Poster #D103

Assessing the Relationship Between Reading Ability and Dyslexia: A Behavioral and fMRI Study

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BACKGROUND

- **Dyslexia** is characterized as a deficit in reading and writing skills, despite having normal intelligence[1].
- Dyslexic children have shown discrepancies in activation ipsilaterally & contralaterally when compared to controls.[2,3,4]
- However, whether these discrepancies are due to dyslexia, differences in brain development or differences in reading experience remains up for debate.

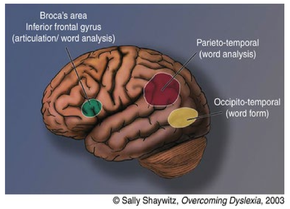

Figure 1. Anatomical regions of the reading network associated with Dyslexia, namely Broca's area, Visual Word Form Area and the Superior Temporal Gyrus.

Pattern	Interpretation
A = D > R	Developmental effect
A = R > D	Dyslexia-specific effect
A > R = D	Skill level effect

Table 1. Implications of activation patterns between groups. Dyslexia (D), Age-matched Controls (A), and Reading-matched Controls (R).

METHODS

Participants: Dyslexia defined either by prior diagnosis or the bottom 15th percentile reading score for their age group.

	Dyslexia	Age matched	Reading matched	Statistics
Sample Size	16	11	8	N/A
Gender Distribution	M (7) : F (9)	M (7) : F (4)	M (2) : F (6)	$\chi^2(2) = 2.83$, $p > .05$
Mean Age (YRS)	11.14 (1.02)^a	11.19 (1.37)^a	8.2 (0.7)^b	$F(2,32) = 22.98$, $p < 0.001$
Age Range (YRS)	10 - 12.92	8 – 12.92	7.5 – 9.5	N/A
TOWRE A Score Mean (SD)	79.5 (14.47)^b	112.82 (11.4)^a	99.12 (12.14)^a	$F(2,32) = 21.83$, $p < 0.001$
TOWRE B Score Mean (SD)	78.75 (14.49)^b	113.18 (12.33)^a	102.14 (13.68)^a	$F(2,31) = 21.98$, $p < 0.001$
WJ-III Word ID Score Mean (SD)	88.06 (13.58)^b	109.55 (8.15)^a	104.25 (14.48)^a	$F(2,32) = 10.94$, $p < 0.001$

Table 2. Descriptive statistics, group comparisons, and Post Hoc analyses for our sample. Super scripts *a* & *b* refer to Post Hoc results using Scheffe's test.

Task

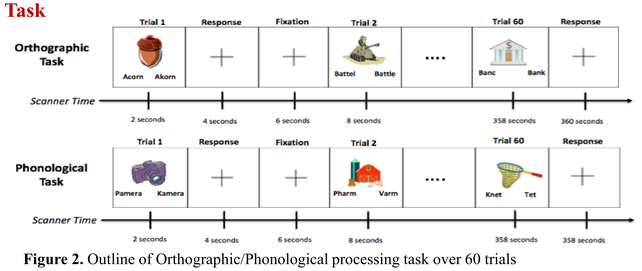

Figure 2. Outline of Orthographic/Phonological processing task over 60 trials

Adaptable task:

- 5 difficulty levels (1 = least difficult, 5 = most difficult)
- Task started at median level of 3
- Subsequent stimuli could range in difficulty level between 1 - 5
- Difficulty increased/decreased based on performance

IMAGING RESULTS

Cluster-thresholded activation maps for the effect of **Development (DA vs R)**, **Dyslexia (AR vs D)**, and **Reading Skill (DR vs A)** on the Orthographic and Phonological task. Dyslexic subjects (D), Age-matched Controls (A), and Reading-matched Controls (R). Bilateral hemisphere volumetric rendering. Beta value of 0 on color bar has corresponding t-statistic of 2.459.

Orthographic task

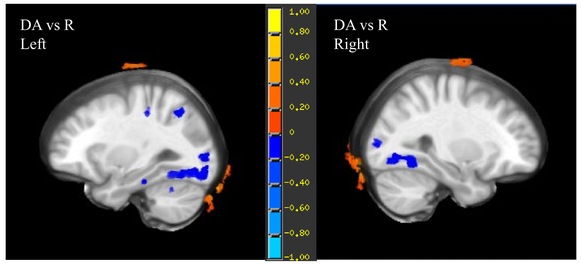

Figure 3. Developmental effect: Blue clusters correspond to greater activation in the R group, while red clusters correspond to greater activation in the D & A group combined.

Regions	Volume (1mm3)	Peak MNI coordinates
Bilateral Lingual/Fusiform gyrus/Occipital/Calcarine	26782	(0, 78, -7)

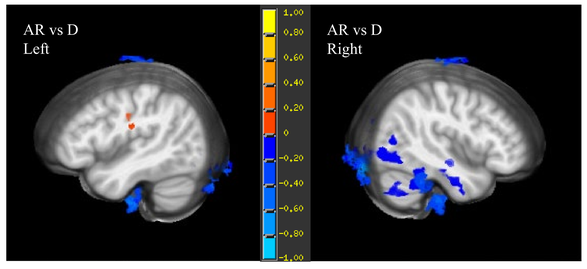

Figure 5. Dyslexic effect: Blue clusters correspond to greater activation in the D group, while red clusters correspond to greater activation in the A & R group combined.

