

ON THE INTERPLAY OF EMOTION AND COGNITIVE CONTROL: IMPLICATIONS FOR ENHANCING ACADEMIC ACHIEVEMENT

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Abstract

Whether or not students are able to perform up to their potential in the classroom can be influenced by their perceptions of situational pressures to perform at a high level, their anxiety about succeeding in subjects such as math, and even the awareness of negative academic stereotypes regarding the ability of the gender or racial group to which students belong. In this chapter, we provide an overview of research that has been conducted to date on a diverse set of negative emotion-inducing situations known to influence performance in the classroom. Despite differences in the stressful academic situations that students encounter, we propose that a common set of mechanisms operate to affect performance. We conclude by outlining

work exploring classroom interventions designed to ensure that all students perform at their best in important learning and testing situations.

1. INTRODUCTION

Many students view school as an opportunity to learn and expand their knowledge base. Take a middle school Algebra I class as an example. This class is designed to provide students with basic algebra knowledge and to also give students a foundation for more advanced math they will encounter in the years to come. Of course, sitting in math class not only garners thoughts of learning and achievement in students. For many, school situations also lead to feelings of tension, apprehension, or fear about performing up to the expectations set by the students themselves or the expectations set by others (e.g., parents, teachers, and peers). In other words, learning and performance in school cannot simply be boiled down to acquiring and demonstrating knowledge. Rather, academic performance involves a mix of memory, attention, and cognitive control processes along with motivational and emotional factors.

As an example, think about how a student might go about determining the answer, in his or her head, to a math problem such as $(32-18) \div 7 = ?$ It involves several steps. First, one must compute the answer to $32-18 = ?$ Second, one must hold this answer in memory and divide the answer 14 by 7. Although there has been a significant amount of research devoted to investigating the attention, memory, and computational processes that support these types of calculations, less work has addressed how such calculations are impacted by the types of real-world academic situations in which math performance often takes place. How might being in an important testing situation impact performance of the above problem? Or, would working through the problem at the chalkboard as an entire class looks on affect one's success? Finally, what if a female student performed this calculation after being told "everyone knows girls can't do math"?

Although students may be motivated to perform well in such stress-laden situations, these environments often cause students to perform at their worst. The term *choking under pressure* has been used to describe the phenomenon whereby people perform more poorly than expected given their skill level in situations where incentives for optimal performance are maximal and the negative consequences associated with poor performance are high (Beilock & Carr, 2001). The term *stereotype threat* (ST) describes situations in which awareness of a negative stereotype about how one's social group should perform (e.g., "girls can't do math")

produces less than optimal execution in group members (Steele, 1997). Finally, the term *math anxiety* describes feelings of tension, apprehension, and fear that some people have when faced with the prospect of performing math (Ashcraft & Kirk, 2001).

Although choking, ST, and math anxiety have all been shown to impact academic performance, these phenomena are often studied in different labs and are largely constrained to separate fields within psychology and education. Nevertheless, many similar conclusions concerning how suboptimal performance arises in academic domains such as math have emerged from their investigation. Our lab is interested in understanding the commonalities among these different phenomena, specifically why they cause performance decrements and for whom poor performance is most likely. Our goal is to leverage this knowledge to devise training regimens, performance strategies, and testing environments to alleviate failure in academic areas such as math.

In this chapter, we bring work together from cognitive psychology, social psychology, developmental psychology, and education in an attempt to understand the interplay of emotion and cognition in education, asking questions about how stressful and emotion-filled academic situations alter the cognitive processes that support performance—processes that, under less-emotion inducing situations, would be readily available for execution. Moreover, we consider implications of the integration of emotion and cognitive control in terms of understanding (a) individual differences in susceptibility to failure and (b) performance sustainability in high-pressure and important situations.

2. CHOKING UNDER PRESSURE

We have all heard the term “choking under pressure” before. In the sports arena, we talk about the “bricks” in basketball when the game-winning free throw is missed. In academics, we refer to “cracking” in important test taking situations. But what exactly do these terms mean and why does less than optimal performance occur—especially when incentives for optimal performance are maximal?

