# Children with Dyslexia/Dysgraphia and DTI parameter Correlations with Reading/Language Scores

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## Introduction

Diffusion tensor imaging (DTI) was used to test the hypothesis that white matter parameters would correlate with behavioral writing measures in children who were diagnosed with dysgraphia (impaired handwriting) and dyslexia (impaired word decoding and word-spelling) using evidence-based diagnostic procedures that included a standardized measure of oral reading.

## Methods

DTI scanning was performed on a Philips 3T Achieva scanner (version 3.2.2) on 8 children with dysgraphia and 6 children with dyslexia who where 11 to 12 years old and in the 6th grade. DTI acquisition parameters were: spin-echo/echoplanar pulse sequence, 32 channel Philips rf coil, matrix size 128x128x64, pixel size 1.7x1.7x2mm, diffusion encoded directions 32, non-diffusion measure 1, averages 1, bvalue strength 1000, TR/TE 8592/78 milliseconds, SENSE ParallelReductionFactorInPlane 1.9. DTI data were processed with DTIPrep/GTRACT software to quality control the data and generate the tensors (http://www.nitrc.org/projects/dtiprep/). Then custom software (GFORTRAN) was used to calculate the DTI parameters from the tensors (1,2) . FSL software called tract-based spatial statistics (TBSS) was used to co-register and prepare the DTI data for group analysis and a higher level design matrix was used to perform a voxel by voxel correlation of the DTI data with the demeaned behavioral measures. The final statistical maps were generated using FSL's Randomise software, which robustly corrects for multiple comparisons using the "Threshold-Free Cluster Enhancement" (TFCE) option using permutation methods (http://fsl.fmrib.ox.ac.uk/fsl/fslwiki/TBSS/UserGuide). The group analysis correlation was calculated separately for the dyslexic and dysgraphic groups. Diagnostic procedures included standardized measures of reading and writing psychometrics.

## Results

The table below shows all the significant correlations between language scores and DTI parameters for the dysgraphic group. As an example, there was a significant correlation of the DTI Volume Ratio with the Single Word Reading score in the left cerebellum as shown in Figure 1 (MNI coordinates: -16, -49, -41 mm, p<.01 corrected, Spearman correlation coefficient 0.98). Figure 2 is a scatter plot illustrating the correlation between Single Word reading with the DTI volume ratio value from this region of brain. The group with dyslexia did not have any significant correlations with this DTI measure, but did have a significant correlation of DTI FA parameter in the fornix white matter (MNI coordinates 1, -14, 20 mm).

**Figure 1** -- Region of significant correlation between Single Word Reading and DTI Volume Ratio in cerebellum

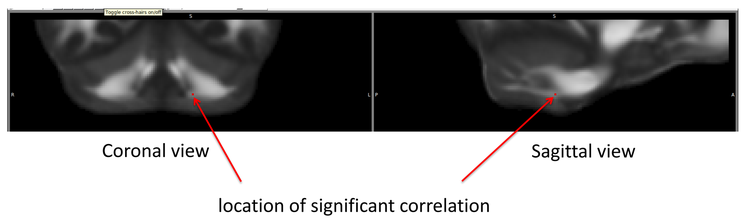
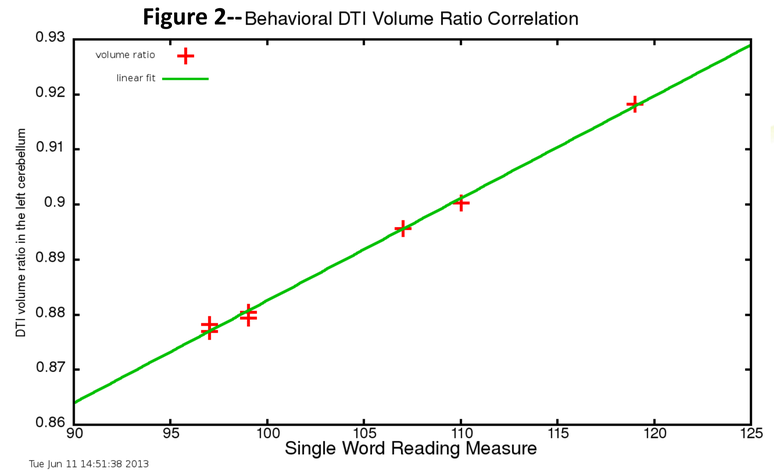



**Figure 2--** Behavioral DTI Volume Ratio Correlation




| Subject | Brain Region | MNI Coordinates (mm) | | | DTI Parameter | Behavior Index* |
|---|---|---|---|---|---|---|
| | | x | y | z | | |
| 1 | inferior longitudinal fasciculus L | -15 | -65 | 47 | eigenvalue L1 | 6 |
| 2 | superior longitudinal fasciculus L | -27 | -34 | 45 | eigenvalue L1 | 7 |
| 3 | cerebellum R | 16 | -75 | -31 | eigenvalue L2 | 3 |
| 4 | superior longitudinal fasciculus L | -32 | -15 | 39 | eigenvalue L2 | 7 |
| 5 | corticospinal tract L | -7 | -19 | -26 | eigenvalue L3 | 4 |
| 6 | superior frontal gyrus | 16 | 19 | 47 | eigenvalue L3 | 5 |
| 7 | cerebellum L | -16 | -49 | -41 | DTI volume ratio | 5 |
| 8 | inferior fronto-occipital fasciculus R | 35 | -40 | 10 | fractional anisotropy | 2 |
| 9 | corticospinal tract L | -23 | -19 | 52 | mean diffusivity | 2 |
| 10 | superior longitudinal fasciculus L | -49 | 1 | 22 | mean diffusivity | 2 |
| 11 | inferior fronto-occipital fasciculus R | 35 | -38 | 8 | relative anisotropy | 2 |

* KEY to Behavior Index:
2 = Verbal IQ score
3 = Rapid Automatic Letter Writing (alph15) score
4 = Spelling score
5 = Single word reading score
6 = Word decoding score
7 = Reading Comprehension score

## Conclusions

Several DTI parameters were found to be correlated with reading and writing behavior in children with dysgraphia. Research has shown that oral reading of single words draws on word-specific spellings for specific pronunciations and meanings. Work in progress is investigating whether the differences in patterns of significant correlation between white matter connectivity and word-specific reading are associated with orthographic coding in children with dysgraphia, but with phonological coding for children with dyslexia.

## References

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