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SCIENCE BRIEF

Back to school: Dealing with academic stress

Simple psychological interventions can reduce stress and improve academic performance.

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It's that time of year again. Across the country, students have returned to school. With a renewed spotlight on standardized testing – sparked, in part, by the Obama Administration's urge that states rely on test scores to make decisions about student progress, teacher salaries and school fitness – emphasis on achievement in the classroom has never been higher.

High-stakes learning and performance situations can put a counterproductive stress on students. However, there is a growing body of research showing that fairly simple interventions can lower students' anxiety about tests and boost what they learn in the classroom. These interventions don't teach academic content, they target students' attitudes. With the right psychological preparation, we can even reduce achievement gaps based on gender and race.

How Do Stressful Academic Situations Compromise Performance?

To develop interventions that help students perform at their best when the pressure is on, you first have to understand why students sometimes perform below their ability in stressful academic situations. My colleagues and I have shown that a diverse set of phenomena – ranging from the negative emotional reaction a female math major might experience when reminded of the stereotype that "women can't do math" (termed *stereotype threat*; Steele, 1997), to the acute pressure anyone might feel when taking a high-stakes college admissions test, to the anxiety people with a chronic fear of math experience when sitting in math class – show striking commonalities in the effects they have on cognitive functioning. Specifically, these stressful academic situations reduce the working-memory available to attend to a task's information processing requirements and to control its execution (Beilock, 2008).

Working-memory is a short-term memory system involved in the control, regulation, and active maintenance of a limited amount of information immediately relevant to the task at hand (Miyake & Shah, 1999). If the ability to maintain task-relevant information in working-memory is disrupted, performance may suffer. We refer to this as the distraction account of failure. Stress-laden environments essentially place people in a dual-task situation in which task execution and performance-related worries vie for the working-memory capacity once devoted solely to the task at hand.

To understand how stress undermines academic performance, my colleagues and I have created a high-stakes testing environment in our laboratory. We often focus on math and science in our tests because students tend to find these

subjects particularly difficult and there are large disparities in who succeeds in STEM (science, technology, engineering and math) classes -- e.g., the gender and racial achievement gaps -- which we believe are due, in part, to stressful learning and testing situations.

In some studies, we have used Gauss's modular arithmetic as a test bed (see Beilock, 2008 for details). Modular arithmetic involves judging the truth-value of equations [e.g., 34=18(mod4)]. One way to do this is to subtract the middle from the first number ("34-18"). This difference is then divided by the last number ("16÷4"). If the dividend is a whole number (here, 4), the statement is true. Problems with remainders are false. Problem validity can also be determined by dividing the first two numbers by the mod number. If the same remainder obtains (here, 34÷4 and 18÷4 both have remainders of 2), the equation is true.

It is important to understand how high-stakes situations compromise tasks like modular arithmetic. This is because careless mistakes on the types of computations inherent in modular arithmetic contribute to less-than-optimal performance in testing situations. Even problems that go beyond modular arithmetic's conceptual demands often require mental computations similar to modular arithmetic. Thus, understanding how stressful situations compromise even relatively simple calculations will shed light on unwanted performance decrements.

In an initial study (Beilock, Kulp, Holt, & Carr, 2004), we asked college students to solve modular arithmetic problems that varied as a function of whether the first problem step involved large numbers (>10) and borrow operations ("45-27"). Larger numbers and borrow operations involve longer sequences of steps and require maintenance of more intermediate products, placing greater demands on working memory (Imbo, Vandierendonck, & Verguewe, 2007). We reasoned that if pressure impacts working-memory, then performance should be more likely to decline on higher working-memory problems [e.g., 51=29(mod4)] in comparison to lower working-memory problems [e.g., 6=3(mod3)].

To test this, some students (assigned to a low-pressure group) were simply told to try their best. Others (assigned to a high-pressure group) were given a scenario based on common pressures in academic testing situations. For instance, we offered students money to perform at a high level, analogous to the scholarships they could earn if they did well in an actual testing situation. We also told students that their performance might be subject to evaluation by others – just as in real-world assessment situations where test scores are judged by parents, teachers, peers.

Not surprisingly, our pressure scenario increased students' reported feelings of pressure. Our pressure scenario also reduced students' math accuracy relative to individuals in the low-pressure group. However, performance decrements were limited to problems highest in working-memory demands. This suggests that pressure exerts its impact by taxing working-memory resources necessary for demanding computations. We have found a similar pattern of results when we create a stereotype threat situation in our laboratory by simply mentioning to female college students that we are studying gender differences in math (Beilock, Rydell, & McConnell, 2007). We show that college-aged women perform as well as men on math problems that purportedly do not show gender differences. However, when women believe that gender differences will be revealed, they perform worse than men. Importantly, women's poor performance is limited to math problems that place the greatest demands on working memory. High-pressure and stereotype threat situations negatively impact performance in the same way, by compromising working-memory resources that could otherwise be devoted to the task at hand.

Who Fails When the Stress is On?

Establishing a link between working-memory and academic failure provides insight into why poor performance occurs. It also hints at important individual differences in susceptibility to failure. Working-memory is often portrayed as a general cognitive construct. Yet, it is also an individual difference variable – meaning some people have more of this general cognitive capacity than others. In general, the more working-memory capacity people have, the better their performance on academic tasks such as problem solving and reasoning (Engle, 2002). Thus, it is important to understand how people with more or less working-memory are affected by the types of high-stakes situations in which academic performance often occurs.

