INTRODUCTION

- Prior lab-based research mostly focuses on training a single aspect of language.
- It is poorly understood how naturalistic training experiences affect the neural organization of sentence processing in early learners of a foreign language.
- Only one fMRI study (Barbeau et al., 2016) has investigated functional plasticity in real-world language learners. However, the sentence reading task simply relies on decoding, rather than comprehension.
- The current study investigates the functional plasticity of auditory sentence comprehension after a one-month classroom-based Mandarin course.

METHODS

Participants
Twenty-four native speakers of American English (8 females and 16 males; mean age = 23.2, SD = 3.68; mean IQ = 118, SD = 12.34). One participant was removed from the analysis due to excessive motion during the fMRI scan.

Language Training
- 3.5 hours per day, 5 days per week and 4 weeks of classroom-based Mandarin course (mean total time in the classroom: 62.3 hours)
- 11 assignments (2.7 hours per assignment), 10 quizzes, one midterm exam, and one final exam.
- Standardized proficiency test (HSK Level 1) was administered immediately after the course and again 3 months later.

fMRI Method
- Fifteen 6-trial blocks in one of the 3 languages in 2 runs
  - English
  - Mandarin
  - Miniature Artificial Language (MAL)
- TR = 2000ms, TE = 30ms, flip angle = 90°, voxel resolution = 3.2 x 3.2 x 3.2 mm, 191 volumes, 12.5 min.
- FSL v5.0.6; Freesurfer v5.3.0; Nipype v0.8; Motion < 1 mm; flip angle = 90°, voxel resolution = 3.2 x 3.2 x 3.2 mm, 191 volumes, 12.5 min.

RESULTS

Behavioral Results
- Significant Main Effect of Language
  - F (2,46) = 520.1, p < .001
- Significant Main Effect of Session
  - F (1,23) = 14.94, p < .001
- Significant interaction between Language and Session
  - F (2,46) = 5.46, p < .01
- Significantly greater increase in accuracy in Mandarin than in English or in MAL
  - Fs (1,23) > 6.8, p’s < .02

fMRI Results

Mandarin vs. English

Mandarin vs. MAL

SUMMARY

A. Functional Plasticity of L2 Sentence Processing
1. After training, compared to English and MAL, the Mandarin condition elicited greater increases in:
   - the activation in left IFG, left pSTG, and SMA;
   - the activation in the frontal-parietal network;
   - the deactivation of DMN and bilateral hippocampi.
2. These changes represent effortful sentence processing in early learners:
   - extra recruitment of the prefrontal and speech-motor networks;
   - deficient activation in left STS.

B. Initial left IFG activation in response to Mandarin is associated with future learning success: both immediate attainment and long-term retention 3 months later, consistent with prior studies in structural MRI and resting-state fMRI (Figs et al., 2009; Ventura-Campes et al., 2013; Chai et al., 2016). Mandarin elicited greater activation in the right STG compared to either English or MAL, which also follows the phonotactic rules of English.

D. Future directions:
   - Are these neural signatures of language learning specific to Mandarin?
   - What are the computational differences between fluent L1 sentence processing and effortful but erroneous L2 sentence processing?

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