Neurites orientation dispersion is associated with reading skill

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Introduction:

- Dyslexia is a common neurodevelopmental disorder characterized by difficulties with reading and spelling and affecting around 5-10% of the school aged children[1,2].
- Several studies have explored neuroanatomic (brain structure) correlates of dyslexia and reading skill and have shown various white matter tissue properties to be correlated with both phonological skills and reading skills[3,4].
- Mean diffusivity (MD) and fractional anisotropy (FA) are widely used surrogate measures with high sensitivity to tissue microstructural changes; however, they lack specificity for individual tissue microstructure features.
- Here, we investigated neurite orientation dispersion and density in order to exploring the underlying specific microstructural features more directly.

Methods:

- Diffusion weighted images (DWI) and anatomical MPRAGE T1 images were obtained from 72 children.

Subjects (N)	Age (years)	Sex	DWI protocol	T1- MPRAGE protocol
72	10.03 ± 3.45	35 F; 37 M	1.8 mm isometric voxel; 64 directions; b= 0, 1000, 2000	TR = 2500 ms; TE = 3.15 ms; 0.8 mm isometric voxel; flip angle = 8

- A battery of behavioral and neuropsychological measures including Test of Word Reading Efficiency (TOWRE-2) and Comprehensive Test of Phonological Processing (CTOPP-2) was obtained.
- The Imaging quality metrics of the obtained MRI data - Contrast to Noise Ratio (CNR), Average Absolute and Relative Motion (AM & RM) of each volume were computed.
- Neurite orientation dispersion index (ODI, influenced by dispersion of axons and dendrites in the intracellular compartment ; 0 to 1; 0 = well-aligned neurites, 1 = highly dispersed neurites) and neurite density index (NDI, influenced by density of axons and dendrites based on intracellular diffusion 0 to 1; 0 = most extracellular diffusion, 1 = most intracellular diffusion) were obtained from 22 major tracts in human brain.
- All of the above-mentioned parameters were obtained using FSL (ver. 6.1.0) and NODDI toolbox[5,6].
- Partial correlation was performed using age, sex, and image quality metrics (CNR, AM and RM) as covariates between Neurite indices (ODI and NDI) and measures of reading and phonological skills (TOWRE and CTOPP).

Conclusions:

- We found that better reading and phonological processing skills are associated with greater tract coherence (lower ODI index).
- Our findings are consistent with prior findings of associations between reading-related skills and WM integrity in tracts that link hubs of the reading network.
- We suggest that neurite complexity could be a useful tool for inferring specific white matter tissue microstructure and may promote better understanding of relations between brain structure and behavior.

