PERCEPTUAL AND MOTOR EFFECTS OF LETTER WRITING ON BRAIN REGIONS ASSOCIATED WITH LETTER PERCEPTION

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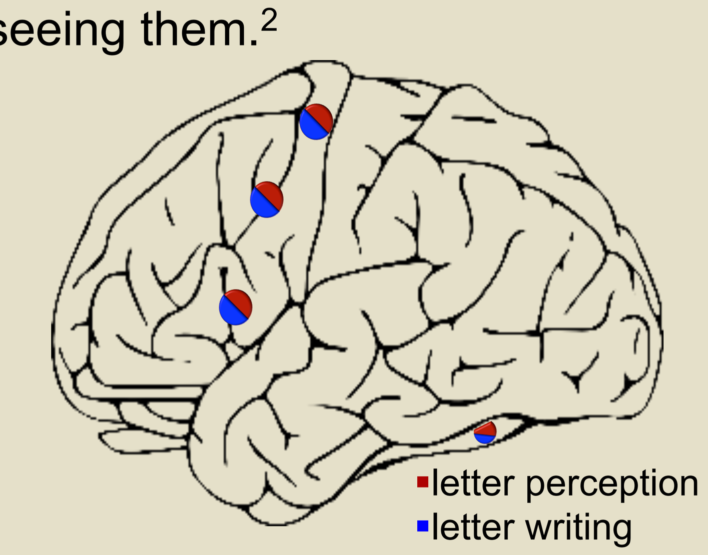
BACKGROUND

❑ Visual perception of individual letters recruits the **visual** association area, fusiform gyri (FuG), and **motor** regions, typically including the left dorsal precentral gyrus (L dPrG), left ventral precentral gyrus/middle frontal gyrus, and left inferior frontal gyrus (L IFG).[1,2]

❑ Similar regions are found when literate adults write letters, even without seeing them.[2]



❑ All of these regions respond most strongly for letterforms with which the observer has experience handwriting.[1,3]

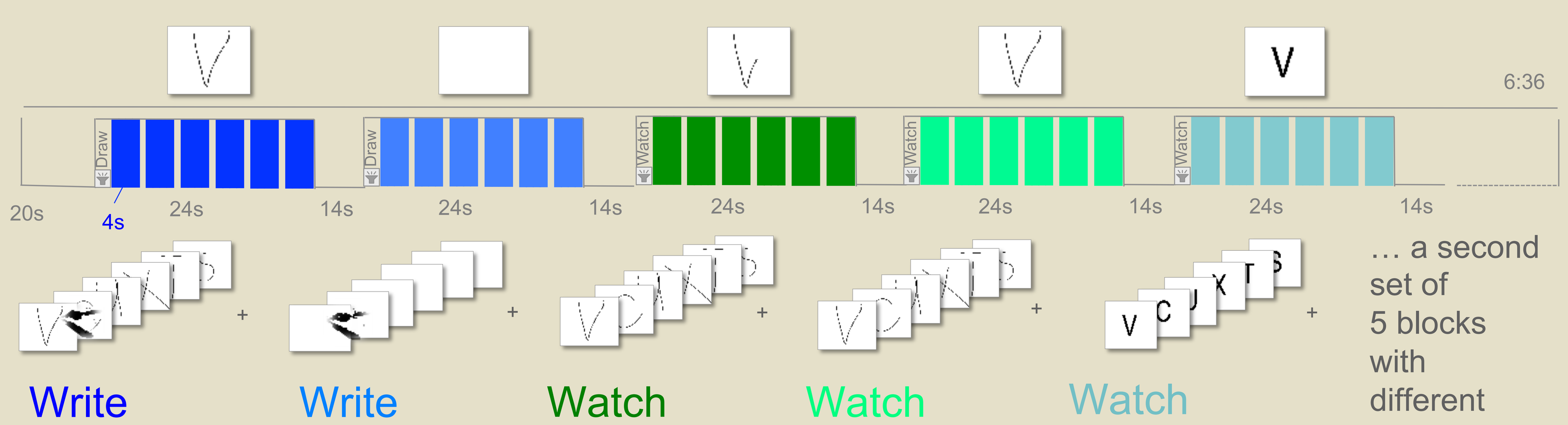
❑ Preliterate children show increased functional connections between L FuG and L dPrG and L IFG after printing experience, and the L FuG – L IFG connection is letter-specific.[4]

➢ Do visual and motor brain systems support adult handwriting and letter perception? If so, do these regions demonstrate functional connectivity during handwriting and/or letter perception?

