White Matter Integrity Predicts Adult Second Language Learning Outcomes

Michelle Han[1], Zhenghan Qi[1], Jack Murtaugh[1], Keri Garel[1,2], Ee San Chen[1,3], & John Gabrieli[1]
[1]Massachusetts Institute of Technology, [2]Massachusetts General Hospital, [3]Boston University

Objective

- To investigate whether inter-subject variability in the microstructure of white matter pathways would predict native English speaker's outcomes in learning Mandarin Chinese.

Methods

- Participants: 21 adults (13 males, mean age = 23.6, mean IQ = 117) with no prior exposure to tonal languages.
- Imaging: T1-weighted anatomical and diffusion-weighted images were acquired on a Siemens Tim Trio scanner before training.
- Mandarin training: Nineteen 3.5 hour classes over 4 weeks. Final proficiency was assessed by a final exam that tested speech production, listening, and reading.

Analysis

- Following image acquisition, all images were corrected for eddy currents and motion; registered to the subject's own T1 and MNI template; and used to generate maps of Fractional Anisotropy (FA). TRACULA[1] was used to reconstruct the 18 major white matter pathways.
- 3 bilateral, language-relevant tracts[2,3] (Fig. 1) were selected and related to Mandarin learning success as measured by performance on the final exam.

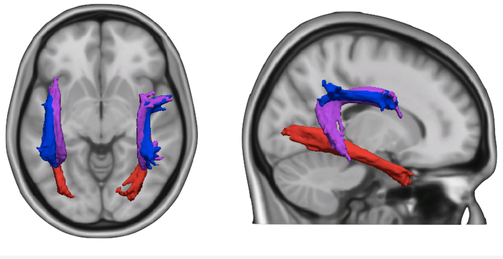
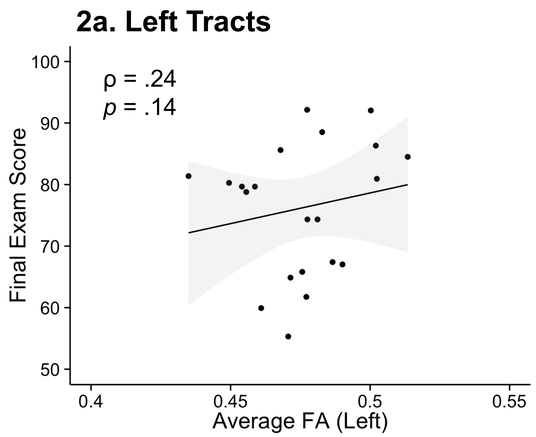
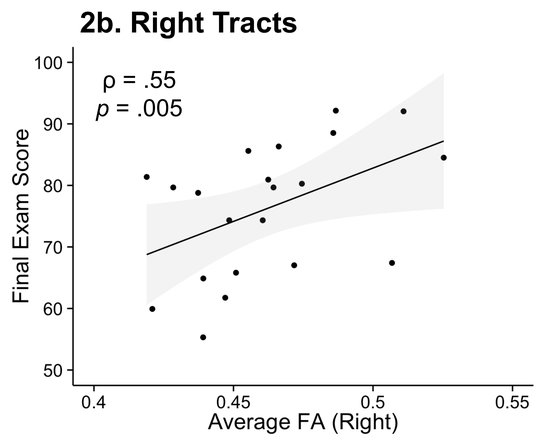
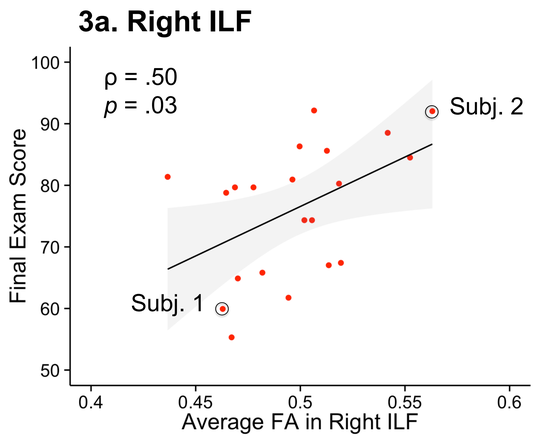
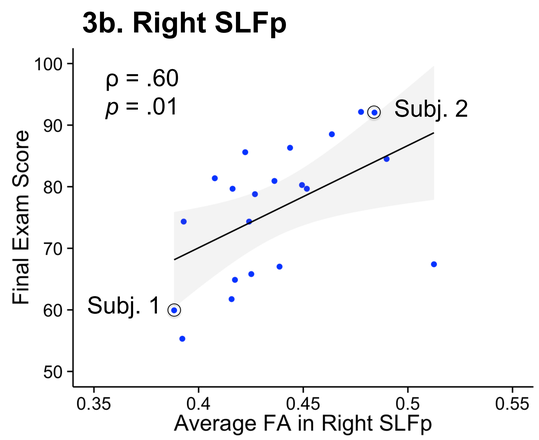


