Neural Processing of Emotional Prosody in Native and Non-native Chinese Speakers

Introduction. Emotional information in spoken languages can be conveyed through semantics (what is being said) and prosody (how it is said). Emotional prosody refers to the way in which the tone of voice can be modulated to convey positive or negative emotions (Kemmerer, 2014). In tonal languages such as Mandarin Chinese, the same acoustic feature (F0) serves a dual function, encoding both semantics and emotional prosody (Xu, 2005; Yip, 2002). Recent studies have found that native and non-native Chinese speakers can accurately perceive emotional prosody in Chinese words and sentences (Xiao & Liu, 2024b), although semantics affects their perception of emotional prosody differently (Xiao & Liu, 2024a). Neuroimaging evidence from non-tonal languages (e.g., English) has revealed right-lateralized frontotemporal activation for emotional prosody processing and left-lateralized activation for semantic processing in native English speakers (Seydell-Greenwald et al., 2020). However, the neural bases of these processes remain understudied in tonal languages. Furthermore, it is unclear whether native and non-native Chinese speakers use similar brain mechanisms to process semantics and emotional prosody. Therefore, this study utilizes fMRI to investigate the processing of emotional prosody in Mandarin Chinese for native Chinese speakers and L1-English L2-Chinese learners.

Stimuli. We selected 96 real Chinese disyllables with positive (e.g., rui^{4}zhi^4, *wise*) and negative semantics (e.g., ao^{4}man^4, *arrogant*) and 48 pseudo-Chinese disyllables with neural semantics (e.g., chun^{4}pou^4, no meaning). All words were matched for syllable length and lexical tone. Real words with positive and negative meanings were further matched for frequency, valence, arousal, concreteness, and age of acquisition. To construct sentence stimuli, these words were embedded in the carrier sentence 'ta^1 hen^3 (*She is very*) _____' to minimize contextual and syntactic influence. A male and a female native Chinese speaker recorded the words and sentences with positive (e.g., joy) and negative (e.g., sad) emotional prosody, generating 1,152 auditory stimuli. To validate the intended emotional prosody of the stimuli, 42 native Chinese speakers (23F19M, mean age = 22.57) rated the valence and arousal of each auditory stimulus on a 0-9 scale. Our results show that for both male and female speaker stimuli, positive prosody was perceived as positive, and negative prosody was perceived as negative (Figure 1).

fMRI design. The study used a block design with six conditions (2 prosody x 3 semantics) across four 10-min function MRI runs, with block order randomized. Each run included twenty-four 23s blocks. Within each block, participants listened to twelve 1s auditory stimuli, followed by a jittered fixation period of 2-4s, and then pressed buttons with index/middle finger to indicate whether the speaker sounded like they were experiencing positive/negative emotions. A 6-min T1-weighted anatomical scan was collected at the end of the session. MRI data were acquired using a Siemens 3T Prisma Fit scanner equipped with a 20-channel head coil. Data were preprocessed using fMRIPrep (Esteban et al., 2019) and analyzed with AFNI (Cox, 1996). Run order, speaker gender, and button-pressing fingers were counterbalanced across participants.

Results. To ensure comparable semantic knowledge of the stimuli, all L1-English L2-Chinese learners must score at least 80% on a pre-experiment vocabulary screening task. Preliminary results (N = 2) showed bilateral activations in the superior temporal gyrus (STG) and middle temporal gyrus (MTG) for the native Chinese speaker in their processing of negative (Figure 2A) and positive (Figure 2C) emotional prosody. In contrast, the L2 learner exhibited activations in the right hemisphere, with weak activation in the left MTG and none in the left STG (Figure 2B, 2D). These findings align with Seydell-Greenwald et al. (2020), which reported right-lateralized processing of emotional prosody in native English speakers. Our preliminary results suggest that native Chinese speakers may process emotional prosody more bilaterally than L1-English L2-Chinese learners, highlighting a difference in tonal and non-tonal language speakers' processing of emotional prosody. We plan to use this pipeline to analyze data from 30 participants (15 native Chinese speakers, 15 L1-English L2-Chinese learners) by March.

