READING ABILITY CORRELATES WITH WHITE MATTER ANISOTROPY IN ELEMENTARY SCHOOL CHILDREN

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INTRODUCTION : Reading is a complex skill requiring the coordination of many brain regions; however, there are few studies of the fibres connecting relevant cortical regions. Diffusion tensor MRI measures of "integrity" (i.e. anisotropy) within the left temporo-parietal white matter of the brain have demonstrated significant correlations with reading scores in both normal and reading impaired *adults* suggesting that functional connectivity between brain regions is important for reading ability [1]. The hypothesis is that inefficient connections could hinder reading performance. Two more recent studies have shown that reading scores and anisotropy are correlated in the same region of the brain in *children* with mean ages ~ 11 years old, in either normal to advanced readers [2] or poor to normal readers [3]. The purpose of this study was to determine whether similar correlations between fractional anisotropy (FA) in the brain and reading ability exist in two even younger cohorts of children (Kindergarten - Grade 1, ages 5-7; Grades 2 – 4, ages 7-10) with varying levels of skill.

METHODS : Healthy children (N=47) aged 5 – 10 years with no history of neurological injury or psychiatric disease were scanned on a 1.5T Siemens Sonata scanner with DTI which used forty 3 mm thick contiguous slices, matrix of 96x128 zero filled to 256x256, 8 NEX, TE/TR of 88 ms/6400 ms, b=0 s/mm^2 and six sets with b=1000 s/mm^2. At the time of the MRI, the children underwent a comprehensive cognitive assessment that yielded age-normalized parameters including reading ability (Woodcock Word ID score) and non-verbal intelligence. The children were separated into two groups based on education level (Group 1: Kindergarten – Grade 1, N=17 and Group 2: Grades 2 – 4, N=30). A whole-brain, voxel-based correlation analysis was performed with SPM2. A template was created for each age group by aligning and averaging the images of each subject in MNI space. The b0 images of each subject were normalized to the generated templates and the resulting transformations were applied to the FA maps. A voxel intensity threshold of FA > 0.2 was used to avoid analysis of voxels that contained gray matter in even one subject. Clusters with significant positive correlations between FA and Word ID were determined via linear regression ($p < 0.05$, minimum cluster size of 10).

RESULTS AND DISCUSSION : The children had a wide range of reading ability as assessed by the Woodcock Word ID which ranged from 71 – 145 (a score of 100 is considered average). Clusters of voxels with significant positive correlations between fractional anisotropy and Word ID were observed in the centrum semiovale of the left hemisphere **(Figs 1-2)**, in agreement with earlier studies on older subjects [1-3]. The left centrum semiovale cluster sizes of 219 (Kind-Gr1) and 177 (Gr2-4) voxels were much larger than the 42 voxel cluster observed in 9-12 year olds [2] and the correlation coefficients of the maxima in the individual clusters were stronger, namely R = 0.61-0.86 in the Kind-Gr1 group (e.g. **Fig 3**) and R = 0.42-0.67 in the Gr2-4 group. Notably, the younger children in our study, particularly the Kind-Gr1 group, have significant correlations over a greater extent of the brain, including the right side. The Kind-Gr1 group showed clusters in the L/R temporal white matter, L/R hippocampus, L/R superior longitudinal fasciculus, and corpus callosum (genu, body, R tapetum) and the Gr2-4 group had clusters in fewer regions but included the R temporal white matter, L/R hippocampus, R superior longitudinal fasciculus, and L genu of the corpus callosum. In summary, quantitative diffusion tensor imaging has provided evidence for a relationship between localized white matter connectivity in the brain and reading performance in elementary school children.

REFERENCES: [1] Klingberg *et al* Neuron 25, 493 (2000); [2] Beaulieu *et al* Neuroimage 25, 1266 (2005); [3] Deutsch *et al* Cereb Cortex 41, 354 (2005).

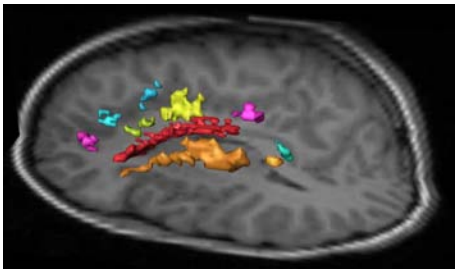

FIGURE 1 : Clusters in the left hemisphere with significant positive correlation between fractional anisotropy and reading ability (Word ID) in 17 Kindergarten - Grade 1 children aged 5 - 7 years old.

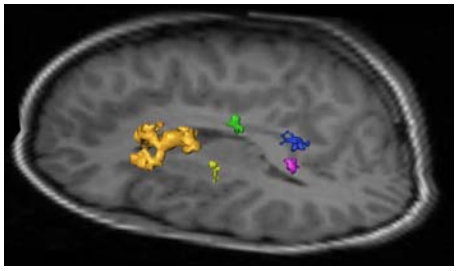

FIGURE 2 : Clusters in the left hemisphere with significant positive correlation between fractional anisotropy and reading ability (Word ID) in 30 Grade 2 - 4 children aged 7 - 10 years old.

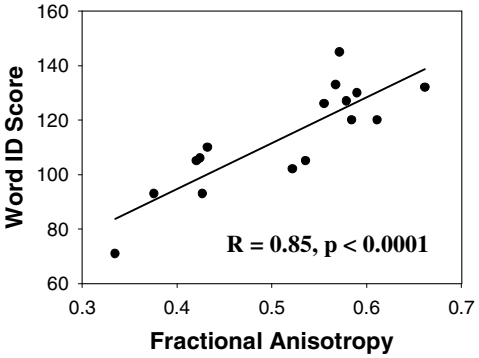

FIGURE 3 : Word ID versus fractional anisotropy at a local maximum in the left centrum semiovale cluster of the Kindergarten – Grade 1 group. The FA in this voxel does not correlate with age (R=0.19, p=0.49) or non-verbal intelligence (R=0.31, p=0.28)