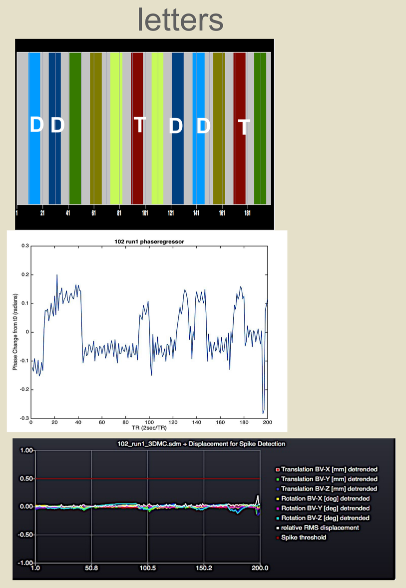
METHODS

Participants: 20 literate 19-25 year-old adults (10 males)

Scanning Protocol:



Additional Motion Correction:
(due to hand movements during task)



- Spike Regression[5]: 0.05 mm threshold
- Motion Regression[6]: 6 rigid-body motion parameters
- Phase Regression[7]: average change in phase across slices

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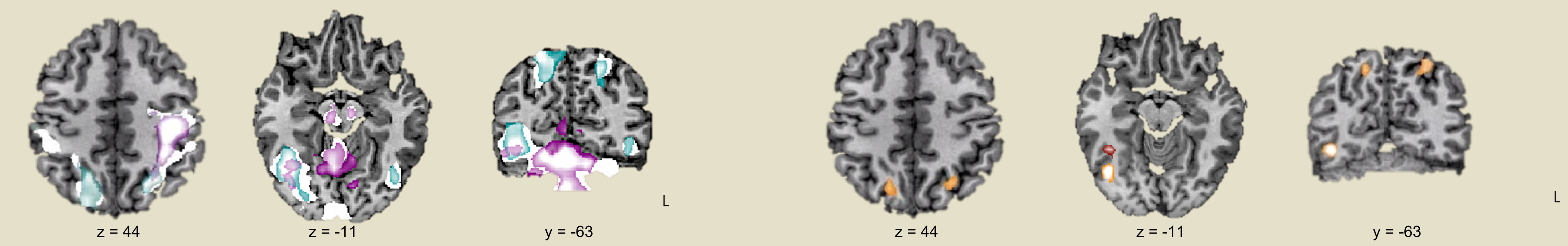
ANALYSES & RESULTS