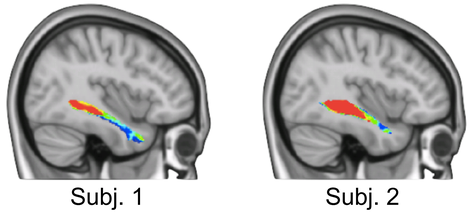
Figure 1: Tracts of interest: Inferior Longitudinal Fasciculus (ILF, red); Superior Longitudinal Fasciculus, parietal (SLFp, blue); Arcuate Fasciculus (AF, purple).

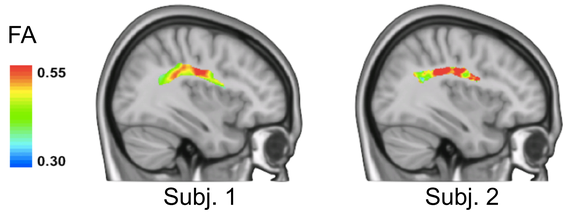


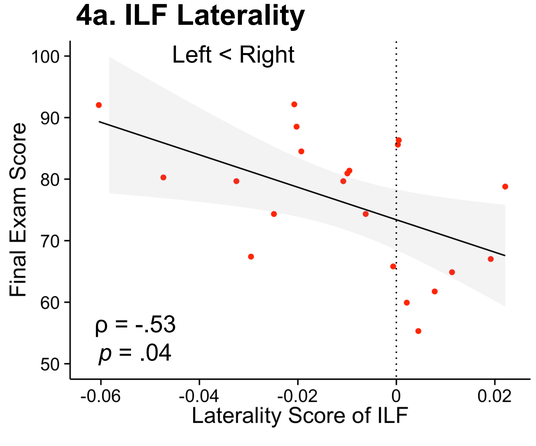












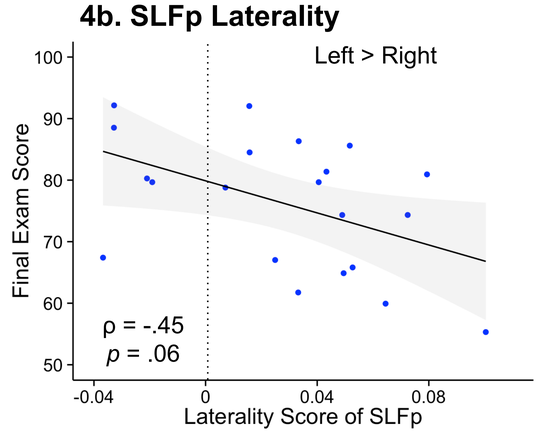


Figure 2: Correlation between the average FA across three tracts of interest (ILF, SLFp, and AF) and final exam scores.

Figure 3: Correlation between FA values of (a) the right ILF and (b) the right SLFp and final exam scores. Example subjects' tracts are also shown with each plot.

Figure 4: Correlation between hemispheric asymmetry of tract FA values (more positive = more left lateralized) and final exam scores.

Results

- The average FA value of the left tracts did not predict Mandarin learning success, while the average FA value of the right tracts did so significantly.
- Greater FA values in the right ILF and right SLFp predict Mandarin learning success.
- Hemispheric asymmetry of FA predicts Mandarin learning. More right-lateralized ILF and less left-lateralized SLFp were associated with higher final exam scores.

Conclusion & Discussion

- In adults, Mandarin learning proficiency is more strongly mediated by the language relevant white matter tracts in the right hemisphere compared to their left hemisphere correlates.
- The contribution of the right hemisphere may be due to the tonal properties[4] or visuo-spatially complex orthography[5] in Mandarin not present in other languages.
- Further study is needed to distinguish Mandarin specific implications of the results from general adult second language acquisition.