The desire to perform as well as possible in situations with a high degree of personally felt importance is thought to create performance pressure. However, despite the fact that performance pressure often results from aspirations to function at one’s best, pressure-packed situations are where suboptimal skill execution may be most visible. The term *choking under pressure* has been used to describe this phenomenon. As mentioned above, choking is defined as performing more poorly than expected given one’s skill level, and is thought to occur in many different tasks.

Some of the first attempts to account for unwanted skill decrements can be traced back to investigations of the arousal–performance relationship. According to the models of this relationship (often termed drive theories or the Yerkes–Dodson curve), an individual’s performance level is determined by one’s current level of arousal or “drive.” With too little arousal, the basketball player will not have the tools necessary to make the shot. Similarly, with too much arousal, the shot will be missed. Although drive theories have been useful in accounting for some types of performance failures, they fall short in a number of ways. First, drive theories are mainly descriptive in that they link arousal and performance, but do not explain how arousal exerts its impact. Second, within drive theory models, there are often debates concerning how the notion of “arousal” should be conceptualized (e.g., as a physiological construct, emotional construct, or both). Third, there are situations in which certain types of drive theories have trouble accounting for observed behavior. For example, one derivation of drive theory (i.e., social facilitation) predicts that one’s dominant response will be exhibited in high arousal or high drive situations. However, this does not always seem to hold when the pressure is on.

2.1. Two mechanisms of performance failure

Building on drive theory accounts of performance failure, more recent work has attempted to understand how pressure changes how one thinks about and attends to the processes involved in skill performance. These accounts are often termed attentional theories. Two main attentional theories have been proposed to explain choking under pressure.

2.1.1. Distraction Theories

First, distraction theories propose that pressure creates a distracting environment that compromises working memory (WM)—a short-term memory system that maintains, in an active state, a limited amount of information relevant to the task at hand (Miyake & Shah, 1999). If the ability of WM to maintain task focus is disrupted, performance may suffer. In essence, distraction-based accounts of skill failure suggest that performance pressure shifts attention from the primary task one is trying to perform (e.g., math problem solving) to irrelevant cues (e.g., worries about the situation and its consequences). Under pressure then, there is not enough of WM’s limited resources for both to successfully support primary task performance and to entertain worries about the pressure situation and its consequences. As a result, skill failure ensues.

Although there is evidence that pressure can compromise WM resources, causing failure in tasks that rely heavily on this short-term memory system, not all tasks do rely heavily on WM. For example, well-learned sensorimotor skills, which have been the subject of the

majority of choking research in sport (e.g., simple golf putting, baseball batting, and soccer dribbling), are thought to become proceduralized with practice such that they do not require constant attention and control—that is, such skills are not thought to depend heavily on WM at high levels of learning. How then do such skills fail, if not via the consumption of WM resources? A second class of theories, generally known as explicit monitoring theories, have been used to explain such failures.

2.1.2. Explicit Monitoring Theories

Explicit monitoring theories suggest that pressure situations raise self-consciousness and anxiety about performing correctly. This focus on the self is thought to prompt individuals to turn their attention inward on the specific processes of performance in an attempt to exert more explicit monitoring and control than would be applied in a nonpressure situation. For example, a basketball player who makes 85% of his/her free throws in practice may miss the game-winning foul shot because, in order to ensure an optimal outcome, he/she tried to monitor the angle of his/her wrist as he/she shot the ball. This component of performance is not something that our basketball player would normally attend to. And, paradoxically, such attention is thought to disrupt well-learned or proceduralized performance processes that normally run largely outside of conscious awareness.

