# Functional Brain Imaging Predicts Mandarin Learning Success

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Introduction

- Foreign language learning is extremely challenging for adults.
- But some learners are more successful than others.
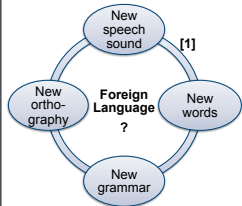
Research Questions:
- Do the neural substrates underlying novel speech sound perception predict holistic usage of a novel language (Mandarin) in individuals?
- How does Mandarin training affect the representation of pitch information for Mandarin speech in the brain?

Experiment Design
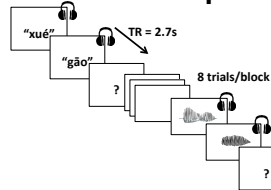
Tone discrimination tasks
- 96 pairs of Mandarin single words
  - ◇ Different syllables
  - ◇ Different speakers
- 96 pairs of corresponding sinewave tones

One-month Mandarin training in classroom
- 3.5 in-class hours per day, for 5 days per week, over 4 weeks
- 11 assignments and 10 quizzes (an average of 2.7 after-class hours per day)

Participants

- 24 native English speakers (8 females and 16 males)
- Age: 18 - 33, Mean: 23.1
- Handedness: 20 right-handers and 4 left-handers
- Post-training Proficiency tests:
  - ◇ Final Exam
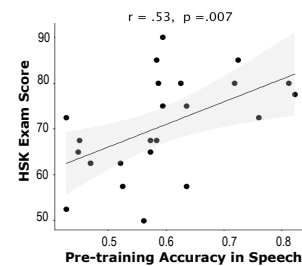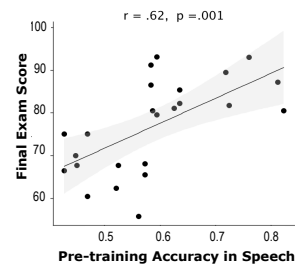 - ◇ Official standardized Chinese language test HSK (Level 1)

	Listening	Reading	Speaking	Total
Final Exam	73 (12.1)	76 (14.6)	81 (8.8)	77 (10.9)
HSK Exam	64 (13.8)	76 (10.9)	-	70 (10.7)

Mean scores of post-training proficiency tests (standard deviation)

Behavioral Results

Pre-training   Post-training

Association with Learning Success

r = .62, p =.001

r = .53, p =.007
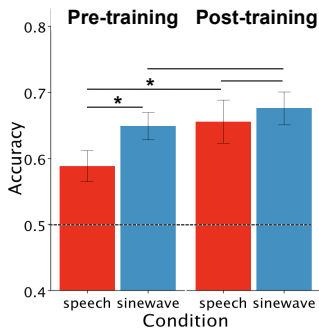
- ➤ Main effect of sound types (Sinewave > Speech)
- ➤ Main effect of sessions (Post-training > Pre-training)
- ➤ Marginal interaction of sound types and sessions (Increase of accuracy only in speech, but not in sinewave)

- ➤ Behavioral accuracy in discriminating Mandarin tones
  - Predicts individual's HSK exam total score.
  - Predicts individual's final exam total score.

- ➤ Post-training accuracy in both conditions were also positively associated with exam scores (r's > .40, p's < .05).
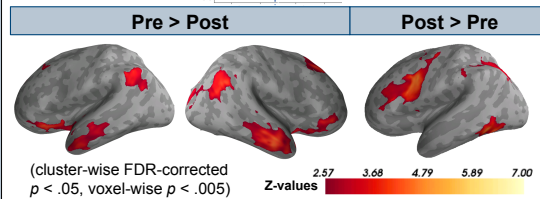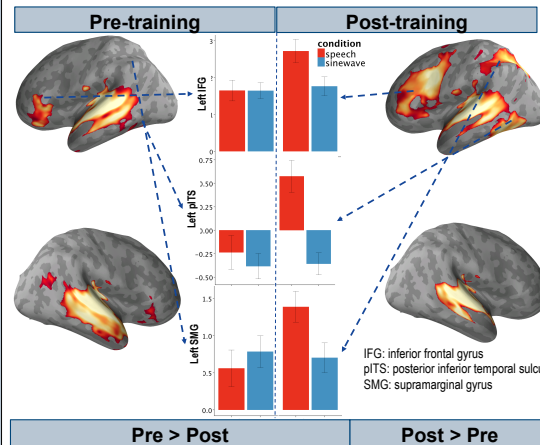
Conclusion

- ➤ Native English speakers who were more sensitive to tonal difference in Mandarin speech showed greater potential as successful language learners.
- ➤ Successful learners showed a dramatic switch of neural recruitment from right IFG before training to left IFG after training.
- ➤ Mandarin training induced increased activation in the left dorsal and ventral stream of speech processing.
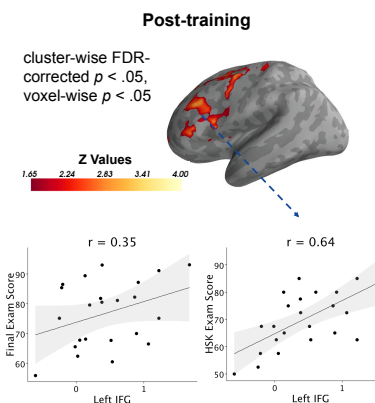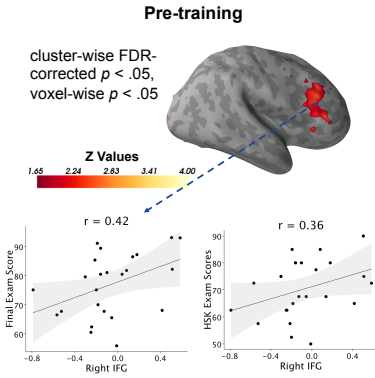
Reference

[1]. Wong, P. C. M., Perrachione, T. K., & Parrish, T. B. (2007). *Human Brain Mapping*, *28*(10), 995–1006.
[2]. Hickok, G., & Poeppel, D. (2007). *Nature Reviews Neuroscience*, 8(May), 393–402.

fMRI Results (Speech vs. Sinewave)

Pre-training   Post-training

IFG: inferior frontal gyrus
pITS: posterior inferior temporal sulcus
SMG: supramarginal gyrus

Pre > Post   Post > Pre

(cluster-wise FDR-corrected $p < .05$, voxel-wise $p < .005$)

- ➤ Decreased activation in bilateral anterior MTG and default-mode network after training: less explicit acoustic analysis, but more engagement in task.

- ➤ Increased activation in Left IFG, pITS and SMG after training: sensory-motor integration and lexical-semantic processing [2]

- ➤ Greater Mandarin learning success was associated with:
  - Greater activation in the right IFG before training.
  - Greater activation in the left IFG after training.

Association with Learning Success

Pre-training

cluster-wise FDR-corrected $p < .05$, voxel-wise $p < .05$

Z Values
1.65 2.24 2.83 3.41 4.00

r = 0.42   r = 0.36

Post-training

cluster-wise FDR-corrected $p < .05$, voxel-wise $p < .05$

Z Values
1.65 2.24 2.83 3.41 4.00

r = 0.35   r = 0.64