



Symbolic and Nonsymbolic Fractions Relate to Different White Matter Tracts: A Cross-Sectional Diffusion MRI Tractography Study

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Background

- Growing evidence suggests the existence of a system dedicated to processing nonsymbolic ratio magnitudes (e.g., the ratio of two line-lengths).
- This system has been dubbed as the ratio processing system (RPS) and it has been proposed that this system can be leveraged to help children acquire *symbolic* fraction.^{1,2,3}
- Neuroimaging studies suggest the RPS and fraction processing engage overlapping fronto-parietal networks.⁴
- However, white matter pathways connecting this network, including the superior longitudinal fasciculus (SLF) and inferior longitudinal fasciculus (ILF), remain unexplored.^{1,3,4}
- In this study, we tested the relations between these white matter pathways and fraction processing in 2nd and 5th graders.

Methods

Participants: The final sample included 44 2nd graders (out of 47) and 42 5th graders (out of 45) completed the MRI scan.

Multiple Notation Comparison Tasks (XFC)

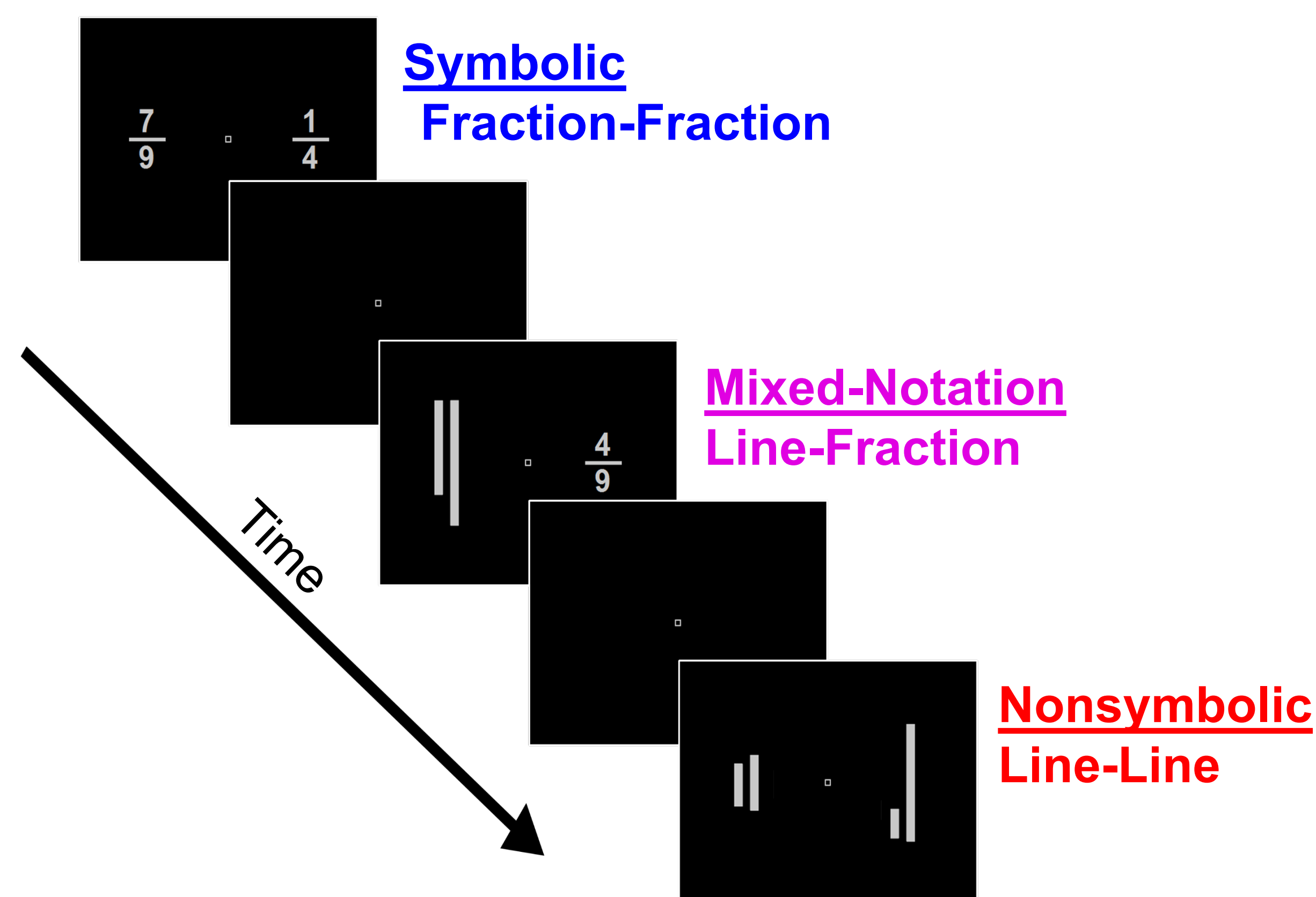


