Using Diffusion Tensor Imaging to Assess White Matter Integrity in Subjects with Math Difficulties

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INTRODUCTION

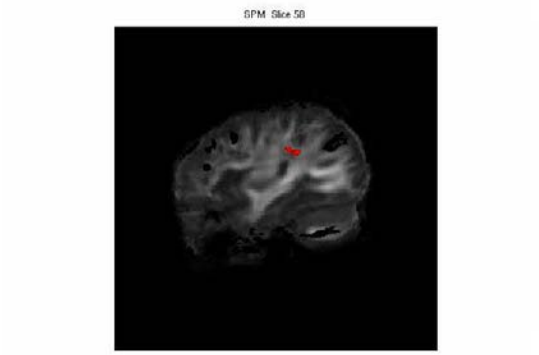
This study investigates whether there are white matter differences in fractional anisotropy (FA) between children that have math difficulties and children who have average or above average math skills. It has been well documented that there is a correlation between reading ability and fractional anisotropy of the white matter in the temporo-parietal region of the brain, however there have been few studies that determine if there is a correlation between white matter FA values and math ability.

METHODS

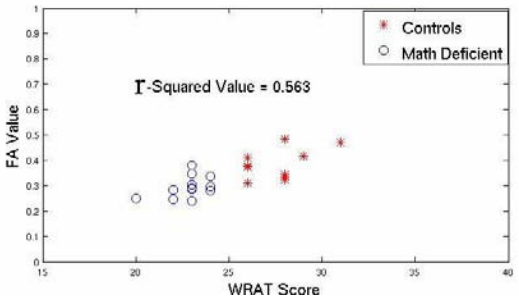
The data sets for each of the 22 subjects were obtained on a 3T Philips Achieva MRI scanner. The study included 10 math deficient subjects and 12 control subjects, which were grouped by performance on the Wide Range Achievement Test-3 (WRAT-3) arithmetic subtest. An additional person was imaged with only an anatomical T1-weighted scan to use as a registration control. 3D T1-weighted TFE SENSE images where obtained with a matrix size of 256 x 256 x 170 and a voxel size of 1mm x 1mm x 1mm. Diffusion Tensor images were obtained using an EPI-SENSE sequence with a matrix size of 128x128x60 and a voxel size of 2mm x 2 mm x 2mm. The FA maps were computed from the tensor data using Philips PRIDE software and registered to a common image space, via the Adaptive Bases Algorithm[3], using the 3D T1-weighted volume of the additional subject as the target space. Statistical analyses, including group t-tests, were performed to compare FA values between the control and math deficient groups. These statistical maps thresholded and superimposed on the FA maps to visualize the regions in which there was a significant difference between the groups. ROI's were drawn on these areas of significant differences and the FA of the region was plotted against the WRAT-3 score for each subject.

RESULTS

Analysis of the FA maps shows that there are significant differences ($p<.05$) between groups in the arcuate fasciculus. Fiber tractography was used to confirm that the affected region lies in the arcuate fasciculus. This is the major connection between the temporal and frontal lobes. It is also shown that there is a correlation ($r^2=0.563$) between FA value in the arcuate fasciculus and the WRAT-3 score for each subject. Neighboring areas in the white matter of the left hemisphere are implicated in diffusion tensor studies of reading ability[2,3].



Region of statistical difference ($p<.05$) between controls and math deficient subjects. The highlighted area is located in the arcuate fasciculus.



Fractional Anisotropy versus WRAT Score of controls and math deficient subjects.

DISCUSSION

We have shown that there is a strong correlation between math ability and FA values in particular regions of the white matter of the brain, including the arcuate fasciculus.. Some of these regions may also be correlated with reading ability and hence represent a biomarker for more general learning disabilities. Future work will compare FA scores between groups of math deficient children and children that have deficiencies in both math and reading abilities to determine if the regions are distinguishable.

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