From the above description of distraction and explicit monitoring theories, one might conclude that performance pressure exerts one kind of impact on cognitive skill performance and another kind of impact on sensorimotor skill performance. It seems more likely, however, that pressure always exerts at least two different effects—it populates WM with worries and it entices the performer to try to pay more attention to step-by-step control, resulting in a double whammy. These two effects may be differentially relevant to performance depending on the attentional demands of the task being performed. If a task depends heavily on WM but does not involve much in the way of proceduralized routines (e.g., difficult and novel math problem solving), then it will suffer from pressure-induced *disruption* of WM, but it will not be harmed by the attempt to focus what attention remains on step-by-step control that is also induced by pressure. Conversely, if a task relies heavily on proceduralized routines but puts little stress on WM (e.g., a well-learned golf putt), then such tasks will suffer from performance pressure because of the *shift* of attention to step-by-step control and not because WM has been disrupted.

In the context of academic performance (and especially mathematical performance), a majority of work supports distraction theories of choking. One reason for this is that many of the skills performed in the classroom require heavy demands on WM.

To explore how situation-induced pressures undermine math performance, we have created a high-stakes testing environment in our laboratory, using Gauss's (1801, as cited by Bogomolny, 1996) *modulararithmetic* (MA) as a test bed. MA involves judging the truth value of equations [e.g., $34 \equiv 18(\text{mod}4)$]. One way to solve these problems is to subtract the middle from the first number ("34–18"). This difference is then divided by the last number (" $16 \div 4$ "). 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 is obtained (here, $34 \div 4$ and $18 \div 4$ both have remainders of 2), the equation is *true*.

It is important to understand how pressure compromises tasks like MA because careless mistakes on the types of computations inherent in MA contribute to less than optimal performance in testing situations. Moreover, even problems that go beyond the conceptual demands of MA often require mental calculations similar to those needed to compute MA answers. 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 students to solve MA 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 WM (Imbo & Vandierendonck, 2007). If pressure impacts WM, then performance should be more likely to decline on high WM-demanding [e.g., $51 \equiv 29(\text{mod}4)$] in comparison to low WM-demanding [e.g., $6 \equiv 3(\text{mod}3)$] problems.

To test this, some individuals (assigned to a low-pressure group) were simply told to try their best. Others were given a scenario based on common pressures (e.g., monetary incentives, peer pressure, and social evaluation). Participants were informed that if they performed at a high level on the math task, they would receive some money. Participants were also told that this award was dependent on both themselves and a partner they were paired with performing well—a "team effort." Participants were then informed that their partner had completed the experiment and improved. Thus, the current participant was entirely responsible for winning (or losing) the money. Participants were also told that their performance would be videotaped and that teachers/students would watch the tapes.

Not surprisingly, this scenario increased participants' reported feelings of pressure and reduced math accuracy relative to individuals in the low-pressure group. However, performance decrements were limited to problems highest in WM demands. This suggests that performance pressure

exerts its impact by taxing WM resources necessary for demanding computations.

Although this work implicates WM in math failure, it does not tell us what exactly pressure-filled environments do to WM to produce suboptimal performance. As previously mentioned, the *distraction account* suggests that situation-related worries reduce the WM available for performance. If so, then math problems heavily reliant on the resources that worries also co-opt should be most susceptible to failure. Thus far, we have conceptualized WM as a general capacity system—meaning that it supports cognitive operations regardless of the type of information involved. However, there is also work suggesting that certain components of WM may be devoted more so to either verbal processes (e.g., inner speech and thinking) or to visuospatial processes (e.g., holding a visual image in memory; Baddeley & Hitch, 1974). If worries tax verbal components of WM, and math problems can be differentiated by the demands they make on verbal versus visuospatial resources, then performance on problems heavily reliant on verbal resources should be especially compromised under stress. Of course, this does not mean that tasks with spatial demands (e.g., mental rotation) will show no signs of failure (especially if, for example, one concocts visual images of feared alternatives or uses a verbal procedure for solving a spatial task). Rather, if verbal ruminations and worries are a key component of stress-induced failure, then performance decrements should be most pronounced in tasks that depend heavily on WM and especially verbal aspects of this system.

DeCaro, Rotar, Kendra, & Beilock (2010) examined this hypothesis by varying the type of math problems people performed. We were particularly interested in whether performance of math problems that relied more heavily on verbal versus visuospatial resources would be differentially harmed. Although all arithmetic problems involve general WM resources, Trbovich and LeFevre (2003) demonstrated that math problems presented in a horizontal format depend heavily on phonological or verbal resources because individuals verbally maintain problem steps in memory (e.g., repeating them in their head). Math problems presented in a vertical format rely more on visuospatial resources because individuals tend to solve vertical problems in a spatial mental workspace similar to how such problems are solved on paper (see Figure 1a).

