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Researchers Probe Causes of Math Anxiety

It's more than just disliking math, according to scholars

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Chicago

Math problems make more than a few students—and even teachers—sweat, but new brain research is providing insights into the earliest causes of the anxiety so often associated with mathematics.

Experts argue that "math anxiety" can bring about widespread, intergenerational discomfort with the subject, which could lead to anything from fewer students pursuing math and science careers to less public interest in financial markets.

"People are very happy to say they don't like math," said Sian L. Beilock, a University of Chicago psychology professor and the author of *Choke*, a 2010 book on brain responses to performance pressure. "No one walks around bragging that they can't read, but it's perfectly socially acceptable to say you don't like math."

Mathematics anxiety is more than just disliking math, however; someone with math anxiety feels negative emotions when engaging in an activity that requires numerical or math skills. In one forthcoming study by Ms. Beilock, simply suggesting to college students that they would be asked to take a math test triggered a stress response in the hypothalamus of students with high math anxiety.

Ms. Beilock and other experts at a Learning and the Brain conference held here May 5-7 are searching for the earliest problems in a child's math career that can grow into lifelong fears and difficulties. The conference, put on by the Needham, Mass.-based Public Information Resources, Inc., brought together several hundred educators and administrators with researchers in educational neuroscience and cognitive science.

Stress in the Brain

Anxiety has become a hot topic in education research, as educators and policymakers become increasingly focused on test performance and more-intensive curricula, and neuroscience has begun to provide a window into how the brain responds to anxiety.

Anxiety can literally cut off the working memory needed to learn and solve problems, according to Dr. Judy Willis, a Santa Barbara, Calif.-based neurologist,

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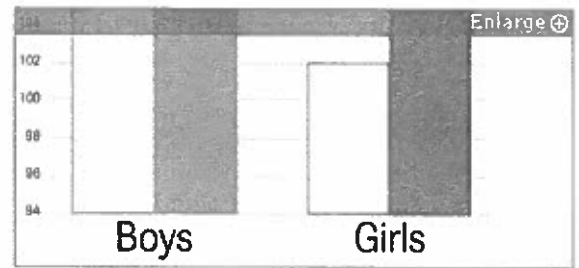
Anxieties and Stereotypes

Researchers have found that the more anxious their female teachers were about math, the more likely girls—but not boys—were to endorse gender-related stereotypes

former middle school teacher, and author of the 2010 book *Learning to Love Math*.

When first taking in a problem, a student processes information through the amygdala, the brain's emotional center, which then prioritizes information going to the prefrontal cortex, the part responsible for the brain's working memory and critical thinking. During stress, there is more activity in the amygdala than the prefrontal cortex; even as minor a stressor as seeing a frowning face before answering a question can decrease a student's ability to remember and respond accurately.

about math ability. In turn, the girls who echoed those stereotypical beliefs were performing less well than other students in math by year's end.



SOURCE: University of Chicago

"When engaged in mathematical problem-solving, highly math-anxious individuals suffer from intrusive thoughts and ruminations," said Daniel Ansari, the principal investigator for the Numerical Cognition Laboratory at the University of Western Ontario, in London, Ontario. "This takes up some of their processing and working memory. It's very much as though individuals with math anxiety use up the brainpower they need for the problem" on worrying.

Moreover, a series of experiments at the Mangels Lab of Cognitive Neuroscience of Memory and Attention at Baruch College at the City University of New York suggests this stress reaction may hit hardest the students who might otherwise be the most enthusiastic about math.

Jennifer A. Mangels, the lab's director, said she tested college students on math in either neutral situations or in ways designed to invoke anxiety, such as mentioning gender stereotypes about mathability to girls being tested, or telling students that their scores would be used to compare their math ability with others'.

Ms. Mangels found, in keeping with other research, that students tested in stressful situations had lower math performance. She also found that stress hit otherwise promising students the hardest.

In nonstressful tests, the students who most identified with math, defined as those who sought out more opportunities to learn within the math program, had the highest performance. While under stress, those same students performed worse than those who didn't identify with the subject.

"We're reducing the diagnostic ability of these tests by having students take them in a stressful situation," Ms. Beilock agreed.

Dyscalculia and Bias

Two problems in a child's earliest school experiences—one biological, the other social—can build into big math fears later on, experts say.

In a **series of studies**, Mr. Ansari and his colleagues at the Numerical Cognition Laboratory have found that adults with high math anxiety are more likely to have lower-than-typical ability to quickly recognize differences in numerical magnitude, or the total number of items in a set, which is considered a form of dyscalculia.

As part of normal development, children become increasingly adept at identifying which of two numbers of items is bigger, but Mr. Ansari found those with high math anxiety were slower and less accurate at that task, and brain scans showed activity different from that of people with low math stress doing the same tasks.

Because understanding numerical magnitude is a foundation for other calculations, Mr. Ansari suggests that small, early deficiencies in that area can lead to difficulties, frustration, and negative reactions to math problems over time.

Moreover, math anxiety can become a generational problem, with adults uncomfortable with math passing negative feelings on to their children or students.

Ms. Beilock found female 1st and 2nd grade teachers with high anxiety about math affected both their students' math performance and their beliefs about math ability. In a **study** of a dozen 1st grade and five 2nd grade teachers and their students, researchers found no difference in the performance of boys and girls in math at the beginning of the year. By the end of the school year, however, girls taught by a teacher with high math anxiety started to score lower than boys in math.

Moreover, those girls were more likely to draw pictures supporting a gender bias—"Boys are good at math; girls are good at reading"—and the stronger the bias, the worse the girls performed.

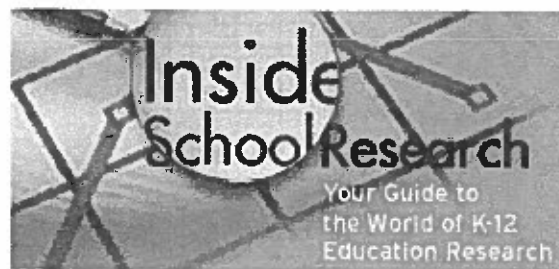
That study, and **similar ones**, highlight a need for more training for parents and teachers on how to conquer their own math fears and avoid passing them to children, Ms. Beilock and Mr. Ansari said.

"Teacher math anxiety is really an epidemic," Mr. Ansari said. "I think a lot of people go into elementary teaching because they don't want to teach high school math or science."

Eugene A. Geist, an associate professor at Ohio University in Athens and the author of the 2001 book, *Children Are Born Mathematicians*, works with math teachers to create "anxiety-free classrooms" for students. He advises teachers to have students focus on learning mathematics processes, rather than relying on the answer keys in a textbook, which can undermine both their own and the teacher's confidence in their math skills.

"If I give the answer, you immediately forget about the question. If I don't give you the answer, you will still have questions and you will be thinking about the problem long after," he said.

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By contrast, constantly referring to an answer key can undermine both students' and teachers' confidence in their own math skills, and encourage students to focus on being right over learning.

Likewise, Dr. Willis, the California neurologist, said that teachers can help students reduce their fear of participating during math discussions by asking all students to answer every question, using scratch paper or electronic clickers to "bet" on answers, and then talking about the problem as a group.

"It helps with wait time [between question and answer], increases participation, and decreases mistake fear," Dr. Willis said. The key to helping students learn not to fear math, she said, is to "get students to expose faulty foundational knowledge, which they can only do if they make mistakes and participate."

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