

Math difficulties may reflect problems in a crucial learning system in the brain

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Summary: Children differ substantially in their mathematical abilities. In fact, some children cannot routinely add or subtract, even after extensive schooling. This new paper proposes that math disability arises from abnormalities in brain areas supporting procedural memory. Procedural memory is a learning and memory system that is crucial for the automatization of non-conscious skills, such as driving or grammar.

FULL STORY

Children differ substantially in their mathematical abilities. In fact, some children cannot routinely add or subtract, even after extensive schooling. Yet the causes of these problems are not fully understood. Now, two researchers, at Georgetown University Medical Center and Stanford University, have developed a theory of how developmental "math disability" occurs.

The article, in a special issue on reading and math in *Frontiers in Psychology*, proposes that math disability arises from abnormalities in brain areas supporting procedural memory. Procedural memory is a learning and memory system that is crucial for the automatization of non-conscious skills, such as driving or grammar. It depends on a network of brain structures, including the basal ganglia and regions in the frontal and parietal lobes.

The procedural memory system has previously been implicated in other developmental disorders, such as dyslexia and developmental language disorder, say the study's senior researcher, Michael T. Ullman, PhD, professor of neuroscience at Georgetown.

"Given that the development of math skills involves their automatization, it makes sense that the dysfunction of procedural memory could lead to math disability. In fact, aspects of math that tend to be automatized, such as arithmetic, are problematic in children with math disability. Moreover, since these children often also have dyslexia or developmental language disorder, the disorders may share causal mechanisms," he says.

The study's lead author, Tanya M. Evans, PhD, who specializes in reading and math, was a graduate student at Georgetown. Evans is currently a postdoctoral research fellow at Stanford University.

Ullman says that their theory, called the procedural deficit hypothesis of math disability, "offers a powerful, brain-based approach for understanding the disorder, and could help guide future research." The paper shows that previous findings are consistent with the theory, and lays out specific predictions that can be thoroughly tested through subsequent research.

To date, several other explanations of math disability have been suggested, such as deficits in spatial short-term memory, which could cause difficulties keeping numbers in mind. However, Evans says "other accounts do not generally explain math disability in terms of underlying brain structures, though the disorder must ultimately depend on aberrations in the brain."

Ullman and Evans say that learning math likely depends on the brain's two primary learning and memory systems -- not just procedural memory, but also declarative memory, where conscious knowledge is learned. "We believe that learning math is likely similar to learning other skills," Evans says. "For example, declarative memory may first be used to consciously learn how to drive, but then with practice driving gradually becomes automatized in procedural memory. However, for some children with math disability, procedural memory may not be working well, so math skills are not automatized."

"Various domains, including math, reading, and language, seem to depend on both declarative and procedural memory. Evidence suggests that when procedural memory is impaired, children may have math disability, dyslexia, or developmental language disorder, though declarative memory often compensates to some extent," Ullman says. "We believe that understanding the role of memory systems in these disorders should lead to diagnostic advances and possible targets for interventions."

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