Figure 1. XFC task procedure

Results

1. Reaction times in 2nd and 5th graders

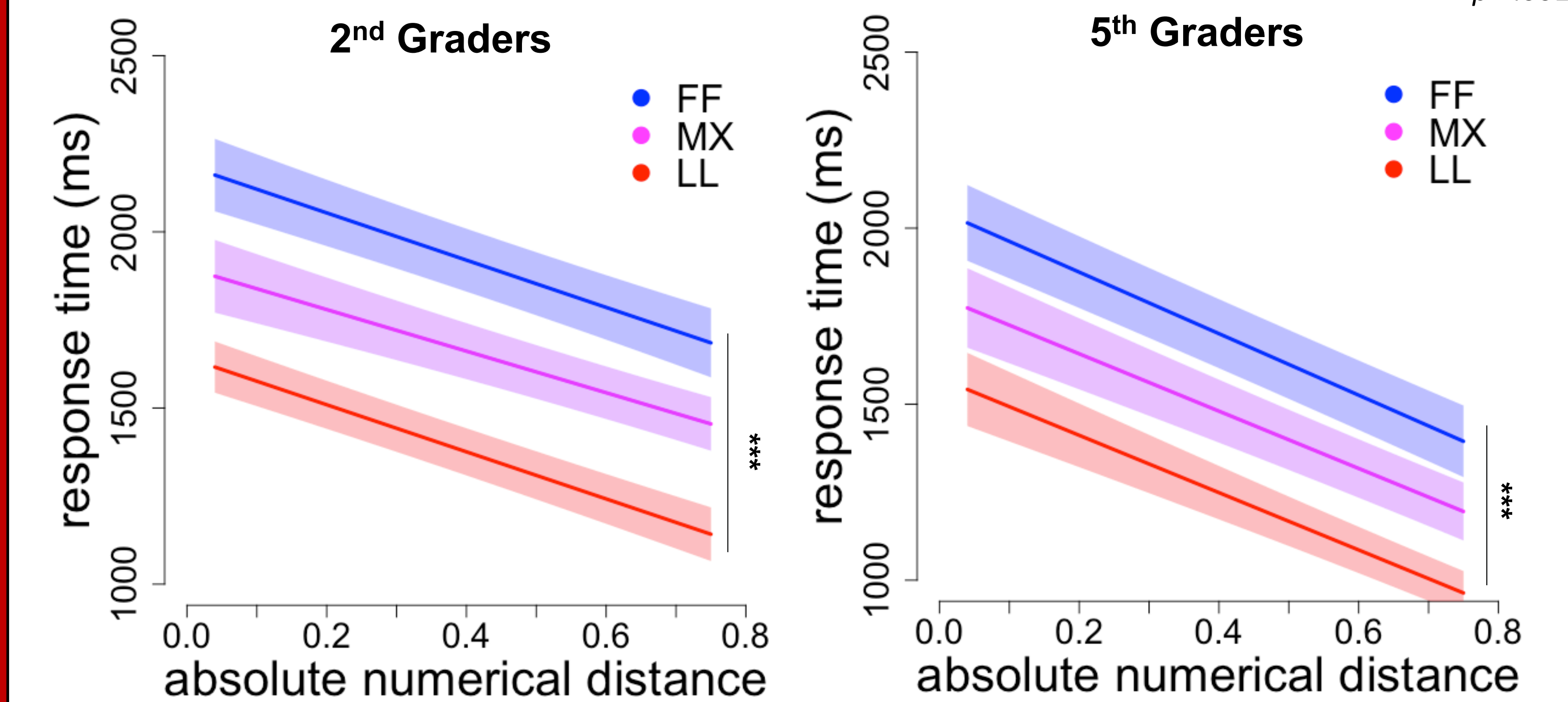


Figure 2. Reaction times for each notation: 5th graders were more rapid compared to 2nd graders ($p < .05$). Non-symbolic (LL) comparison was the easiest and symbolic (FF) comparison was the hardest ($p < .001$).

2. Correlations between the SLF and *nonsymbolic* ratio processing

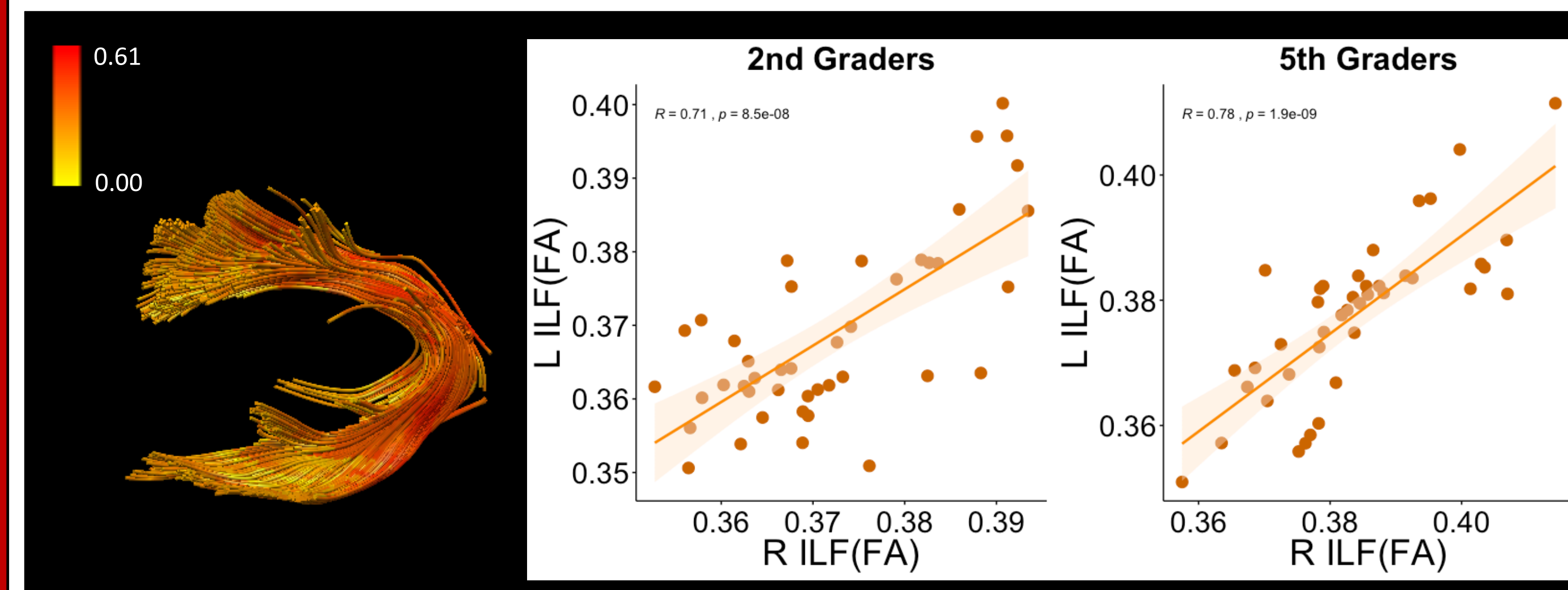


Figure 3. Extracted left SLF. The high interhemispheric correlations between the left and right SLFs showed the quality of the tract extractions.