Whole Brain Contrasts

RFX GLM, $p_{vox} < .0001$, $p_{clust} < .001$

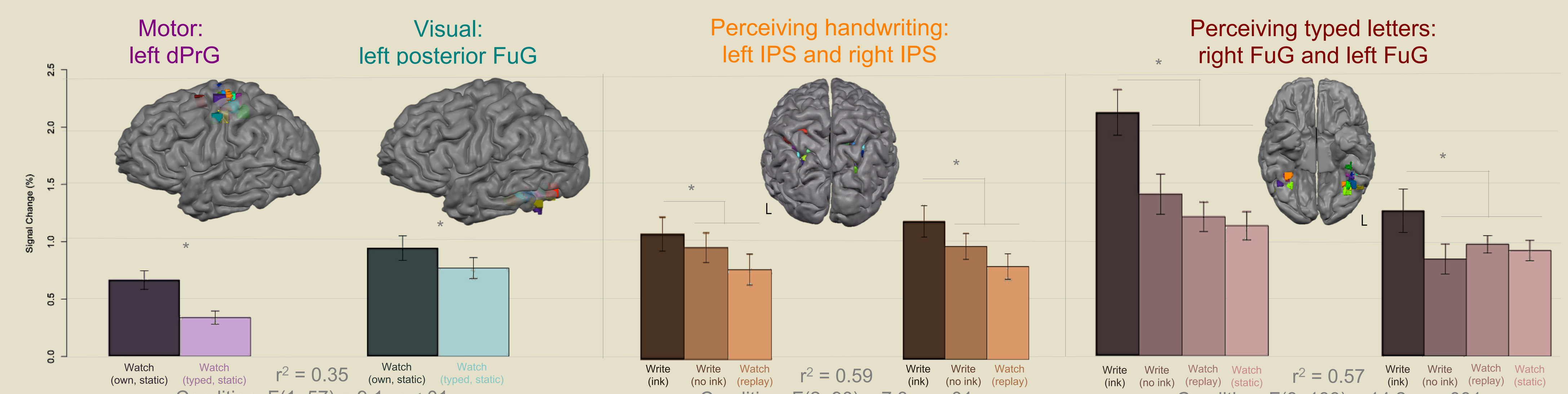


ROI Analyses

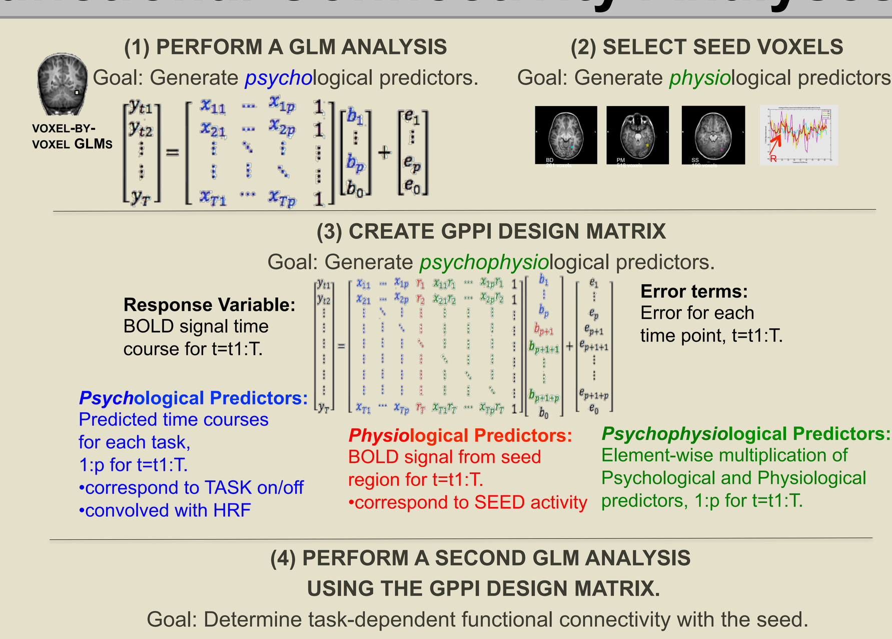
(1) Do the motor and visual brain regions involved in letter writing respond differently to handwritten vs. typed letters?
(2) Do brain regions that respond strongest for handwritten letters respond differently during handwriting than during passive viewing?
(3) Do brain regions that respond strongest for typed letters respond differently during handwriting than during passive viewing?

All ROIs were defined using individual functional and anatomical criteria.

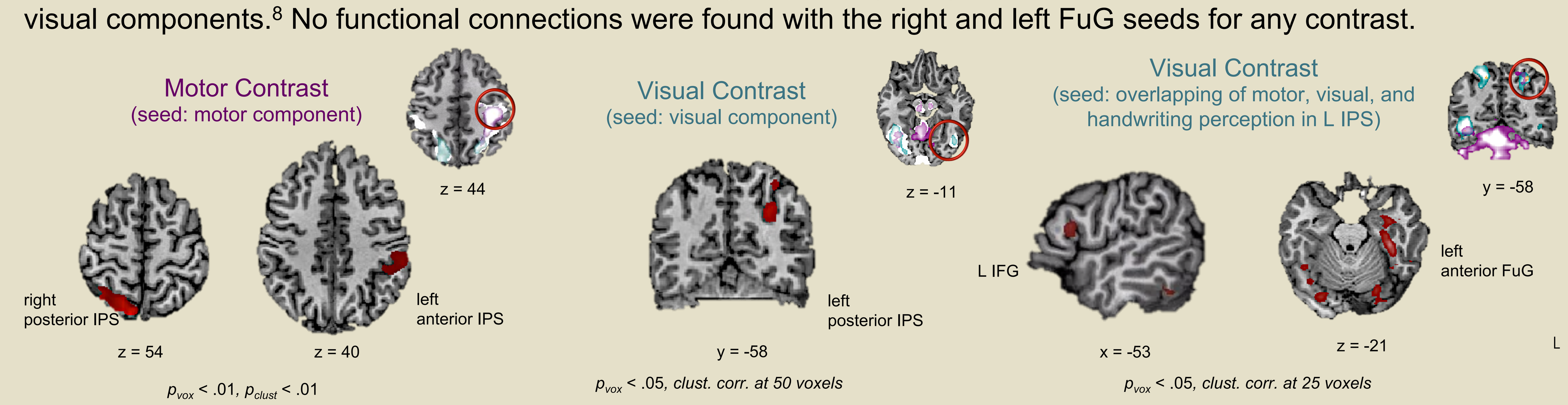
Linear mixed effects analysis of the relationship between condition and region in predicting peak signal change.
Fixed Effects: condition, region
Random Effect: subject



