# Imaging Study Reveals Brain Function of Poor Readers Can Improve

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A brain imaging study has shown that, after they overcome their reading disability, the brains of formerly poor readers begin to function like the brains of good readers, showing increased activity in a part of the brain that recognizes words. The study appears in the May 1 *Biological Psychiatry* and was funded by the National Institute of Child Health and Human Development (NICHD), one of the National Institutes of Health.

"These images show that effective reading instruction not only improves reading ability, but actually changes the brain's functioning so that it can perform reading tasks more efficiently," said Duane Alexander, M.D., Director of the NICHD.

The research team was led by Bennett Shaywitz, M.D., and Sally Shaywitz, M.D, of Yale University, in New Haven, Connecticut. Other authors of the study were from Syracuse University, in Syracuse, New York; Vanderbilt University, in Nashville, Tennessee; and the NICHD.

According to Dr. Sally Shaywitz, the results show that "Teaching matters and good teaching can change the brain in a way that has the potential to benefit struggling readers."

Along with testing the children's reading ability, the researchers used functional magnetic resonance imaging (fMRI), a sophisticated brain imaging technology, to observe the children's brain functioning as they read.

In all, 77 children between the ages of 6 and about 9 and Â½ took part in the study. Of these, 49 had difficulty reading, and 29 children were good readers. Of the 49 poor readers, 12 received the standard instruction in reading that was available through their school systems. The remaining 37 were enrolled in an intensive reading program based on instruction in phonemic awareness and phonics.

In the study, the 37 poor readers in the intensive reading program outpaced the 12 poor readers in the standard instruction groups, making strong gains in three measures of reading skill: accuracy, fluency, and comprehension. These gains were still apparent when the children were tested again a year later. Moreover, fMRI scans showed that the

brains of the 37 formerly poor readers began functioning like the brains of good readers. Specifically, the poor readers showed increased activity in an area of the brain that recognizes words instantly without first having to decipher them.

The intensive reading program the 37 children took had strong components in phonemic awareness and phonics. Phonemic awareness refers to the ability to identify phonemes, the individual sounds that make up spoken words. The word "bag," for example, is made up of three such elemental units of speech, which can be represented as bbb, aaa, and ggg. The brain strings together the 40 phonemes making up the English language to produce hundreds and thousands of words. In speech, this process is unconscious and automatic.

Beginning in the 1970s, NICHD-funded researchers learned that developing a conscious awareness of the smaller sounds in words was essential to mastering the next step in learning to read, phonics. Phonics refers to the ability to match spoken phonemes to the individual letters of the alphabet that represent them. Once children master phonics, the NICHD-funded studies showed, they could make sense of words they haven't seen before, without first having to memorize them. Further NICHD-supported research found that instruction in phonemic awareness was an essential part of a comprehensive program in reading instruction that could help most poor readers overcome their disability.

In the 1990s, the Shaywitzes had used fMRI to learn that reading ability resides in the brain's left half, or hemisphere. Within the hemisphere, three brain regions work together to control reading. In the left front of the brain, one area recognizes phonemes. Further back, another brain area "maps" phonemes to the letters that represent them. Still another brain area serves as a kind of long-term storage system. Once a word is learned, this brain region recognizes it automatically, without first having to decipher it phonetically.

Poor readers, the researchers had learned in the earlier studies, have difficulty accessing this automatic recognition center. Instead, they rely almost exclusively on the phoneme center and the mapping center. Each time poor readers see a word, they must puzzle over it, as if they were seeing it for the first time.

In the current study, the researchers discovered that, as the 37 poor readers progressed through their instruction program, their brains began to function more like the brains of good readers. Specifically, the brains of these children showed increased activation in the automatic recognition center.

"This study represents the fruition of decades of NICHD-supported reading research," said G. Reid Lyon, Ph.D, Chief of NICHD's Child Development and Behavior Branch. "The findings show that the brain systems involved in reading respond to effective reading

instruction."

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The NICHD is part of the National Institutes of Health (NIH), the biomedical research arm of the federal government. NIH is an agency of the U.S. Department of Health and Human Services. The NICHD sponsors research on development, before and after birth; maternal, child, and family health; reproductive biology and population issues; and medical rehabilitation. NICHD publications, as well as information about the Institute, are available from the NICHD Web site, http://www.nichd.nih.gov (/Pages/index.aspx), or from the NICHD Information Resource Center, 1-800-370-2943; e-mail NICHDInformationResourceCenter@mail.nih.gov (mailto:NICHDInformationResourceCenter@mail.nih.gov).

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