Brain Networks for Pre- and Beginning School-Aged Readers: A Resting-State FMRI Study

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INTRODUCTION

Reading Development: Understanding how brain networks evolve during reading acquisition is essential for supporting early literacy. As children transition from pre-readers to beginning readers, neural connectivity becomes more specialized.

Resting-State Functional Connectivity (RSFC): RSFC captures spontaneous brain activity, offering a window into cognitive development.

Current Study: We examined RSFC in 29 children aged 4.61–9.97 years using six reading-related regions of interest (ROIs). ROIs included bilateral inferior frontal gyrus (IFG), visual word-form area (VWFA), and angular gyrus (AG).

MATERIALS & METHODS

Participants: 29 typically developing, right-handed children (mean age = 7.02, SD = 1.19; 14 males), aged 4.61–9.97 years. Children were grouped as pre-readers (n = 17, mean age = 6.24 ± 0.67; 8 M) and beginning readers (n = 12, mean age = 8.11 ± 0.83; 6 M). All were monolingual native English speakers with normal or corrected vision and hearing.

FMRI Acquisition: Data were collected during a resting-state scan using the 3T Siemens Magnetic Resonance Imaging (MRI) system at the Center for Brain, Biology and Behavior (CB3). Participants were instructed to remain still and relaxed.

Preprocessing & Denoising: Data were preprocessed using an SPM-based pipeline: motion correction, outlier removal, segmentation, MNI normalization, smoothing (8 mm FWHM), and CompCor-based denoising. Bandpass filtering was applied (0.008–0.09 Hz).

Connectivity Analysis: ROI-to-ROI correlations were computed using Fisher-transformed bivariate correlations. Group comparison between two groups was done with two sample T-tests. The results were cluster-level FDR corrected ($p < 0.05$).

RESULTS

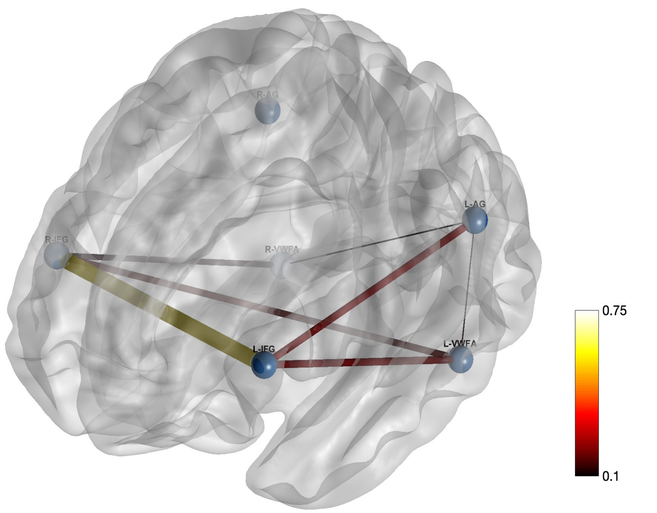

Figure [1]

Figure 1. Integrated Reading Network in Beginning Readers

Beginning readers showed increased cross-hemispheric integration and VWFA–IFG connectivity, reflecting the emergence of specialized and efficient reading networks of both dorsal and ventral pathways.

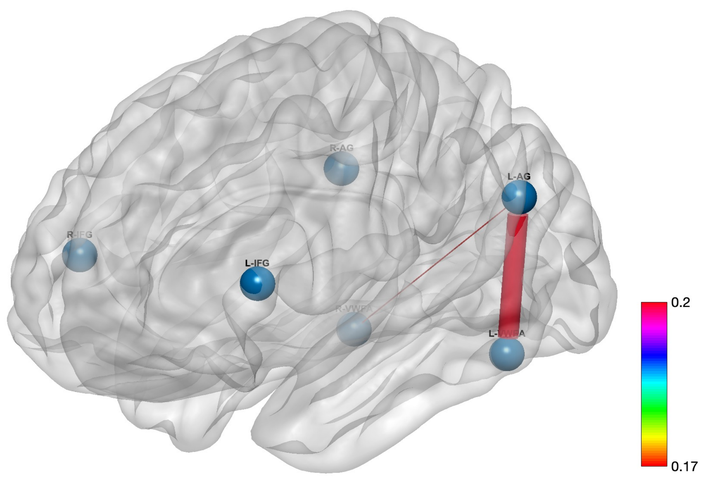

Figure [2]

Figure 2. Focused Connectivity in Pre-Readers

Pre-readers exhibited stronger connectivity between the left VWFA and left AG (limited cross-network integration).

This pattern suggests <u>early reliance</u> on the <u>dorsal pathway</u> supporting phonological processing before they become more efficient readers.

CONCLUSION

Developmental Implications

Findings support a shift from diffuse reading networks in pre-readers to more specialized reading networks in beginning readers. This reflects increased orthographic and phonological processing efficiency with reading experience.

Future Applications

This RSFC approach can be used to track reading development and inform interventions. Insights from RSFC may guide educational strategies and early diagnostics for reading difficulties.

REFERENCES

1. Whitfield-Gabrieli, S., et al. 2012. *Brain Connectivity*, 2(3), pp.125–141.
2. Nieto-Castanon, A. 2020. *Handbook of Functional Connectivity Magnetic Resonance Imaging Methods in CONN*, Hilbert Press, pp.17–25.
3. Friston, K.J., et al. 1995. *Human Brain Mapping*, 3(3), pp.165–189.
4. Ashburner, J., and Friston, K.J. 2005. *NeuroImage*, 26(3), pp.839–851.
5. Ashburner, J. 2007. *NeuroImage*, 38(1), pp.95–113.

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