The development of neural systems supporting handwriting and letter perception from kindergarten to adulthood

Vinci-Booher, S. & James, K.H.

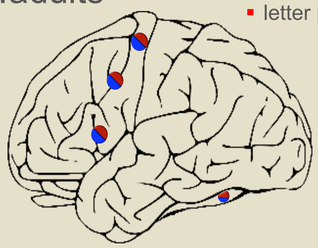
Psychological & Brain Sciences, Indiana University

Background

❖ Handwriting and letter perception in …

…adults[1]

- handwriting
- letter perception



…children[2]
(after printing practice)

❖ Handwriting produces several levels of visual input[3]

❖ Study questions

1. How does the brain system supporting handwriting change with experience?

2. What does the brain extract from the letterforms produced during handwriting – does this response change with experience?

Methods

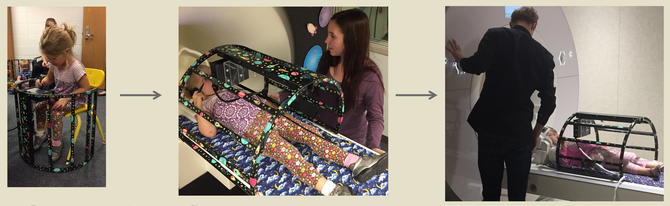
Participants

Early-literate children (5 – 6 years, n = 14)

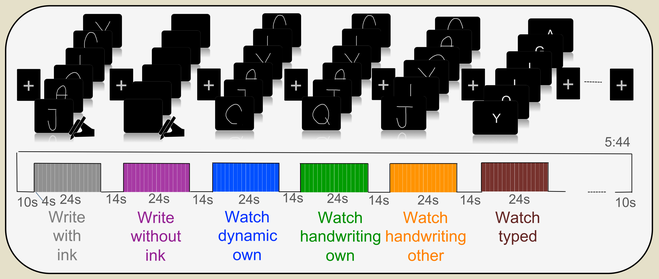
Literate children (7 – 8 years, n = 14)

Literate adults (19 – 25 years, n = 14)

Materials and procedure



Scanning protocol



Standard preprocessing

Slice scan time correction, 3D motion correction, Spatial smoothing (FWHM = 6mm), Temporal high-pass filtering

Additional motion correction

- Spike regression[4]: 2.00 mm threshold
- Motion regression[5]: 6 rigid-body motion parameters

Whole brain contrasts

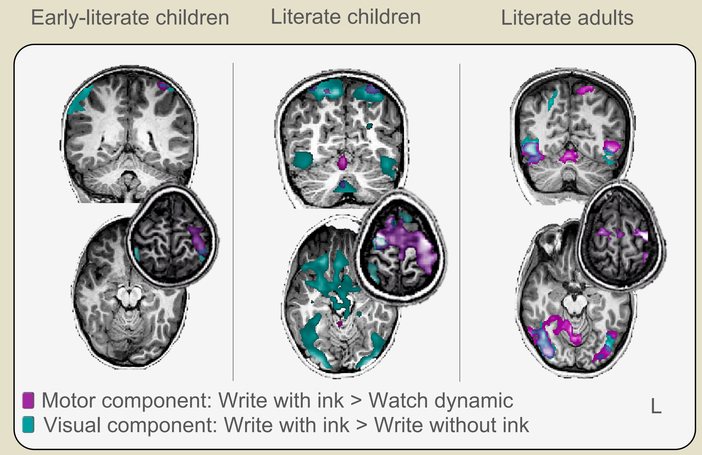
- Motor component: Write with ink > Watch dynamic
- Visual component: Write with ink > Write without ink
- Unfolding: Watch dynamic(own) > Watch handwriting(own)
- Own handwriting: Watch handwriting(own) > Watch handwriting(other)
- Variability: Watch handwriting(other) > Watch typed
- Letters: Watch typed > fixation

Results & Discussion

1. The neural response during handwriting changes with experience.

… progression from a frontal-parietal system to including the ventral visual stream.

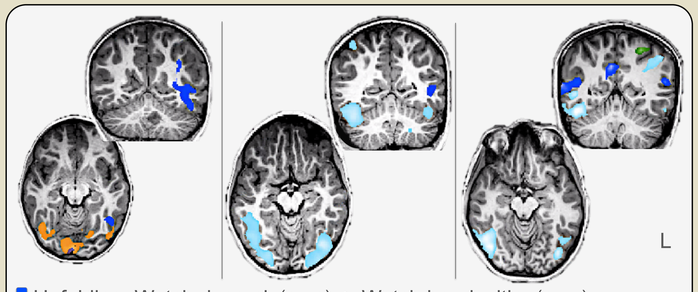
... overlap in L IPS/SPL is replaced by overlap in the ventral visual stream in adults.



2. What the brain extracts from the letterforms produced during handwriting changes with experience.

… before a letter-category response is established, variability prevails.

… after a letter-category response is established, a new category emerges.



$p_{vox} < .01$, $p_{clust} < .05$

References

1. James, K. H., & Gauthier, I. (2006). Letter processing automatically recruits a sensory–motor brain network. *Neuropsychologia*, *44*(14), 2937-2949.
2. James, K. H., & Engelhardt, L. (2012). The effects of handwriting experience on functional brain development in pre-literate children. *Trends in Neuroscience and Education, 1*(1), 32-42.
3. Li, J. X., & James, K. H. (2016). Handwriting Generates Variable Visual Output to Facilitate Symbol Learning. *Journal of experimental psychology. General.*
4. Satterthwaite, T. D., Elliott, M. A., Gerraty, R. T., Ruparel, K., Loughead, J., Calkins, M. E., ... & Wolf, D. H. (2013). An improved framework for confound regression and filtering for control of motion artifact in the preprocessing of resting-state functional connectivity data. *Neuroimage*, *64*, 240-256.
5. Bullmore, E. T., Brammer, M. J., Rabe-Hesketh, S., Curtis, V. A., Morris, R. G., Williams, S. C. R., ... & McGuire, P. K. (1999). Methods for diagnosis and treatment of stimulus-correlated motion in generic brain activation studies using fMRI. *Human brain mapping*, *7*(1), 38-48.

Funding: Imaging Research Facility Brain Scan Credit Program, Indiana Clinical and Translational Sciences Institute, National Institute of Health, T32 Grant # HD 07475, Indiana University Office of the Vice President for Research Emerging Area of Research Initiative, Learning: Brains, Machines and Children