Regions	Volume (1mm3)	Peak MNI coordinates
Bilateral Lingual/Fusiform gyrus/Occipital/Calcarine	73208	(-28, 96, -23)

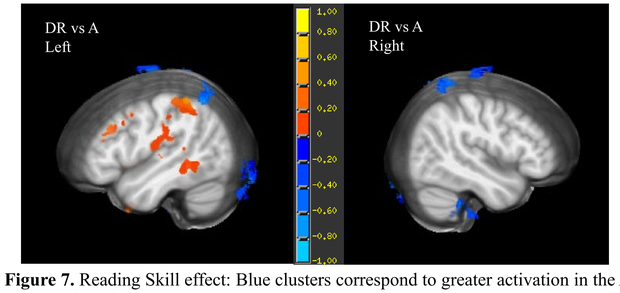

Figure 7. Reading Skill effect: Blue clusters correspond to greater activation in the A group, while red clusters correspond to greater activation in the D & R group combined.

Regions	Volume (1mm3)	Peak MNI coordinates
Left Putamen/Temporal	7827	(47, 51, -6)
Left Parietal/Angular	4394	(46, 48, 58)

Phonological task

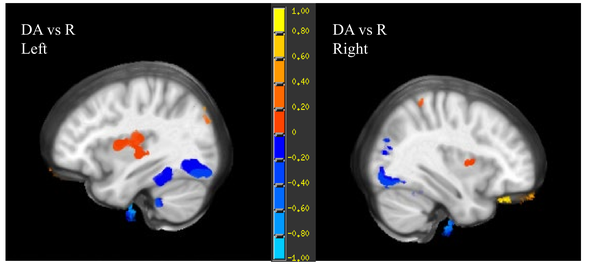

Figure 4. Developmental effect: Blue clusters correspond to greater activation in the R group, while red clusters correspond to greater activation in the D & A group combined.

Regions	Volume (1mm3)	Peak MNI coordinates
Bilateral Lingual/Fusiform	51526	(-1, 69 , -1)
Left Precentral/Rolandic Opercula/Insula/Postcentral	6362	(36, -2, 7)

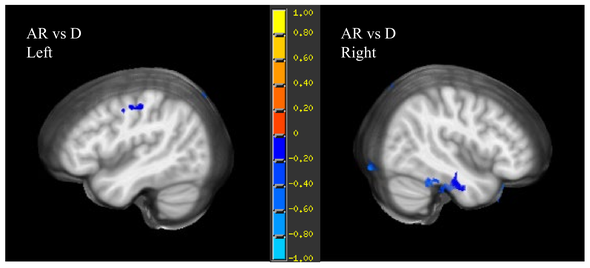

Figure 6. Dyslexic effect: Blue clusters correspond to greater activation in the D group, while red clusters correspond to greater activation in the A & R group combined.

Regions	Volume (1mm3)	Peak MNI coordinates
Right Lingual/Fusiform	3979	(0, 25, -6)
Right Fusiform	3951	(-47, 43, -28)

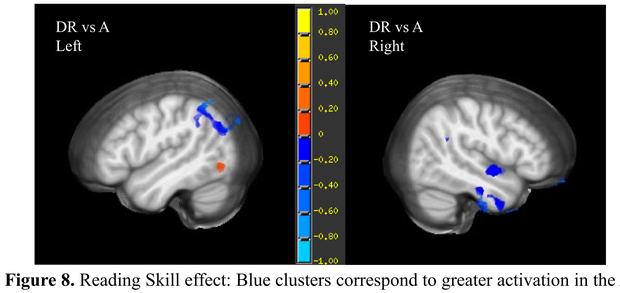

Figure 8. Reading Skill effect: Blue clusters correspond to greater activation in the A group, while red clusters correspond to greater activation in the D & R group combined.

Regions	Volume (1mm3)	Peak MNI coordinates
Right Temporal	4744	(47, 60, 54)
Right Fusiform/Temporal	4348	(-33, -29, -37)

IMAGING PROTOCOL

Preprocessing

Skull removal was performed using FSL's BET Toolbox, with robust center estimation selected. Motion correction was performed using FSL's MCFLIRT. Volumes with a Framewise Displacement value that exceeded our threshold of 0.9 m were censored. An 8mm smoothing kernel was applied to the data, and images were normalized to 1000 ms. Linear and non-linear transformations using FSL's flirt, fnirt, and 'applywarp' functions.

First- and Second-level Analyses: For the first-level GLM analysis, AFNI's 3dDeconvolve tool was used to model the data as a Gamma Wave function relative to the Hemodynamic Response Function (HRF). AFNI's 3dMEMA tool was used for our second-level GLM analysis. **Multiple Comparisons** correction performed using AFNI's 3dClustSim program, with a per-voxel threshold of $p < 0.02$ and a cluster size of 3890 voxels with a smoothness of 8.12 mm.

CONCLUSION

Imaging Findings

- Greater activation in bilateral language areas for the Reading-matched group, compared to the Dyslexic and Age-matched groups, suggests an underdeveloped reading network that recruits both hemispheres on word-decoding tasks.
- Greater activation in right hemisphere language areas of Dyslexic subjects suggests a right lateralized reading network and reliance on the right hemisphere for word-decoding tasks.
- Greater activation in left hemisphere language areas of Age-matched controls, compared to Dyslexics and reading-matched controls, suggests these areas are implicated in greater reading ability and/or higher level reading skill.

For more info on this sample, please visit Posters #D56 & #E55

REFERENCES

1. Willcutt, E.G., & Pennington, B.F. (2000). Psychiatric Comorbidity in Children and Adolescents with Reading Disability. *Journal of Child Psychology and Psychology,* 41(8), 1039-1048.
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ACKNOWLEDGEMENTS

This project is supported by the National Institutes of Health Grants R00HD065832, R21NS091586, P41EB015922 and U54EB020406. The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH.