Structural Differences in the Reading Network for Adults with Dyslexia

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Introduction

Developmental dyslexia (DYS) is characterized by impaired phonological processing and typically identified at a young age. Brain based differences in classic language regions have been identified in children and adults with dyslexia (Pugh et al., 2000). Poor phonological ability remains a hallmark deficit, even for young adults with dyslexia.

Reading is a language based skill relying on various neural substrates. Dyslexia and language impairment are considered distinct but co-morbid developmental disorders (Catts, 2005), yet sample populations are not clearly identified in the field and there remain unanswered questions regarding the underlying neural correlates specific to dyslexia.

This study aims to identify structural differences in gray matter regions and white matter pathways. A complex reading network comprised of 7 pathways was targeted in adults with developmental dyslexia.

Participants

30 native English speakers participated in the study and ranged in age from 18 to 25. 15 young adults (7 female, 8 male) participated in the DYS group (M = 19.67, SD = 2.02) and 15 (7 female, 8 male) were included in the TYP group (M = 19.33, SD = 1.23).

Individuals in the DYS group reported a history of reading and writing difficulty or speech language services AND scored at least -1 SD on non-word reading (WJ-III).

Additional cognitive and language based assessments were administered to identify language impairment (Fidler et al., 2011). 89% of DYS and11% of TYP exhibited a co-morbid language impairment.

Behavioral Measures

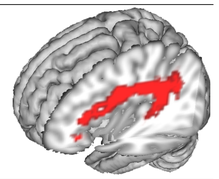
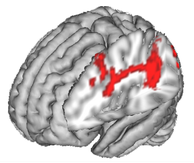
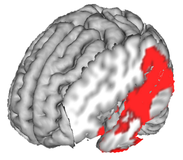
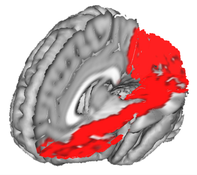
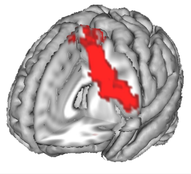
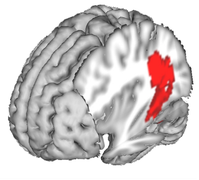
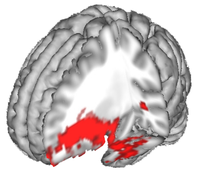
	Typical		Dyslexia		Hypothesized
	Mean	SD	Mean	SD	Neural Correlates
TONI-3	109.17	14.24	99.33	16.42	
WJ-III					
Broad Reading Cluster	106.11**	10.96	92.72	8.58	
Letter-Word Identification	103.28**	7.27	87.44	6.50	TPJ, SLF & IFG
Reading Fluency	106.00*	13.79	95.11	11.21	IOF, VWFA
Passage Comprehension	101.94**	5.37	93.11	9.31	SLF
Word Attack	99.17**	7.97	77.67	5.99	TPJ
Non-word Repetition	14.39**	1.95	12.44	2.18	Aslant
Toe Tapping	2.26	0.52	2.49	0.52	
Language Impairment					
Dictated Spelling	11.06**	3.12	5.06	2.84	
CELF-4 WD	12.39*	1.82	10.83	1.92	
Modified Token	38.44**	5.38	33.22	5.78	

*p<.05,**p<.01

Methods

Bidirectional Iterative Parcellation (BIP) (Patterson et al., 2014) was conducted to identify tracts of interest and connected gray matter.

Liberal masks for white matter tracts and gray matter regions were created in standard space. BIP parcellates the connective gray matter over multiple iterations until ONLY gray matter that is connected by the tract of interest remains.

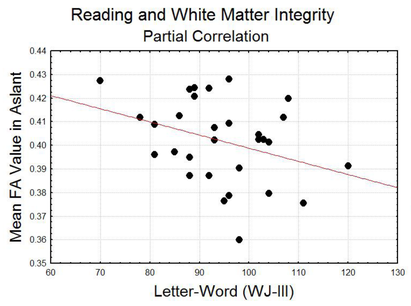
White Matter Tract	Gray Matter Endpoint	
Arcuate Fasciculus	A: Inferior Frontal Gyrus B: Temporal Parietal Region	
Superior Longitudinal Fasciculus	A: Angular Gyrus B: Inferior Frontal Gyrus	
Inferior Longitudinal Fasciculus	A: Anterior Temporal Lobe B: Visual Wordform Area	
Inferior Occipital Fasciculus	A: Inferior Frontal Gyrus B: Occipital Region	
Aslant	A: Inferior Frontal Gyrus B: Supplementary Motor Area	
Vertical Occipital Fasciculus	A: Angular Gyrus B: Visual Wordform Area	
Uncinate	A: Anterior Temporal Lobe B: Inferior Frontal Gyrus	

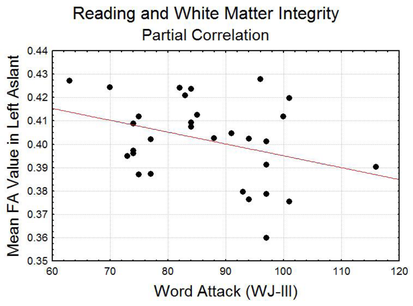
Results

Fractional anisotropy (FA) is a measure of water molecule diffusion and an indirect measure of white matter integrity. FA values range between 0 and 1.

Two mixed measures ANOVA were conducted on FA and Gray Matter Volume, separately. There was no main effect of group for FA values or gray matter volume. FA; F(1, 12) = 0.009, p = 0.92; G ray Matter Volume F(1, 17) = 0.66, p = 0.43.

Partial correlations, controlling for age, were used to identify neural correlates of reading. Real word (Letter-Word, WJ-III) and pseudo word (Word Attack, WJ-III) reading were negatively correlated with mean FA in the aslant. Letter-Word; r = -0.65, n=12, p < .05; Word Attack; r = -0.69, n = 12, p < .05.





Discussion

These findings provide insight into structural differences for young adults with developmental dyslexia. Results from the partial correlation provide additional evidence of the relationship between frontal regions and the reading network. Previous findings show individuals with dyslexia rely more heavily on frontal regions (Pugh, 2000). Heavy reliance in this region might result in increased FA values. However, as the present study shows, higher FA values in this frontal pathway are associated with lower reading scores.

Large variance in the DYS group is one possible explanation for the current lack of group effects. The methodological approach for identifying tracts and gray matter regions did not identify ROIs for all participants and could explain a lack of findings.

References

Patterson, D.K., et al., (2014). Bidirectional iterative parcellation of diffusion weighted imaging data: Separating cortical regions connected by the arcuate and extreme capsule.

Pugh, K.R., et al. (2000). Functional neuroimaging studies of reading and reading disability (developmental dyslexia).

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