Functional Connectivity Analyses



Individual ROIs were then used as seeds in a gPPI functional connectivity analysis to determine if any of these regions demonstrated functional connectivity during handwriting and letter perception that was more associated with the motor or visual components.[8] No functional connections were found with the right and left FuG seeds for any contrast.

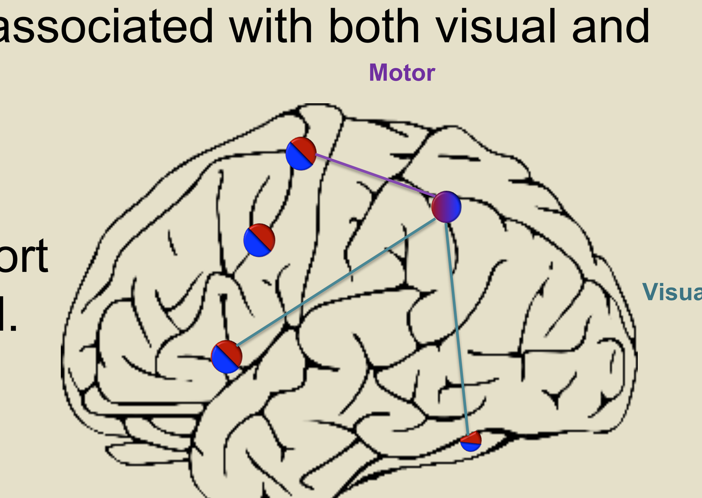


CONCLUSIONS

❑ Handwriting is a complex visual-motor task that relies more heavily upon bilateral ventral-temporal cortex for the visual component and more heavily upon right ventral-temporal and frontal cortex for the motor component. Parietal cortical regions appear to be associated with both visual and motor components, with the parietal motor component being located ipsilateral to its frontal counterpart.

❑ Handwriting perception relies upon different areas within ventral-temporal cortex than typed-letter perception; however, both regions respond stronger during handwriting than any handwriting subtask. Similarly, regions that support motor and visual components of handwriting also respond stronger for the perception of handwritten letters than typed.

❑ Functional connections between visual and motor brain regions support handwriting in adults; however, they appear to be mediated by parietal cortex.



REFERENCES: [1] 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. [2] James, K. H., & Gauthier, I. (2006). Letter processing automatically recruits a sensory–motor brain network. *Neuropsychologia, 44*(14), 2937-2949.[3] James, K. H., & Atwood, T. P. (2009). The role of sensorimotor learning in the perception of letter-like forms: Tracking the causes of neural specialization for letters. *Cognitive Neuropsychology, 26*(1), 91-110. [4] Vinci-Booher, S., James, T.W., & James, K. H (2016). *Functional connections during letter perception reflect aspects of letter writing: A gPPI functional connectivity study.* Under review. [5] 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. [6] 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. [7] Cheng, H., & Li, Y. (2010). Respiratory noise correction using phase information. *Magnetic Resonance Imaging, 28*(4), 574-582. [8] McLaren, D. G., Ries, M. L., Xu, G., & Johnson, S. C. (2012). A generalized form of context-dependent psychophysiological interactions (gPPI): a comparison to standard approaches. *Neuroimage, 61*(4), 1277-1286.