References

[1] Yendiki, A., Panneck, P. al. *Front. Neuroinform.* 2011.
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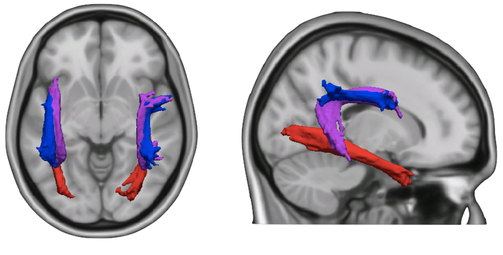

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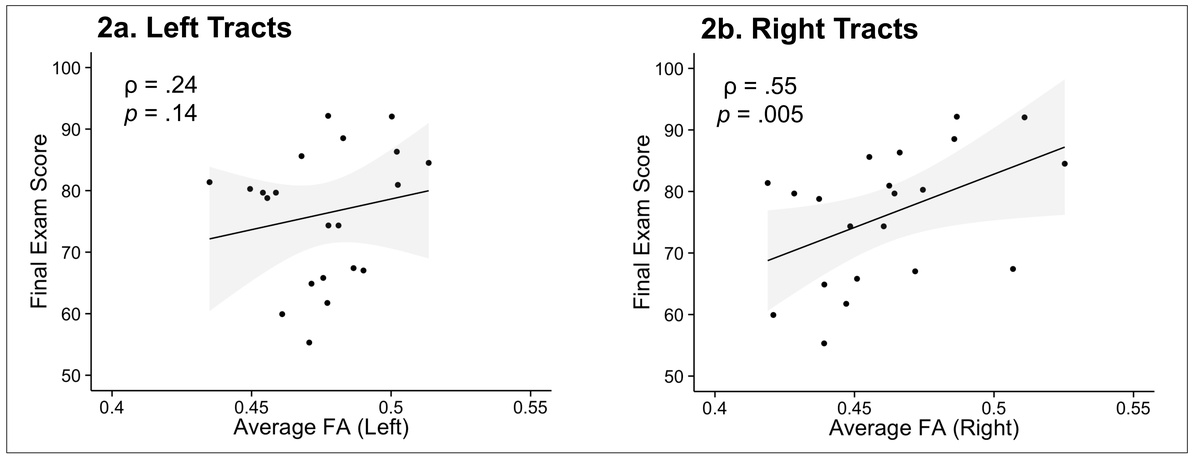

