Brain scans better forecast math learning in kids than do skill tests, study finds

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Vinod Menon and his colleagues found that scans of brain structures indicated which childen would be the best math learners over the next six years. Credit: Steve Fisch

Brain scans from 8-year-old children can predict gains in their mathematical ability over the next six years, according to a new study from the Stanford University School of Medicine.

The research tracked 43 children longitudinally for six years, starting at age 8, and showed that while brain characteristics strongly indicated which children would be the best math learners over the following six years, the children's performance on math, reading, IQ and memory tests at age 8 did not.

The study, published online Aug. 18 in The *Journal of Neuroscience*,

moves scientists closer to their goal of helping children who struggle to acquire math skills.

"We can identify brain systems that support children's math skill development over six years in childhood and early adolescence," said the study's lead author, Tanya Evans, PhD, postdoctoral scholar in psychiatry and behavioral sciences.

"A long-term goal of this research is to identify children who might benefit most from targeted math intervention at an early age," said senior author Vinod Menon, PhD, professor of psychiatry and behavioral sciences. "Mathematical skills are crucial in our increasingly technological society, and our new data show which brain features forecast future growth in math abilities."

At the start of the study, the children received structural and functional magnetic resonance imaging brain scans. None of the kids had neurological or psychiatric disorders, and their intelligence fell in a range considered normal for their age. The scans were conducted while the children lay quietly in the scanner; the scans measured brain structure and intrinsic functional connections between brain regions, and were not tied to performance on any particular math task.

The 8-year-olds also took standardized tests (given outside the scanner) to measure IQ, as well as reading, math and working-memory skills. All of the children returned for at least one follow-up assessment of these skills before age 14, and many children had other additional follow-ups.

Surprising results

The scientists were surprised by the extent and nature of the connections between brain regions that predicted the development of the children's math skills. Greater volume and connectivity of two areas forecast skill

development: the ventro-temporal occipital cortex, which is a brain region that supports visual object perception, and the intra-parietal sulcus, which helps people compare and make judgements about numbers, such as understanding that four is more than three. The strength of these regions' interconnections with the prefrontal cortex was also predictive. The work identifies a network of brain areas that provides a scaffold for long-term math skill development in children, Menon said.

The 8-year-olds' initial IQ, reading, working-memory and math scores did not predict long-term learning in math. The lack of predictive ability of standard math tests taken at age 8 suggests that brain features more precisely predict children's math learning, Evans said. The brain scans capture many different aspects of information processing, thus better forecasting which children will fall behind and which will excel, Menon added.

"Next, we are investigating how brain connections change over time in children who show large versus small improvements in math skills, and designing new interventions to help children improve their short-term learning and long-term skill acquisition," Menon said. Although it is still impractical to give brain scans to children on a large scale, the team's studies provide a baseline understanding of normal development that will help experts develop and validate remediation programs for children with learning disabilities, he noted.

In the meantime, the team's findings suggest that parents and teachers should encourage children to exercise their mental math muscles. "Just because a child is currently struggling doesn't necessarily mean he or she will be a poor learner in the future," Evans said.

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