If horizontally oriented MA problems recruit verbal resources that vertical problems do not (Figure 1b) and the performance pressure induces an inner monologue of worries that relies heavily on verbal WM, then horizontal problem performance should be more negatively impacted by pressure than vertical problem performance. This is exactly what was found. People under pressure performed more poorly than people in a nonpressure condition. However, this poor performance was limited to horizontal problems heavily reliant on phonological aspects

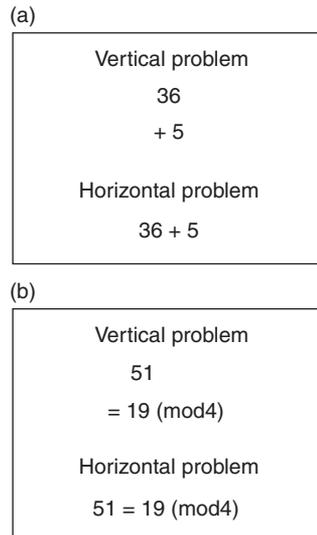


Figure 1 (a) Example of vertically and horizontally oriented arithmetic problems. (b) Example of vertically and horizontally oriented MA problems. Reprinted with permission from DeCaro et al. (2010).

of WM. Performance on vertical problems did not differ as a function of group.

2.2. Individual differences and choking under pressure in math

Establishing a link between WM and math failure not only provides insight into why poor performance occurs but it also hints at important individual differences in susceptibility to failure. Although WM is often portrayed as a general cognitive construct, it is also an individual difference variable—meaning some people have more of this general cognitive capacity than others. The more WM capacity individuals have, the better their performance on academic tasks like problem solving and reasoning (Engle, 2002). Thus, it is important to understand how those who come to the table with more or less of this resource are impacted by the types of high-stakes situations in which math performance often occurs.

To explore this issue, Beilock and Carr (2005) asked individuals lower (Lows) and higher (Highs) in WM to perform MA problems in a low-pressure and a high-pressure test (using the same pressure scenario as above). WM was assessed via measures that capture differences in one's general ability to maintain task-relevant information in the face of less

relevant or interfering information (Turner & Engle, 1989). Not surprisingly, higher WM individuals (Highs) outperformed lower WM individuals (Lows) under low-pressure conditions. However, Highs' performance fell to the level of Lows' under pressure. Lows' performance did not suffer under pressure—even though it was not at floor levels to begin with (about 75% correct). Thus, Lows had room to drop.

Why does pressure change the high-level performance of Highs while sparing Lows? To answer this, my colleague and I (Beilock & DeCaro, 2007) examined individuals' perceptions of pressure and their problem solving strategies in low-pressure and high-pressure situations—again, using MA as a test bed. Recall that MA involves judging math equations' truth value. Although one can do this by executing WM-demanding procedures, there are shortcuts that can be employed as well. For example, if one concludes that problems with even numbers are true because dividing two even numbers is associated less often with remainders than dividing two numbers of different parity, this will produce the correct answer on some trials [$34 \equiv 18(\text{mod}4)$] but not always [$52 \equiv 16(\text{mod}8)$]. This shortcut circumvents the demands on WM, but it is not always correct.

If Highs are more likely to rely on demanding procedures (vs. shortcuts) precisely because they have the resources to successfully compute answers in this way—“if you've got it, flaunt it”—then this may be exactly what makes Highs susceptible to failure (i.e., pressure may impact the WM supporting such demanding procedures). In contrast, if Lows rely on shortcuts because they do not have the resources to successfully execute demanding computations, the pressure-induced consumption of WM should not disrupt performance.