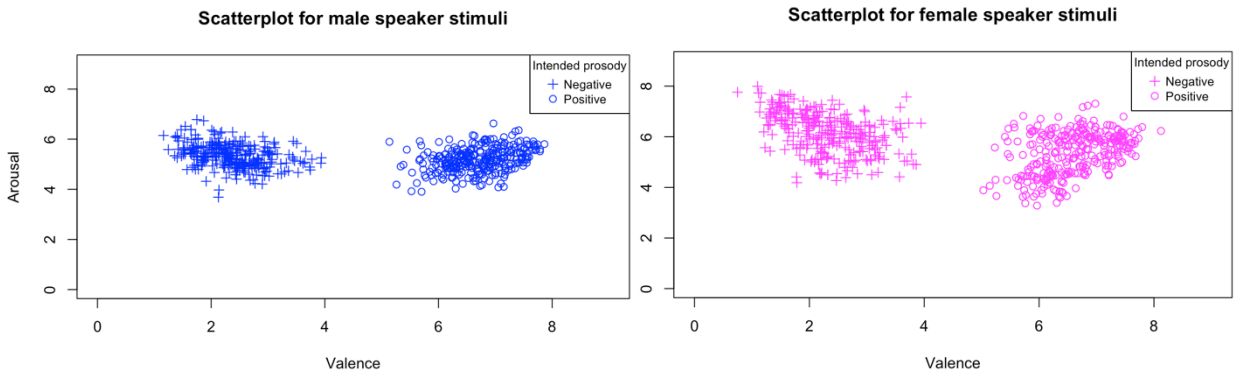

Figure 1. Scatterplots of the mean valence (x-axis) and mean arousal (y-axis) ratings for each stimulus produced by male (left) and female (right) speakers on a scale from 0 to 9. On the x-axis (valence), 0 indicates “very negative” and 9 indicates “very positive;” on the y-axis (arousal), 0 indicates “very excited” and 9 indicates “not excited.” A cross (+) represents that the stimulus was intended to convey negative emotional prosody, and a circle (O) represents intended positive emotional prosody.

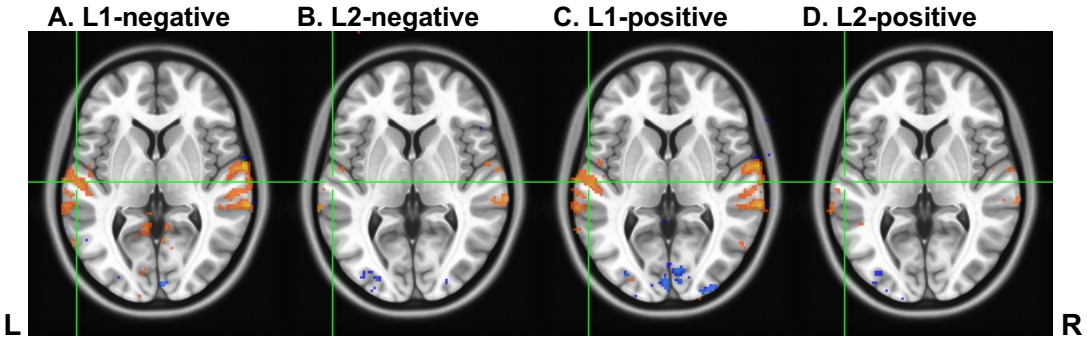

Figure 2. Whole-brain activations (yellow) and deactivations (blue) for one native Chinese in the processing of negative (A) and positive (C) emotional prosody, and for one L1-English L2-Chinese learner in the processing of negative (B) and positive (D) emotional prosody, contrasting to baseline. Brain (de)activation maps are projected on the MNI152 template at a voxel-level threshold of $P < 0.001$ (uncorrected). The green cross indicates the superior temporal gyrus (STG, x, y, z = 59, 18, 6)

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