An obvious hypothesis is that lower working-memory individuals (LOWs) will perform more poorly in stressful academic situations because LOWs have limited capacity for problem computations to begin with. Consumption of working-memory may shrink this available capacity below a minimum needed to successfully solve problems. However, there is a less intuitive prediction. Higher working-memory individuals (HIGHs) might be more prone to performance disruptions when the stakes are high. If HIGHs rely heavily on problem solving strategies that load working-memory, this may make them susceptible to the impact of stressful situations.

Our research supports the latter prediction (Beilock & Carr, 2005; Beilock & DeCaro, 2007; Beilock, 2008). The academic performance of those individuals highest in working-memory (HIGHs) is most likely to falter under both high-pressure testing situations and stereotype threat. Not surprisingly, HIGHs outperform LOWs in non-pressure-filled situations. However, HIGHs' performance falls to the level of LOWs' when under pressure. LOWs' performance doesn't change from low to high-pressure situations. This pattern of data occurs even though both LOWs and HIGHs report feeling similar levels of pressure and show similar physiological stress-related responses (e.g., salivary cortisol levels; Mattarella-Micke, Mateo, Kozak, Foster, & Beilock, 2011) in high-stakes situations.

One explanation for these findings is that HIGHs rely more than LOWs on strategies that load working-memory during problem solutions – "if you've got it, flaunt it." When working-memory is compromised, HIGHs are denied the capacity they usually rely on to produce their superior performance. Because LOWs normally use problem solving strategies that don't rely heavily on working-memory (e.g., short-cuts that produce the correct answer only some of the time), their performance doesn't suffer under pressure. There is considerable debate concerning the ability of high-stakes tests (e.g., SAT,GRE) to predict future academic performance. Our work demonstrates that the stressful situations in which tests are taken diminish meaningful individual differences in performance because both LOWs and HIGHs tend to perform equally poorly.

Interventions of Alleviate Failure

Understanding the mechanisms by which stressful academic situations impact performance allows us to design quick, cost-effective, and easy-to-use interventions to help students in the classroom. For instance, recently we (Ramirez & Beilock, 2011) demonstrated that asking students to write about their thoughts and feelings about an upcoming test immediately before they take the test can lessen the negative impact of pressure on performance. This research builds on work in clinical and social psychology demonstrating that writing or journaling decreases ruminations and alleviates depressive symptoms. If expressing negative thoughts on paper decreases rumination about such topics, this may free up available working-memory for the task at hand (Pennebaker & Graybeal, 2001; Klein & Boals, 2001).

In the laboratory, we have shown that writing about one's worries about an upcoming test for ten minutes before taking the test eliminates poor performance under pressure. We have also shown that it is not merely any writing (e.g., writing about one's day), but specifically writing about one's worries that is needed to produce such inoculation effects.

We have also extended our laboratory results to the classroom (Ramirez & Beilock, 2011). In one study, ninth graders were randomly assigned to an expressive writing condition (writing about their worries about the upcoming test) or control condition (thinking about items that would not be on the upcoming test) for 10 minutes immediately prior to the first final exam (biology) of their high-school career. Both students and teachers were blind to the particulars of the study and the condition students were in. We obtained students' grades for the fall, winter, and spring quarter along with their final exam scores. There was no grade difference in any quarter for students in the writing and control groups. However, for the final exam, those who expressively wrote outperformed controls. This was especially true for students who have a tendency to worry on tests (i.e., students high in test anxiety). High test anxious students (test anxiety was measured six weeks before the final exam) who wrote down their thoughts beforehand received an average grade of B+, compared with those who didn't write, who received an average grade of B-.

Recent work suggests that writing also helps boost math performance for the chronically math anxious. Math anxiety is characterized by feelings of tension, apprehension, or fear about performing math and it has been suggested that, similar to other stressful situations, high math-anxious individuals perform poorly in math due, at least in part, to transient disruptions of the working-memory available for math performance (Ashcraft, 2002). We have shown that writing about worries before a big math test helps alleviate this disruption (Park, Ramirez, & Beilock, in preparation).

How can such a simple writing exercise have such a big impact? We think the answer has to do with the content of the writing itself. Writing reduces people's tendency to ruminate because it provides them with an opportunity to express their concerns. Expressing concerns gives people some insight into the source of their stress, allowing them to reexamine the situation such that the tendency to worry during the actual stressful situation (and the resulting disruption of working-memory) is limited.

Importantly, writing is not the only way to boost academic performance. Actions as simple as having students reaffirm their self-worth, by listing important values like relationships with friends and family, have been shown to boost the test scores of minorities and females in math and science from junior high school through college (Cohen, Garcia, Apfel, & Master, 2006, Cohen et al., 2009; Miyake et al., 2010). Affirming important values buffers students from worrying about

their ability to succeed because of their gender or race – freeing up working-memory to focus on the problems at hand. Even having students think about why they might succeed ("I am a student at a high-level University") rather than fail ("I am a girl taking a difficult math test") can turn a potentially poor performance into a successful one (Rydell, McConnell, & Beilock, 2009).

Learning habits to combat academic stress can bring benefits beyond the classroom. High-stakes situations are an inevitable part of life – at school and especially at work. If students can learn to perform up to their ability in school, the same anxiety-easing techniques can make them better prepared for job interviews, business presentations, or other stressful tasks in life.

People assume that large problems require large solutions. But the truth is that simple psychological interventions can have powerful effects. Perhaps part of the $300 million that President Obama has pledged to revamp and expand the use of standardized tests would be better spent educating students about the mental tools that can help them succeed in tests and in life.

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