Participants performed MA under low-pressure or high-pressure conditions and reported their problem solving strategies and perceptions of pressure during math performance. Under low-pressure conditions, Highs were more likely to use demanding subtraction and division steps to solve MA (vs. simpler shortcuts) and performed more accurately. Under high-pressure conditions, Highs used simpler (and less efficacious) shortcut strategies and their performance suffered. Lows always relied on shortcuts and were not impacted by pressure. Moreover, all individuals, regardless of WM, reported similar feeling under high levels of pressure during the high-pressure test (although see Gimmig, Huguet, Caverni, & Cury (2006), who suggest that Lows and Highs may interpret high-stress situations differently). Thus, Highs appear to be most susceptible to pressure-induced performance decrements precisely because of their reliance on the WM resources that pressure co-opts.

In sum, when individuals find themselves in a high-stakes situation in which there are monetary and social consequences associated with poor performance, these stress-laden environments can negatively impact

performance. In the next section, we turn to another type of stressful performance phenomenon, stereotype threat (ST). We review some of the recent research on this phenomenon and show that many similar mechanisms underlie performance failure in choking and ST work.

3. STEREOTYPE THREAT

The fear of confirming an existing negative stereotype about one's social, gender, or ethnic group has been referred to as stereotype threat (ST) (Steele & Aronson, 1995). However, ST is not simply a transient concern about how others will see one's performance; it can also shape the quality of task performance of individuals in the stereotyped domain. The term ST was first used by Steele and Aronson, who published a series of studies that attempted to explain the racial achievement gap between African-Americans (AA) and European-Americans (EA). Steele and Aronson reasoned that individuals are motivated to perform well; however, when AA students are called to perform an intellectual task, they must do so against the backdrop of widely held negative expectations and fears of confirming such expectations. Consequently, the researchers suggested that highlighting an existing negative stereotype (whether by direct instruction or subtle cues) can create an added burden of stress that can undermine academic performance and ironically cause students to perform in line with the negative stereotype that they are trying to avoid.

Steele and Aronson (1995) asked a group of AA and EA students to complete a difficult verbal test that was described as problem solving task that was not diagnostic of ability (non-ST condition). However, a separate group of AA and EA students were asked to complete the same difficult verbal test, but it was described as diagnostic of intellectual ability (ST condition). Contrary to societal stereotypes, AA performed equal to EA students when the verbal task was framed as nondiagnostic. But when the test was described as diagnostic of verbal ability, AA students performed significantly worse than their EA peers.

This original study enjoyed wide recognition as it demonstrated how group differences in academic performance between AA and EA could be explained, at least in part, by the performance situation itself rather than inherent differences in ability. Of course, AA are not the only minority group that is stigmatized, which is why researchers wondered whether ST could account for performance difference in other stigmatized groups as well. And indeed, ST has been shown to lead to performance deficits among Latino/a students (Gonzales, Blanton, & Williams, 2002; Schmader & Johns, 2003), women in math (Beilock, Rydell, & McConnell, 2007; Good, Aronson, & Harder, 2008; Inzlicht & Ben-Zeev, 2000; Spencer, Steele, & Quinn, 1999), French Arab students (Chateignier, Dutrevis,

Nugier, & Chekroun, 2009), and students from a lower socioeconomic background (Croizet & Claire, 1998; Desert, Preaux, Jund, 2009).

Importantly, ST should not be thought of as a phenomenon that only individuals from a minority or lower status group experience, since even individuals from a dominant group (e.g., EA males) can suffer from ST in particular contexts. For example, white males perform poorly on a math test when told that their performance will be compared with a group of Asian males (Aronson et al., 1999). Also, men perform more poorly than women at interpreting others' expressive behavior when the task is described as measuring social sensitivity, but not when the task is described as assessing complex information processing (Koenig & Eagly, 2005). This work suggests that ST can be experienced by anybody, provided that they are made aware of an existing negative stereotype about how they are expected to perform in that particular situation.

