

Comparison of white matter in normal and dyslexic children using TBSS

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Introduction: Developmental dyslexia is defined as impaired reading abilities in subjects with normal intelligence; results derived from investigation in dyslexic adults cannot necessarily be extrapolated to children. We studied cohorts of normal reading children (C) and age-matched children with simple developmental dyslexia (D) using DTI at 3T and Tract Based Spatial Statistics (TBSS) to search for maturational changes and differences in diffusion tensor metrics between C and D.

Materials and Methods: The investigation was prospective IRB approved. Monolingual, English-speaking, right handed children with normal IQ and developmental dyslexia (n=19, mean 9.9 years) and normal reading, age-matched controls (n=18) underwent WISC-III or WASI, and tests of reading including Woodcock-Johnson Letter-Word Identification, and Woodcock-Johnson Word Attack. Differences in performance on intelligence (Full-scale, verbal, and perceptual intelligence quotients) and reading tests between dyslexic subjects and control subjects were examined using two-sample t-test. DTI was performed at 3T (Philips Achieva R2.5) using a 30 noncolinear gradient direction SS-EPI sequence, b = 700, 56 slices, voxel size 2 mm, TR/TE = 8237/74 acquisition matrix 128 x 128, 1NSA x 3. Images were processed off-line using FSL (FMRIB [The Oxford Centre for Functional Magnetic Resonance Imaging of the Brain] Software Library, <http://www.fmrib.ox.ac.uk/fsl>) including BET to extract brain tissue and brain mask, eddy current correction and registration to the b = 0 image volume, and DTIFit to reconstruct diffusion tensors and FA. Data from all subjects was aligned to a 9 year old control brain using a nonlinear registration and affine transformed into MNI152 standard space. Mean FA image was created and thinned to create a mean FA skeleton. Aligned FA data was analyzed using voxelwise cross-subject statistics. Nonparametric 2-sample unpaired t tests were done with the FSL randomization tool using threshold free cluster enhancement. Explanation variables (EVs) in the randomization tests included group membership and demeaned ages for each group. The randomization procedure resulted in maps of corrected p-values for: (i) differences in the mean FA value between the two groups without the effects of age, and (ii) differences in the slope of FA vs. age between C and D subjects. Internally developed software written in IDL was used for further visualization of the skeletonized FA values as a function of age for all subjects at various MNI coordinates. The software also included features for ROI based parametric statistical analysis.

Results

There was no significant age difference between the dyslexic and control groups or IQ differences were noted between C and D. There were statistically significant differences in reading test performance between the dyslexic and control groups; Woodcock Johnson Letter-Word Identification (p < .0001) and Woodcock Johnson Word Attack (p < .0001) with lower performances in the dyslexic subjects. Threshold free cluster enhancement (p < 0.05) showed multiple regions of age-related differences for C > D including: anterior commissure, corticospinal tracts, ventral inferior fronto-occipital fasciculus, external capsules, left superior longitudinal fasciculus (SLF), anterior corona radiate, inferior frontal subcortical white matter, and subcortical white matter at the junction of the left temporal and occipital lobes. For p < 0.01 clusters for C>D were seen only in the corticospinal tracts. Within the control group, FA increased with age in all tracts studied. For the dyslexic subjects, the mean FA values within the IFO-ILF and PLIC but not the SLF were greater than those of the controls for the IFO-ILF (p = .009) and PLIC (p < 0.0001) up to around 11 years of age after which the mean FA values were lower for the dyslexic than the control subjects.

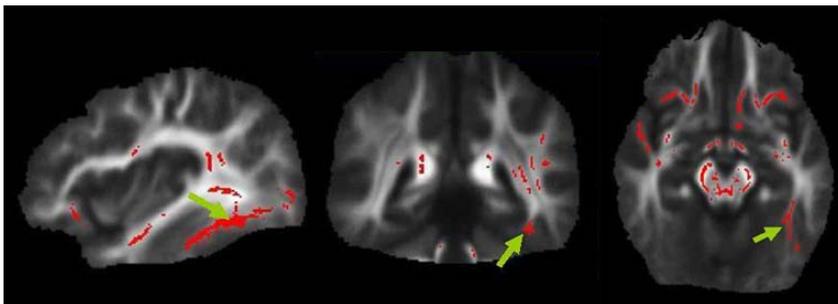


Figure 1. Cluster regions on the FA skeleton where FA vs. age slope is significantly different between dyslexia and control subjects are overlaid in color on the mean FA image (TFCE corrected p < 0.05). The arrows point to the visual form recognition region at the left temporal-occipital junction.

Conclusions: DTI at 3T using TBSS suggests lack of age-related maturational changes in dyslexic subjects beyond those reported in adults within the SLF. There are apparent alterations in white matter composition in multiple regions of the brain in children not seen in adults including a critical visual form recognition region at the left temporal-occipital junction.