Brain Images Show Individual Dyslexic Children Respond To Spelling Treatment

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Brain images of children with dyslexia taken before they received spelling instruction show that they have different patterns of neural activity than do good spellers when doing language tasks related to spelling. But after specialized treatment emphasizing the letters in words, they showed similar patterns of brain activity. These findings are important because they show the human brain can change and normalize in response to spelling instruction, even in dyslexia, the most common learning disability.

The research is unique in that it looks at images of individual brains rather than the composite group images, or maps, that are typically produced to show which areas of the brain are activated when people are engaged in specific tasks. Being able to study how individual brains differ between good and poor spellers and how they normalize after receiving one of two treatments is an important advance, according to University of Washington neuroimaging scientist Todd Richards and neuropsychologist Virginia Berninger, who headed the research team.

The new findings were published in the January issue of the journal Neurolinguistics.

"Most people think dyslexia is a reading disorder, but it is also a spelling and writing problem," said Berninger, who directs the UW's Learning Disabilities Center. "Our results show that all dyslexics in the 9- to 12-year-old range have spelling problems and children who cannot spell cannot express their ideas in writing."

Earlier research by the UW team and others has shown that dyslexic children exhibit a different pattern of brain activity while reading compared to youngsters who are good readers, but that the brain is malleable and this pattern can normalize with specialized instruction. However, even after receiving reading instruction, many dyslexic children still have persistent spelling problems, according to Berninger. Even so, she said, parents report that their children with dyslexia are typically dismissed from special education once they learn to read but before their spelling and writing problems are adequately treated.

Researchers have found that humans code words in three forms while learning how to read and spell. These codes draw on common and unique brain circuits. The brain codes words by their sound (or phonology), by the parts of words that signal meaning and grammar (morphology), and by their visual or written form (orthography).

In the new study, researchers used functional magnetic resonance imaging, or fMRI, to examine the brain activity of 18 dyslexic children (5 girls and 13 boys) who had problems with spelling and 21 children (8 girls and 13 boys) who were good readers and spellers. All of the children were of normal intelligence and were in the fourth through sixth grades.

Both groups of children had their brains scanned twice while doing a series of language tasks. The good spellers were scanned to provide a picture of normal brain activity while doing the tasks. The brains of the dyslexic children were imaged both before and after receiving 14 hours of one of two kinds of specialized spelling instruction over a three-week period. The dyslexic children were randomly assigned to either of two spelling treatments. One emphasized the letters in the written forms of words while the other focused on the parts of words that signal meaning and grammar.

Earlier research has shown that spelling development progresses through three stages - phonological, orthographic and morphological. The treatment that was developmentally appropriate for children in grades four through six - orthographic - was the one associated with normalization of brain activation. After receiving the orthographic instruction that emphasized strategies for focusing on and remembering the letters in written words, the brain activity of the dyslexic children changed to more closely resemble that of the good spellers. The children's spelling on a standardized test also improved. Dyslexic children who received the other treatment, a morphological one that was more developmentally advanced, did not show normalized brain activation.

Prior to receiving either kind of instruction, the dyslexic children exhibited different patterns of brain activity than did the good spellers when performing each of the language tasks related to spelling. The dyslexics showed both absence of activity in a number of brain regions exhibited by the good spellers as well as activity in other brain areas that were not activated in the good spellers.

Richards said that significant differences between the dyslexics and good spellers occurred in a small number of regions, suggesting that a few brain regions may have abnormal function during spelling development.

Berninger noted that three word codes involved in spelling during middle childhood - phonology, morphology and orthography - activate common and unique brain regions, but the specific activated brain regions associated with each word code may change during the course of a child's development in learning how to spell. For example, beginning readers create orthographic codes from the relationship of letters and phonology. Morphology plays a greater role in the longer, more complex words in middle school and high school curriculum.

"Our research is telling us good spellers are taught, not born, as is often assumed," she said. "Unfortunately, what happens in most schools is dyslexic children learn how to read and then get dismissed from special education classes even though they still need specialized instruction until they learn to spell. Moreover, spelling is not systematically and explicitly taught in many classrooms in the United States.

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The National Institute of Child Health and Human Development funded the research. Co-authors of the paper are Elizabeth Aylward, a UW neuroimaging scientist; William Nagy, a Seattle Pacific University educational linguist; and former UW graduate students Katherine Field, Amie Grimme and Anne Richards.

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