3.1. Who is most likely to fail under stereotype threat?

It is important to highlight that there are individual differences in the degree to which people are affected by ST—meaning that not all individuals within a group are destined to perform poorly. There are certain factors that have been identified as predictors of ST susceptibility. For example, individuals who strongly value success in a particular domain (e.g., domain identity) typically perform worse under ST than those who do not value the domain (Cadinu, Maass, Frigerio, Impagliazzo, & Latinotti, 2003; Keller, 2007; Levy, 1996; Leyens, Desert, Croizet, & Darcis, 2000; Spencer et al., 1999). Also, the degree to which one identifies with a particular group (e.g., gender identity, and ethnic identity) increases the likelihood that one will perform poorly when faced with a negative group stereotype about performance (Marx, Stapel, & Muller, 2005; Ployhart, Ziegert, & McFarland, 2003; Schmader, 2002). This makes sense as students with low group identity, who place very little value on a stigmatized domain, are likely to feel indifferent about stereotypes that assume how other members within their group should perform. Another major factor that predicts susceptibility to performing poorly under ST is a student's own prior awareness of negative societal expectation of success (what is referred to as stigma consciousness; Pinel, 1999). In other words, it is not merely awareness of a negative expectation of success that produces ST effects but also an activation of what one has previously known themselves (Brown & Lee, 2005; Brown & Pinel, 2003; Pinel, 1999).

3.2. Toward a mechanistic explanation

Work in our lab has primarily contributed to the ST literature by attempting to address the mechanism by which ST impairs performance. Similar

to our work on high-pressure situations, we view WM as an essential component of the relationship between stereotypes and performance.

We and others (Cadinu et al., 2003; Schmader, Johns, & Forbes, 2008) posit that ST creates a state of imbalance between one's concept of self and expectation of success that interferes with the WM resources necessary for problem solving success. However, as we have previously discussed, the precise manner by which WM is involved in performance failure depends on the type of activity being performed. We contend that ST can reduce WM availability while at the same time increase attention to performance processes and procedures best left outside WM. Similar to the performance pressure work discussed previously, disruption of WM has been most central to the investigation of poor performance in academic contexts, while enhanced attention helps explain why individuals may perform poorly in proceduralized skills that require very little WM to begin with.

Some of the earliest evidence for the role of WM in ST comes from work that directly implicates WM as an essential element in explaining performance deficits of students under stereotype in the classroom. Schmader and Johns (2003) conducted a study in which female participants were either told that they would complete a task that measures math aptitude between men and women (ST condition) or that they would complete a task for the purpose of obtaining normative data on college students (control condition). In addition, female students in the ST condition completed the study in a room with a male experimenter and two confederates, whereas students in the control condition completed the study in a room with a female experimenter and two female confederates. After receiving the study instructions, all the participants completed a vowel-counting WM test before moving on to the main math task.

As in previous experiments, performance of the women in the ST condition was significantly lower on the math test than that of the women in the control condition. Moreover, performance on the WM test mediated (or accounted for) the effects of the ST manipulation on math accuracy. These results have since been replicated in studies that employ alternative WM tasks (Inzlicht, McKay, & Aronson, 2006; Regner, et al., 2010) and those that use physiological indicators of WM (e.g., heart variability; Croizet et al., 2004).

Additional confirmation of the role of WM in ST comes from work in our own lab showing that ST harms performance for those problems that place a heavy demand on WM (Beilock et al., 2004). In another study, we reasoned that if ST creates worries that impose a demand on the phonological component of WM, then performance for problems that require verbal WM resources should be most susceptible to failure under ST. This is exactly what we have found (Beilock et al., 2007). Thus, similar to choking under pressure, ST appears to exert its impact on a variety of

academic tasks via a compromising of WM resources necessary for task performance.

3.3. The developmental approach

Given that we have focused much of our discussion thus far on the impact of negative group stereotypes on the performance of adults, one might wonder when awareness of these stereotypes comes about and the developmental trajectory of their impact. To answer this question, Ambady, Shih, Kim, and Pittinsky (2001) asked young Asian-American girls (in kindergarten through eighth grade) to complete an age-appropriate math task. However, children preceded this task by either coloring a picture of a young child eating with chopsticks (which was meant to prime their ethnic identity) or coloring a picture of a young child playing with a doll (which was meant to prime their gender identity), or coloring a picture of a landscape scene (the control condition). Since Asian-Americans generally share a positive stereotype about their performance in math, the study found that math performance was enhanced when children were given an ethnic identity prime. However, the students' performance was harmed when they were given the gender identity prime. These results are sobering as they indicate that children at a young age have already internalized negative gender stereotypes and their math performance can be impacted by being reminded of such stereotypes. These results also lead one to question where children are getting these stereotypes from.