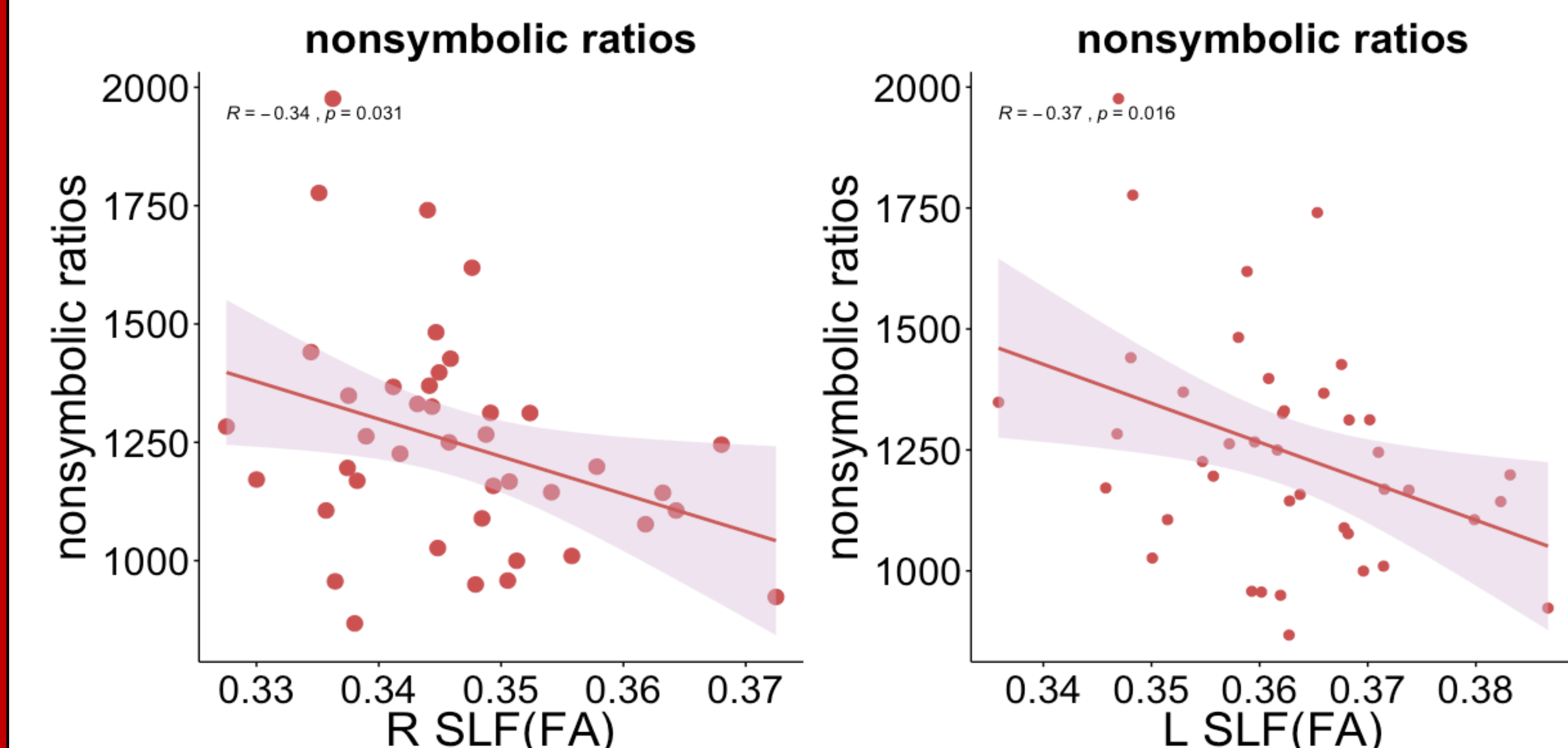


Figure 4. Only 5th graders' bilateral SLF showed significant correlations with nonsymbolic ratio processing.

