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Math anxiety: who has it, why it develops, and how to guard against it

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Basic math skills are important for success in school and everyday life. Yet many people experience apprehension and fear when dealing with numerical information, termed math anxiety. Recently, researchers have started to probe the antecedents of math anxiety, revealing some surprising insights into its onset, risk factors, and remediation.

Understanding math anxiety

For people with math anxiety, opening a math textbook or even entering a math classroom can trigger a negative emotional response, but it does not stop there. Activities such as reading a cash register receipt can send those with math anxiety into a panic. Math anxiety is an adverse emotional reaction to math or the prospect of doing math [1]. Despite normal performance in most thinking and reasoning tasks, people with math anxiety perform poorly when numerical information is involved.

Why is math anxiety tied to poor math performance? One idea is that math anxiety is simply a proxy for low math ability, meaning that individuals with math anxiety are less skilled or practiced at math than their non-anxious counterparts. After all, math anxious individuals tend to stay away from math classes and learn less math in the courses they do take [1]. Yet low math ability is not the entire explanation for why math anxiety and poor math performance co-occur. It has been shown that people's anxiety about doing math – over and above their actual math ability – is an impediment to math achievement [2]. When faced with a math task, math anxious individuals tend to worry about the situation and its consequences. These worries compromise cognitive resources, such as working memory, a short-term system involved in the regulation and control of information relevant to the task at hand [3]. When the ability of working memory to maintain task focus is disrupted, math performance often suffers.

Despite the progress made in understanding how math anxiety relates to math performance, only limited attention has been devoted to the antecedents of math anxiety. Determining who is most likely to develop math anxiety, when they will develop it, and why is essential for gaining a full understanding of the math anxiety phenomenon and its role in math achievement.

Math anxiety: antecedents and developmental trajectory

The first years of elementary school are critical for learning basic mathematical skills. Yet until recently the dominant view among educators and researchers alike was that math anxiety only arose in the context of complex mathematics (e.g. algebra) and thus was not present in young children. Math anxiety was thought to develop in junior high school, coinciding with the increasing difficulty of the math curriculum towards the end of elementary school [2]. Recent research challenges this assumption. Not only do children as young as first grade report varying levels of anxiety about math, which is inversely related to their math achievement [4], but this anxiety is also associated with a distinct pattern of neural activity in brain regions associated with negative emotions and numerical computations. When performing mathematical calculations, math anxious children, relative to their less anxious counterparts, show hyperactivity in right amygdala regions important for processing negative emotions. This increased amygdala activity is accompanied by reduced activity in brain regions known to support working memory and numerical processing (e.g. dorsolateral prefrontal cortex and posterior parietal lobe) [5].

Both social influences and cognitive predispositions probably play a role in the onset of math anxiety in early elementary school. In terms of social influences, teachers who are anxious about their own math abilities impart these negative attitudes to some of their students. Interestingly, this transmission of negative math attitudes seems to fall along gender lines. Beilock and colleagues found that it was only the female students of highly math anxious female teachers (>90% of elementary teachers in the USA are female) who tended to endorse the stereotype that 'boys are good at math, girls at reading' by the end of a school year. Girls who endorsed this stereotype were also most likely to be behind in math at the end of the school year [6]. Similar to how social mores are passed down from one generation to another, negative math attitudes seem to be transmitted from teacher to student.

Some children may also have a cognitive predisposition to develop math anxiety. In adults, math anxiety is associated with deficits in one or more of the fundamental building blocks of mathematics. For example, adults who are math anxious are worse than their non-anxious peers at counting objects, at deciding which of two numbers represents a larger quantity, and at mentally rotating 3D objects [7–9]. Similar to how people who lack knowledge in a particular domain are often easily swayed by negative

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messages [10], children who start formal schooling with deficiencies in these mathematical building blocks may be especially predisposed to pick up on social cues (e.g. their teacher's behavior) that highlight math in negative terms.

Alleviating math anxiety

Understanding the antecedents of math anxiety provides clues about how to prevent its occurrence. For instance, bolstering basic numerical and spatial processing skills may help to reduce the likelihood of developing math anxiety. If deficiencies in basic mathematical competencies predispose students to becoming math anxious, then early identification of at-risk students (coupled with targeted exercises designed to boost their basic mathematical competencies and regulate their potential anxieties) may help to prevent children from developing math anxiety in the first place.

Knowledge about the onset of math anxiety also sheds light on how to weaken the link between math anxiety and poor math performance in those who are already math anxious. If exposure to negative math attitudes increases the likelihood of developing math anxiety, which in turn adversely impacts math learning and performance, then regulation of the negativity associated with math situations may increase math success, even for those individuals who are chronically math anxious. Support for this idea comes from work showing that when simply anticipating an upcoming math task, math anxious individuals who show activation in a frontoparietal network known to be involved in the control of negative emotions perform nearly as well as their non-anxious counterparts on a difficult math test [11]. These neural findings suggest that strategies that emphasize the regulation and control of negative emotions – even before a math task begins – may enhance the math performance of highly math anxious individuals.

One means by which people can regulate their negative emotions is expressive writing in which people are asked to write freely about their emotions for 10–15 min with respect to a specific situation (e.g. an upcoming math exam). Writing is thought to alleviate the burden that negative thoughts place on working memory by affording people an opportunity to re-evaluate the stressful experience in a manner that reduces the necessity to worry altogether. Demonstrating the benefits of expressive writing, Ramirez and Beilock showed that having highly test anxious high school students write about their worries prior to an upcoming final exam boosted their scores from B– to B+ (even after taking into account grades across the school year) [12]. Similar effects have been found specifically for math anxiety. Writing about math-related worries boosts the math test scores of math anxious students [13].

Negative thoughts and worries can also be curtailed by reappraisal or re-framing techniques. Simply telling students that physiological responses often associated with anxious reactions (e.g. sweaty palms, rapid heartbeat) are beneficial for thinking and reasoning can improve test performance in stressful situations [14]. Having students think positively about a testing situation can also help them to reinterpret their arousal as advantageous rather than debilitating. For example, when students view a math test as a challenge rather than a threat, the stronger their physiological response to the testing situation (measured here in terms of salivary cortisol), the better, not worse, is their performance [15].

Summing up

Education, psychology, and neuroscience researchers have begun to uncover the antecedents of math anxiety. Not only is math anxiety present at the beginning of formal schooling, which is much younger than was previously assumed, but its development is also probably tied to both social factors (e.g. a teacher's anxiety about her own math ability) and a student's own basic numerical and spatial competencies – where deficiencies may predispose students to pick up on negative environmental cues about math. Perhaps most striking, many of the techniques employed to reduce or eliminate the link between math anxiety and poor math performance involve addressing the anxiety rather than training math itself. When anxiety is regulated or reframed, students often see a marked increase in their math performance. These findings underscore the important role that affective factors play in situations that require mathematical reasoning. Unfortunately, it is still quite rare that numerical cognition research takes into account issues of math anxiety when studying numerical and mathematical processing. By ignoring the powerful role that anxiety plays in mathematical situations, we are overlooking an important piece of the equation in terms of understanding how people learn and perform mathematics.

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