Research Project Brief

Cognitive, Neural, & Translational Implications of a New Reading Disorder (2013-2016)

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Research Question: Can diagnosis and treatment of reading disorders be improved through an interdisciplinary approach combining cognitive science, neuroscience, educational, and computer science methods?

Interdisciplinary Approach: The project integrates cognitive, neural, educational, and computational perspectives to achieve a better understanding of reading disorders, and better methods for diagnosis and treatment.

Potential Implications of Research: This research should lead to improved methods for diagnosing and treating reading disorders in children learning to read, and in adults with neurological conditions.

The ability to read is crucial in school, in the workplace, and in daily life. However, many children struggle in learning to read, and many adults suffer disruption of their reading ability as a result of stroke or other neurological conditions. Despite an enormous amount of research, understanding of reading disorders remains limited, especially with regard to the broad range of causes and consequences of impaired reading ability. Most research has focused on the most typical forms of reading disability, often failing to recognize that reading can be disrupted in a variety of ways and for a variety of reasons. This project investigates a range of reading disorders, applying cognitive, and neural methods to obtain a better understanding of the underlying causes, and educational and computer science methods to develop effective remediations.

A major focus of the project is a new form of reading disorder we have discovered. In this disorder, which we refer to as AVAD (Alphanumeric Visual Awareness Disorder), vision is normal except that letters and/or digits appear so blurred or distorted that they cannot be read. We have carried out extensive studies with three AVAD participants: RFS, MTS, and KRS. Figure 1 top, for example, shows RFS’s attempt to copy the digit 8, which appears to him as a jumble of lines. Results from cognitive, fMRI, and ERP studies suggest that basic neural and cognitive processing of letters and digits remains intact in AVAD, but awareness of the shapes and identities of the characters is nevertheless disrupted. One possibility is that pathological neural feedback from higher to lower levels of the brain’s visual system disrupts awareness of character shapes, leading to an inability to read the characters, or the words or numerals composed from them.

Rehabilitation studies with the AVAD participants have led to development of a method in which the characters that cannot be perceived accurately are replaced by “surrogate” characters. RFS, who sees digits only as jumbles of lines, has been able to learn and use surrogate digit characters, with the assistance of custom software we developed (e.g., a calculator app; see Figure 1 middle). For MTS, who sees standard letters and digits only as blurs, we found that double-strikethrough characters (Figure 1 bottom) could be recognized without blurring, and she now uses these characters for all her reading and math, again with the assistance of custom software.

For more information, please contact Michael McCloskey (Michael.McCloskey@jhu.edu).
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In addition to AVAD we are investigating causes, diagnosis, and treatment of other forms of reading impairment in children learning to read, and in adult stroke patients. Among the findings from these studies are 1) impaired spatial cognition can play a significant role in reading difficulties for some children, and 2) dynamic letter displays showing the process of writing a letter may be useful in rehabilitation of stroke patients who cannot read due to difficulty in recognizing letters.

We expect that research stimulated by this project will lead to identification of additional forms of reading impairment, and point the way toward further methods for rehabilitation.

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