3. Correlations between the ILF and *symbolic* fraction processing

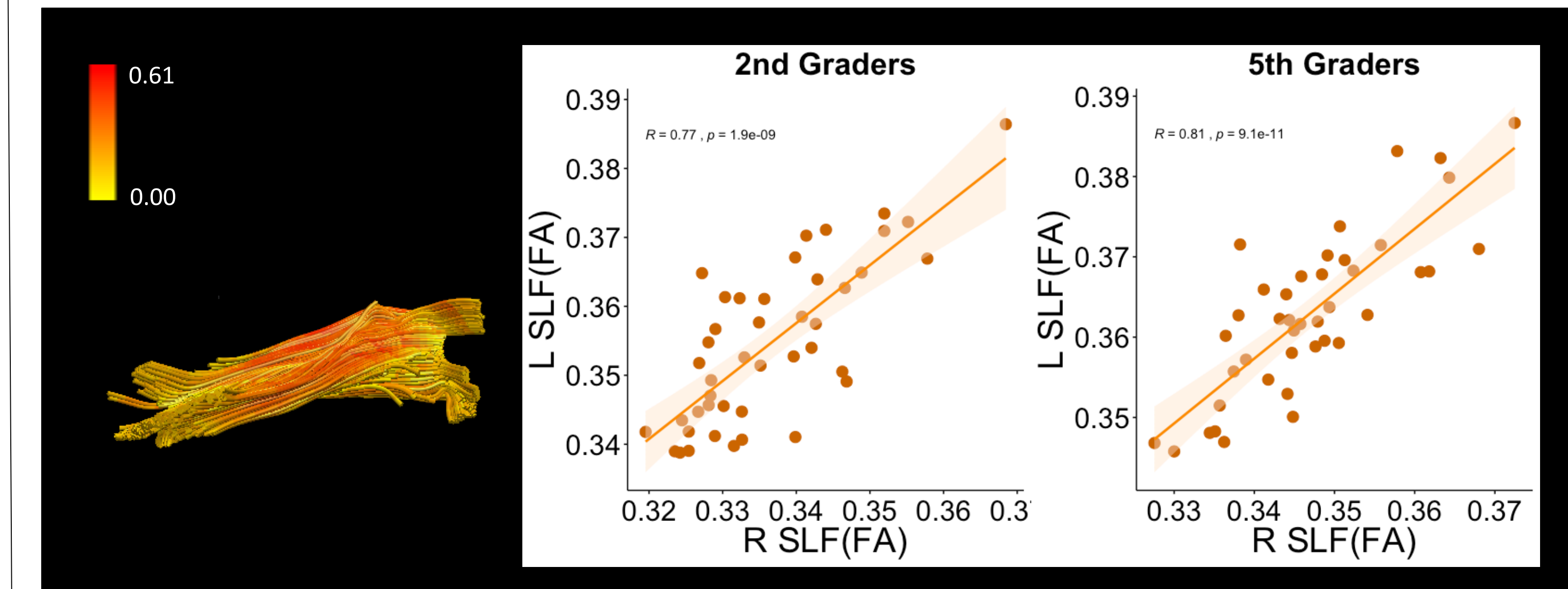


Figure 5. Extracted left ILF. The high interhemispheric correlations between the left and right SLFs showed the quality of the tract extractions.