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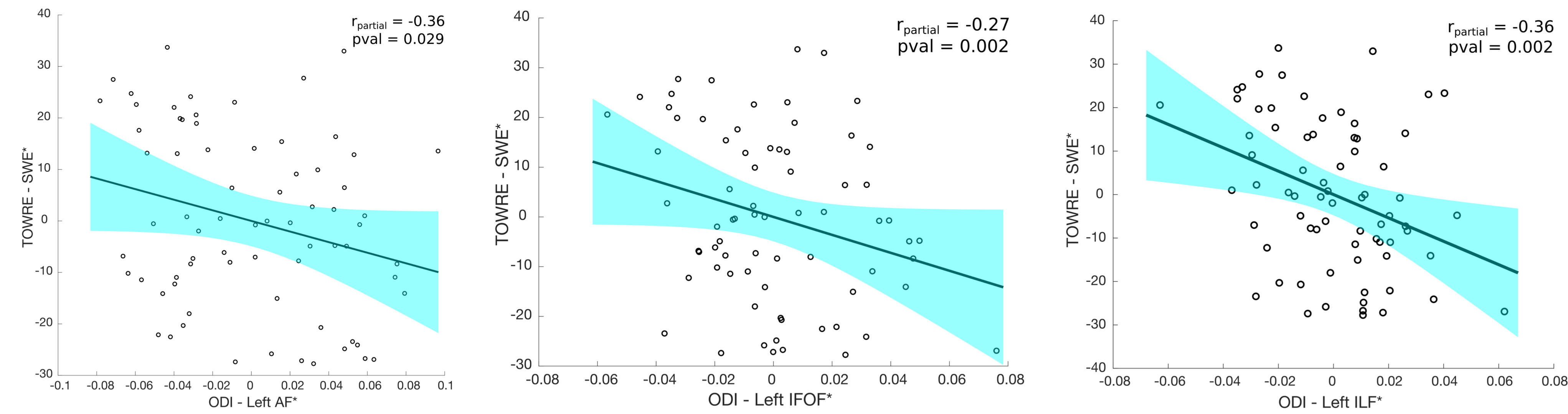
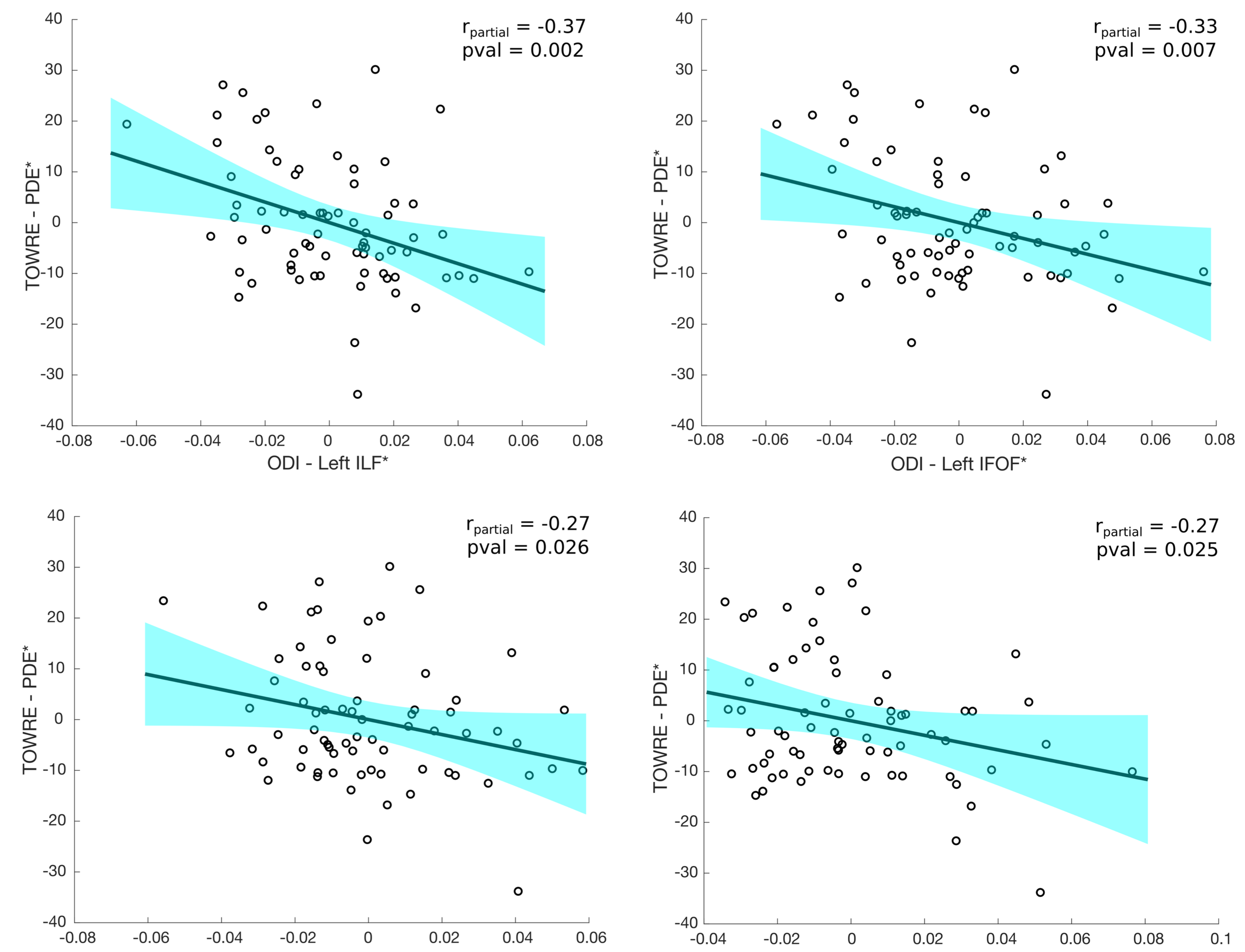
Results:

- ODI was negatively correlated with TOWRE and CTOPP scores in several tracts in the brain.
- Sight word efficiency (TOWRE) was significantly ($p < 0.05^{\#}$) correlated with ODI in left - arcuate fasciculus (AF), inferior longitudinal fasciculus (ILF), Inferior Fronto-Occipital Fasciculus (IFOF). #Bonferroni corrected



- Phonemic decoding efficiency (TOWRE) was significantly correlated with ODI in left – Superior longitudinal fasciculus (SLF), ILF, IFOF and bilateral uncinate fasciculus (UF).



- CTOPP - composite score of Blending words and Elision was significantly correlated with ODI in right AF, left – ILF, IFOF, SLF and bilateral UF.