Brain imaging study illustrates how remedial instruction helps poor readers

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Just as a disciplined exercise regimen helps human muscles become stronger and perform better, specialized workouts for the brain can boost cognitive skills, according to Carnegie Mellon scientists. Their new brain imaging study of poor readers found that 100 hours of remedial instruction — reading calisthenics, of sorts, aimed to shore up problem areas — not only improved the skills of struggling readers, but also changed the way their brains activated when they comprehended written sentences.

The results may pave the way to a new era of neuro-education. Carnegie Mellon researchers say poor readers initially have less activation in the parietotemporal area of the brain, which is the region responsible for decoding the sounds of written language and assembling them into words and phrases that make up a sentence, than do good readers. However, remedial instruction increases the struggling readers' activation to near normal levels.

This also was the first brain imaging study in which children were tested on their understanding of the meanings of sentences, not just on their recognition of single words.

"This study demonstrates how the plasticity of the human brain can work for the benefit of remedial learning," says neuroscientist Marcel Just, director of Carnegie Mellon's Center for Cognitive Brain Imaging (CCBI), and senior author of the new study currently available on the Web site of the journal *Neuropsychologia*. "We are at the beginning of a new era of neuro-education."

The poor readers worked in groups of three for an hour a day with a reading "personal trainer," a teacher specialized in administering a remedial reading program. The training included both word decoding exercises in which students were asked to recognize the word in its written form and tasks in using reading comprehension strategies. The poor readers were 25 fifth-graders taken from a stratified sample from schools in Allegheny County, which is home to Pittsburgh and a number of its surrounding municipalities.

Using functional magnetic resonance imaging (fMRI), CCBI Research Fellows Ann Meyler and Tim Keller measured blood flow to all of the different parts of the brain while children were reading and found that that the parietotemporal areas were significantly less activated among the poor readers than in the control group. The sound-based representation that is constructed in the parietal areas is then processed for the meanings of the words and the structure of the sentence, activating other brain areas.

The sentences were relatively straightforward ones, which the children judged as being sensible or nonsense, such as "The girl closed the gate" and "The man fed the dress." The children's accurate sensibility judgments ensured that they were actually processing the meaning of the sentences, and not just recognizing the individual words.

Further, the activation increases in the previously underactivating areas remained evident well after the intensive instruction had ended. When the children's brains were scanned one year after instruction, their neural gains were not only maintained but became more solidified.

"With the right kind of intensive instruction, the brain can begin to permanently rewire itself and overcome reading deficits, even if it can't entirely eliminate them," Just said.

These findings of initial parietotemporal underactivation among poor readers provide evidence against a common misconception about dyslexia. There is a persistent but incorrect belief that dyslexia is primarily caused by difficulties in the visual perception of letters, leading to confusions between letters like "p" and "d". However, such visual difficulties are the cause of dyslexia in only about 10 percent of the cases. The most common cause, accounting for more than 70 percent of dyslexia, is a difficulty in relating the visual form of a letter to its sound, which is not a straightforward process in the English language. The same parietotemporal areas of the brain that showed increased activation following instruction are centrally involved in this sound-based processing.

The findings also give hope to using the marvels of brain plasticity for instructional purposes in "new" (for the brain) subject areas. "The human brain did not evolve to process written language, which is a cultural invention dating back only 5000 years," Just said. "Some people's brains happen to be less proficient at relating written symbols to the sounds of language, and they need focused instruction to get those areas up to an adequate level of performance." Other skills that may be valuable as newer technologies (than written language) arise should also be amenable to neuroinstruction.

"Any kind of education is a matter of training the brain. When poor readers are learning to read, a particular brain area is not performing as well as it might, and remedial instruction helps to shape that area up," Just said. "This finding shows that poor readers can be helped to develop buff brains. A similar approach should apply to other skills."

Source: Carnegie Mellon University