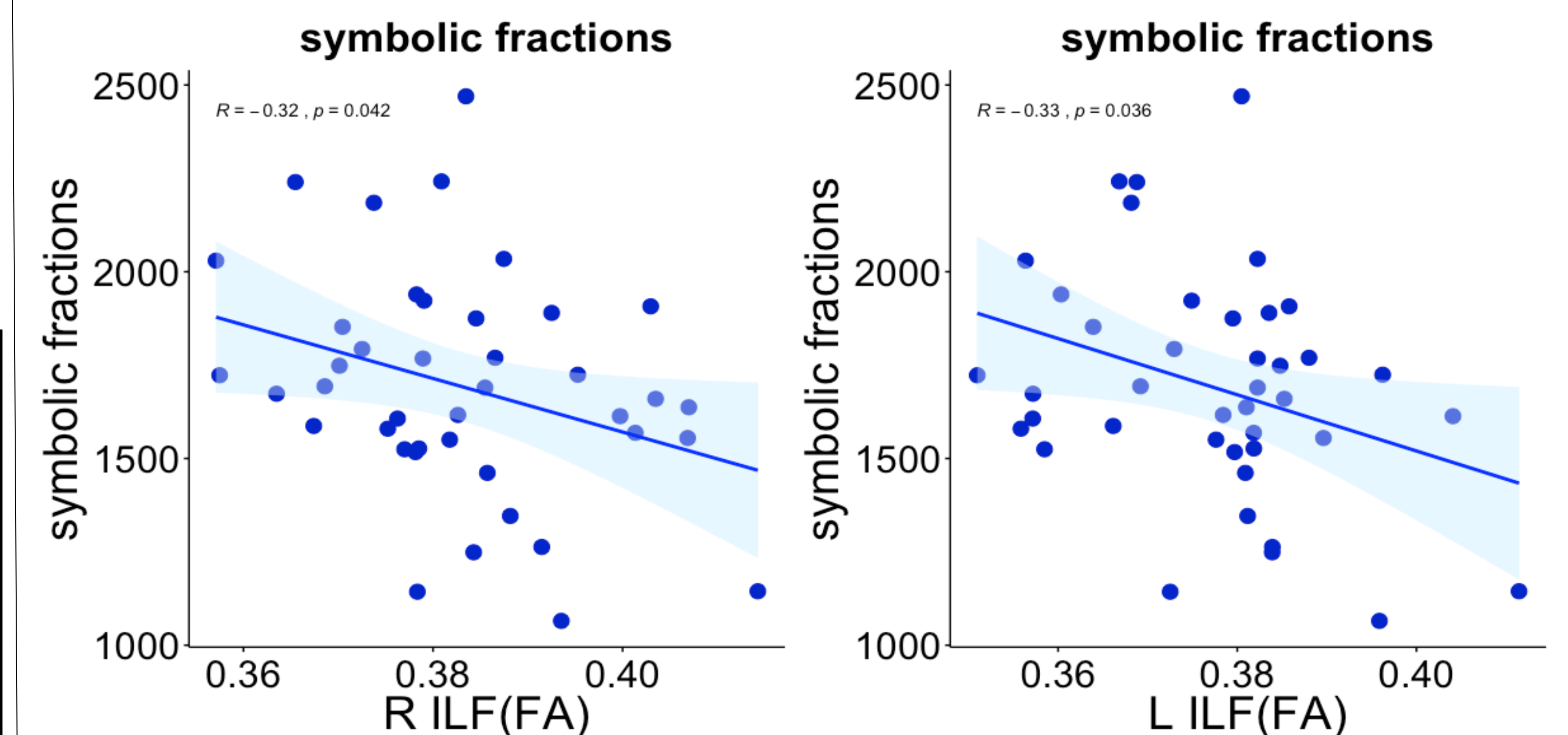


Figure 6. Only 5th graders' bilateral ILF showed significant correlations with symbolic fraction processing.

Summary

- Symbolic fraction comparison was the hardest, and the nonsymbolic ratio comparison was the easiest.
- **Only in 5th graders, but not in 2nd graders,** right parietal-frontal and frontal-temporal white matter were associated with ratio processing ability.
- ILF was particularly associated with symbolic fraction comparisons.
- Associations between structural connectivity and the ratio processing skills change during the early elementary school years.

References

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- 3 Jacob, S. N., Vallentin, D., & Nieder, A. (2012). Relating magnitudes: the brain's code for proportions. *Trends in Cognitive Sciences*, 16(3), 157–166.
- 4 Park, Y., Binzak, J.V., Toomarian, E.Y., Kaira, P.B., Matthews, P.G., & Hubbard, E.M. (July, 2018). Developmental changes in children's processing of nonsymbolic ratio magnitudes: A cross-sectional fMRI study. Poster presented at the 40th Annual Meeting of the Cognitive Science Society, Madison, WI.