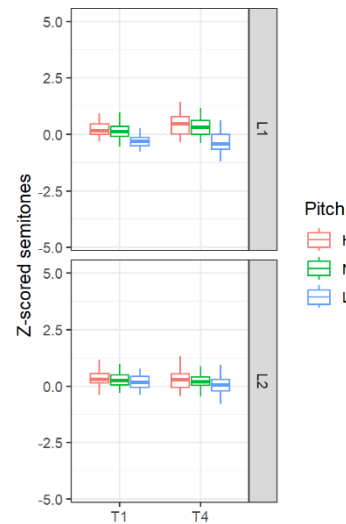


Fig. 2. Z-scored semitone values from the imitation task, plotted by tone (x-axis) and manipulated pitch (legend), and faceted by language context.

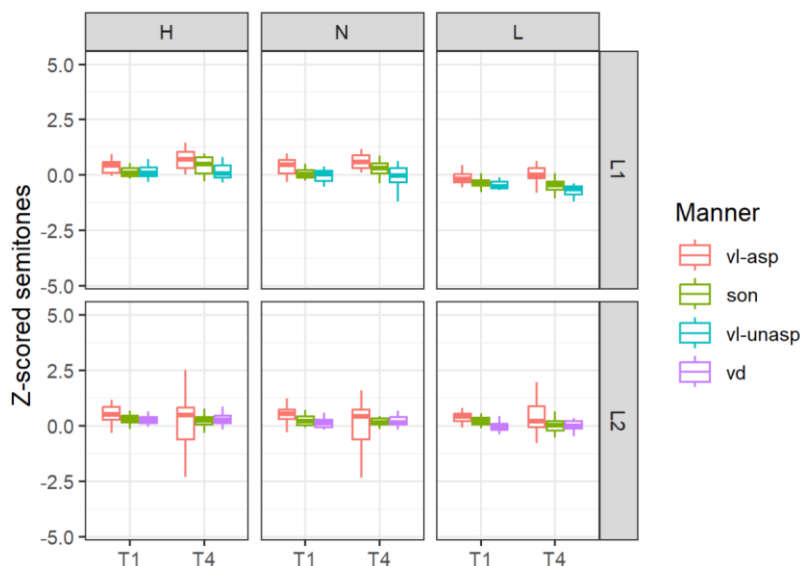


Fig. 3. Z-scored semitone values from the imitation task, plotted by tone (x-axis) and Manner (legend), and faceted by manipulated pitch and language context.

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