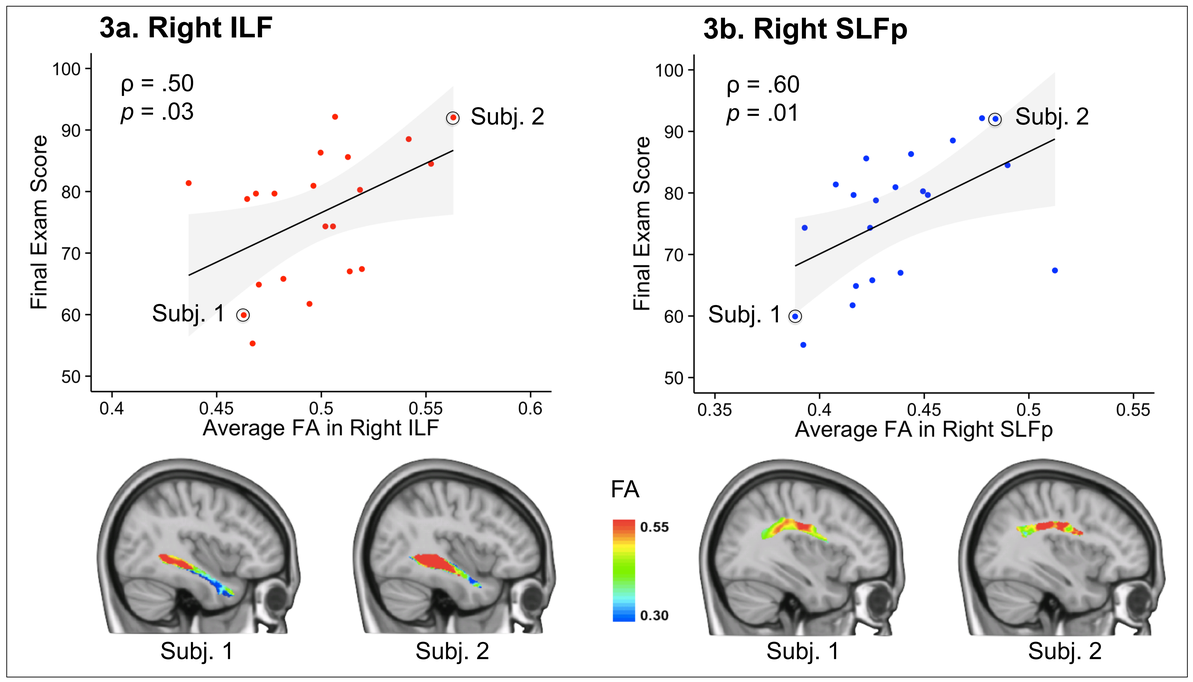

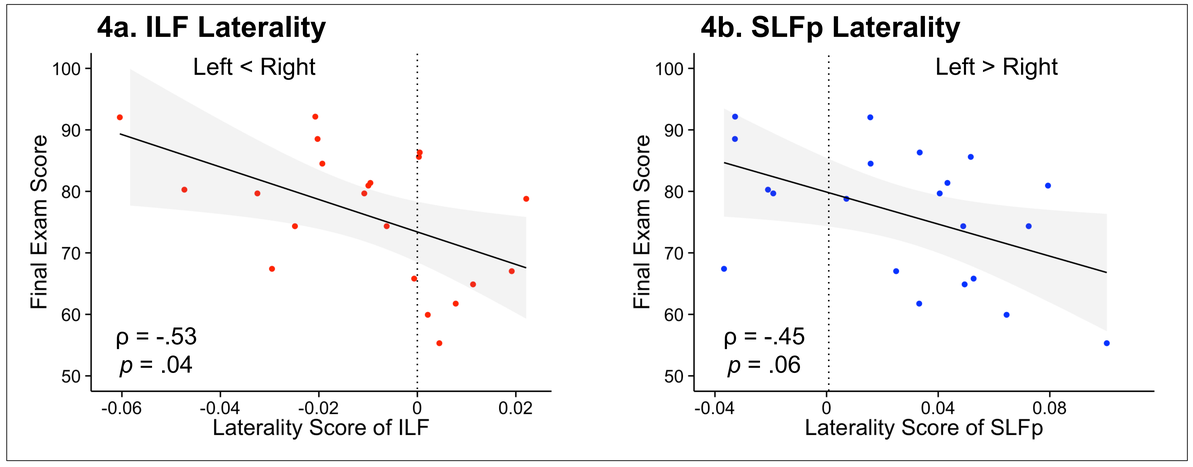

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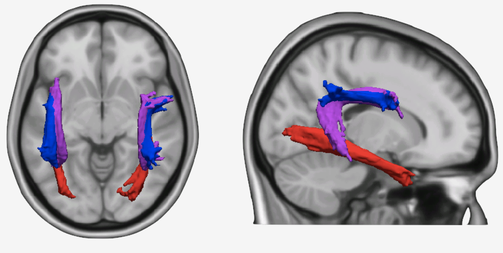
- Dorsal and ventral pathways[2,3] in both hemispheres (Fig. 1) were selected and related to learning success as measured by performance on the final exam.



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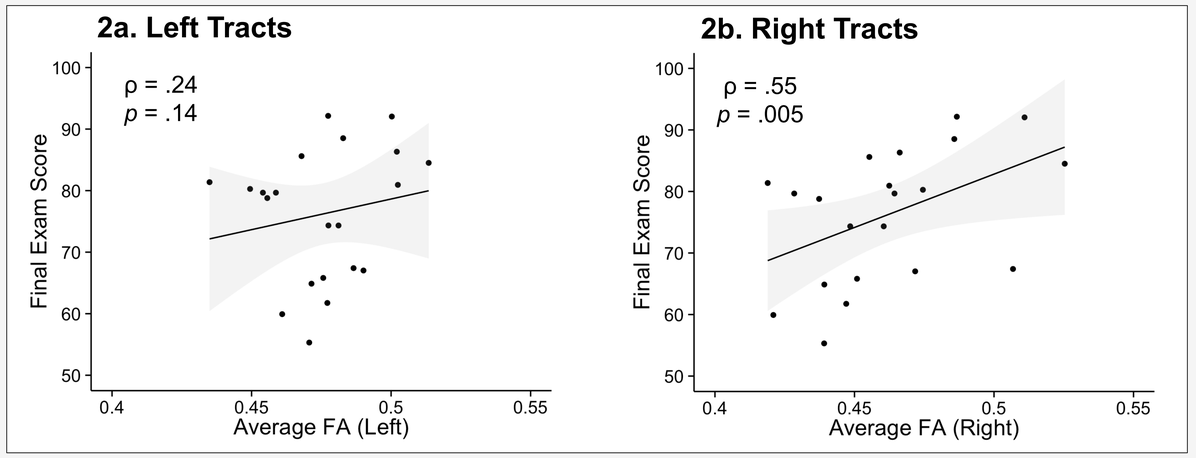

