### Co-Investigators:
- Brenda Rapp, Ph.D.
  Professor & Chair
  Dept. of Cognitive Science
  Krieger School of Arts & Sciences
- Gregory Hager, Ph.D.
  Professor & Chair
  Dept. of Computer Science
  Whiting School of Engineering
- Mariale Hardiman, Ed.D.
  Professor & Assistant Dean
  Director, Neuro-Education Initiative
  School of Education
- Argye Hillis, M.D.
  Professor
  Dept. of Neurology
  School of Medicine
- Mariale Hardiman, Ed.D.
- Gregory Hager, Ph.D.
- Mariale Hardiman, Ed.D.
- Argye Hillis, M.D.

Reading is a complex ability that emerges from learning extended over many years. In this project Professor Michael McCloskey and colleagues will pursue two exciting findings from their research on reading deficits caused by brain damage. First, they have discovered a new form of reading impairment in which visual perception is normal except that letters and/or digits appear blurred or otherwise distorted, and so cannot be read. Second, they have had remarkable success with a rehabilitation method in which ‘surrogate’ characters are substituted for the letters or digits affected by the disorder. These discoveries lay the groundwork for a project in which researchers from JHU’s Cognitive Science, Neurology, and Computer Science Departments, and the School of Education, combine investigation of fundamental scientific questions with pursuit of important diagnosis and rehabilitation opportunities.

Two cases of the impairment (labeled Alphanumeric Visual Awareness Deficit, or AVAD) have been identified. MTS, a 13-year-old girl, suffered a brain hemorrhage at age 11. Since this stroke, she has seen letters and digits only as unidentifiable blurs. Remarkably, MTS perceives shapes other than letters and digits normally, including typographic symbols such as the number (#) and percent (%) signs. RFS, a 61-year-old man with a progressive neurological disease, sees most letters normally, but perceives Arabic digits (e.g., 8) as jumbles of lines (which he calls ‘spaghetti’) and is entirely unable to recognize or comprehend these digits.

McCloskey and colleagues found that MTS could perceive and identify characters in a modified font that adds a double strikethrough to each character. With the font installed on a laptop, MTS can read for the first time in nearly two years. For RFS, the researchers developed a set of surrogate digits that he learned and now uses for all of his numerical work.

Pursuing these preliminary findings, the project funded by the Science of Learning Institute has three goals:

1. **Additional AVAD Cases.** The research team will seek new cases of AVAD, not only among individuals who have suffered brain damage, but also among children having difficulty in learning to read. Studying additional cases should shed light on the scope, causes, and consequences of the disorder.

2. **Cognitive and Neural Aspects of AVAD.** Using multiple methods, including functional magnetic resonance imaging, the project team will probe the underlying brain malfunctions that give rise to AVAD, in the previously-identified and new cases.

3. **Rehabilitation Methods.** Finally, the team will develop, implement, and evaluate methods for remediating the reading impairments in AVAD. For example, one aim is to create mobile apps that convert standard characters that cannot be perceived normally into the surrogate characters that can be read (e.g., an iPhone app that takes a photo of a number and converts it to the surrogate digits used by RFS).

For more information, please contact Michael McCloskey (mcckloskey@cogsci.jhu.edu).