

Myelin Water Imaging of Children with Diverse Reading Ability

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Introduction: Dyslexia is a learning disability that affects one's ability to read, despite adequate intelligence, education and socio-economic opportunities[1]. Magnetic Resonance Imaging allows one to non-invasively investigate its neurological basis. Recent diffusion tensor imaging (DTI) brain studies in children suggested a link between white matter development and reading ability[2]. Another MR technique, based on the myelin water fraction (MWF) measured from multi-echo T₂ relaxation curves has been used to quantitatively assess brain myelination in white matter diseases such as multiple sclerosis [3]. In this study, we investigate the relationship between reading ability in children and their white matter development using this myelin water imaging technique.

Methods: 20 subjects (16 males, 4 females, mean age 12.7 (range: 10 to 18 years)) with diverse reading ability were recruited from several local school districts. A series of cognitive tests were performed, including Woodcock Johnson III (WJ-III) tests of cognitive abilities, which contained tests of verbal comprehension, concept formation and visual matching. These scores were combined to assess the intelligence of the subjects. For assessment of reading ability, the WJ-III tests of achievements, which included word identification (Word-ID) and word attack components, were used. Word-ID and word-attack scores were combined to give a composite reading score. The reading component of the wide-range achievement test (WRAT-III) was also used to assess

reading ability of the subjects. GRASE based 32-echo T₂ images [4] and T₁ weighted images were acquired in a 3.0T Philips scanner. Twelve brain structures were manually contoured as regions of interests (ROI) on the T₁ weighted images. 32-echo data were registered against T₁ images using FSL[5]. MWF values for each pixel were calculated using a non-negative least squares algorithm (NNLS) [6]. Reading assessment scores were used to split the subjects between normal readers (above 35th percentile, n = 11) and poor readers (below 25th percentile, n=7), with two remaining subjects classified as borderline. Group comparisons of MWF values between normal and poor readers, as well as correlation analysis were performed.

Results and Discussion: Group analysis data showed that normal readers appeared to have higher mean MWF in the all regions of interests compared to the poor readers (Figure 1). However, these differences were only statistically significant ($p < 0.05$) in left posterior internal capsule and the splenium. For correlation analysis, to account for multiple comparisons, a conservative Bonferroni correction is applied to reduce the threshold of significance to $p < 0.0005$. After the correction, significant correlations were found between MWF in the left posterior internal capsules vs. WRAT-III reading ($r = 0.73$, $p = 0.0003$), left thalamus vs. WRAT-III reading ($r = 0.71$, $p = 0.0004$), right thalamus vs. WJ-III word attack and reading composite ($r = 0.73$, $p = 0.0002$ and $r = 0.71$, $p = 0.0005$, respectively) (Figure 2). No correlation was found between MWF and intelligence scores. Using a less stringent threshold ($p < 0.01$), significant correlations were found between MWF in left posterior internal capsules, splenium, and left thalamus with all reading assessments except word-attack. In the right thalamus, significant correlations were found with all reading assessments. No correlation was found with intelligence scores with the less stringent threshold. As dyslexia affects reading independently of intelligence, our results suggest that myelin development in these structures may play a role in dyslexia.

Conclusion: Our data showed significant group difference in MWF between normal and poor readers, and that MWF in several white matter structures correlated with reading ability but not intelligence in children. Further investigation of the relationship between children's myelin development and dyslexia is warranted.

References

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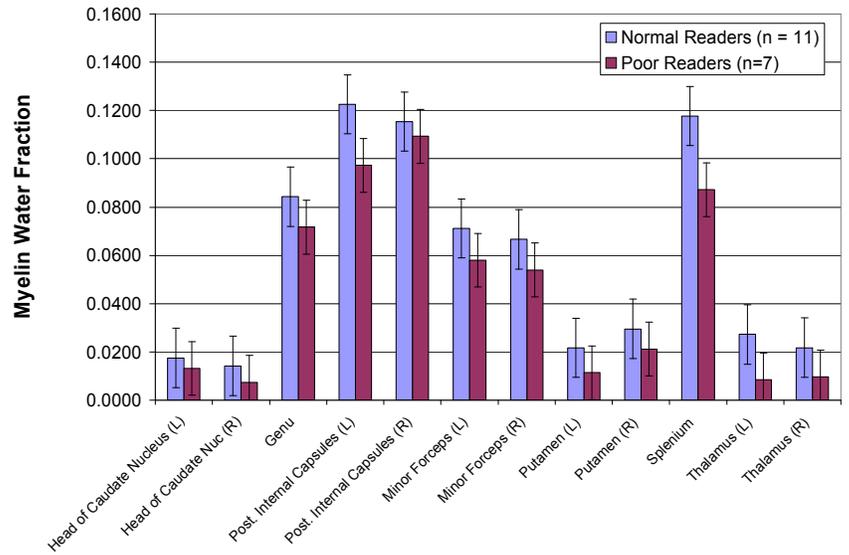


Figure 1-MWF Group Comparison between normal and poor readers

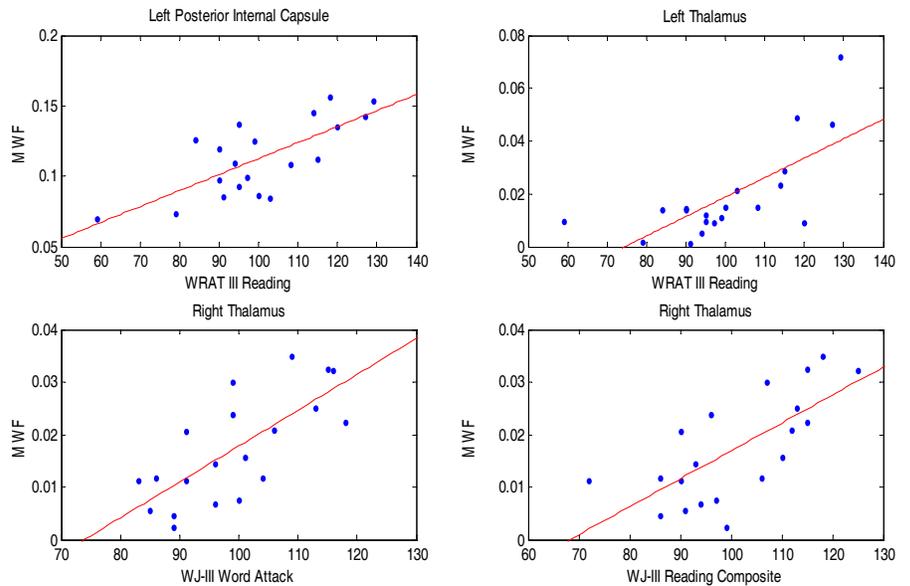


Figure 2-Correlation analysis: Left posterior internal capsules MWF vs. WRAT III Reading (Upper Left), Left Thalamus MWF vs. WRAT III Reading (Upper Right), Right Thalamus MWF vs. WJ-III Word Attack (Lower Left) and WJ-III Reading Composite (Lower Right)