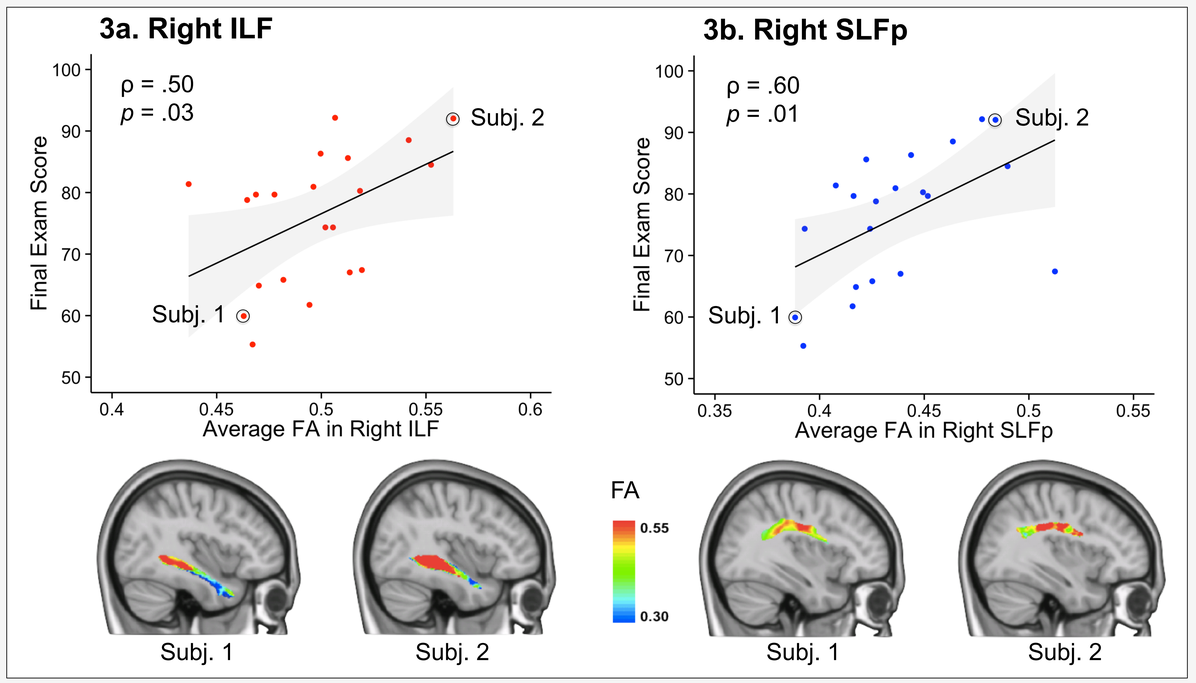

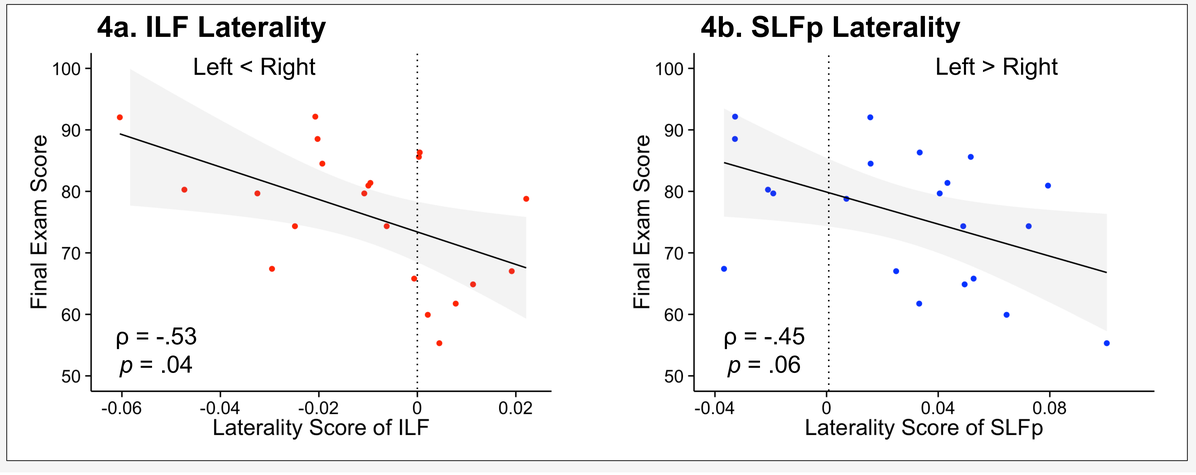

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Results

- Mandarin learning success was predicted by:
  - Greater FA values in the right tracts
  - Greater FA values in the right ILF and right SLFp
  - Hemispheric asymmetry measured by FA
    - More right-lateralized ILF
    - Less left-lateralized SLFp.

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