One source that seems strongly involved in shaping children's ability beliefs and awareness of stereotypes is their parents. For example, parents tend to believe that boys have higher math ability and have greater expectations of success than they do with girls (Eccles, Jacobs, & Harold, 1990). This is also reflected in parents' perceptions that boys have to try less hard in math than girls (Yee & Eccles, 1988). This is despite the fact that gender differences in math performance tend to be nonexistent at the ages of the children for which parents were sampled in these studies.

Recently, we published a study that examined how teachers may also influence young children's gender ability beliefs and math achievement (Beilock, Gunderson, Ramirez, & Levine, 2010). This work was motivated by past research suggesting that teachers also show stereotyped beliefs. For instance, teachers believe that boys like math more than girls (Fennema, Peterson, Carpenter, & Lubinski, 1990) and that boys have greater competency in math than girls (Tiedemann, 2000a, 2000b, 2002). Since the majority of early elementary school teachers are female (>90%; National Education Association, 2003), we wondered if female teachers may be communicating their beliefs about their own insecurities in math to their students (especially to their female students).

Specifically, we speculated that female teachers' insecurities about math (as measured by math anxiety—see later in the chapter) would influence their students' math achievement by way of changing their students' gender abilities beliefs. We also hypothesized that girls should be most influenced by their teachers' insecurities since children emulate same gender behaviors and attitudes (Bussey & Bandura, 1984; Perry & Bussey, 1979). This was exactly what we found. By the end of the school year, teachers' insecurities about math were negatively associated with their girls' math achievement; however, girls gender ability beliefs accounted for (or mediated) this relationship. These effects were not found among boys. This study demonstrates two important points. First, ST and stereotypes in general have a self-perpetuating nature and hence are difficult to put to rest. Second, one way to change a child's negative stereotype may be to provide children with role models that can extinguish widely held negative expectations of success. We will return to this idea in the intervention section later in the chapter.

In the next section, we turn to another factor that impacts academic performance in math, namely, math anxiety. As you will see, there are many commonalities in the mechanisms and sources of math anxiety, ST, and choking under pressure. Such commonalities give us leverage to develop universal interventions that can be used to alleviate poor performance in whatever situation a student might encounter in school.



4. MATH ANXIETY

Thus far, we have discussed two factors that can create a contextually salient form of stress: high-stakes testing situations and reminding students of a personally relevant negative stereotype that challenges their self-concept. However, within the domain of math, some students perform poorly because of prior anxieties they bring with them to the performing table. Specifically, some students are made nervous not by the context of a testing situation as much as the *content* that makes up the test. Math anxiety describes the persistent feelings of tension, apprehension, and fear about performing math (Ashcraft & Ridley, 2005). Math anxiety is important to study, as previous research has shown that students with high math anxiety typically have lower mathematical knowledge, math grades, and perform more poorly on standardized test scores than those with low math anxiety (Ashcraft & Kirk, 2001; Ashcraft & Krause, 2007).

Math anxiety can be particularly problematic to deal with since math anxious individuals need not be put in an evaluative context (that characterizes high-pressure situations) or be reminded of negative societal expectations of failure (which defines ST) to experience stress. In fact, for math anxious individuals, simply the prospect of doing math is enough

to elicit a negative emotional response (Ashcraft & Kirk, 2001; Chipman, Krantz, & Silver, 1992; Lyons & Beilock, 2010; Suinn, 1972) that includes increased heartbeat and cortisol (Faust, 1992; Mattarella-Micke, Mateo, Kozak, Foster, & Beilock, 2011), worrisome thoughts (Richardson & Woolfolk, 1980), and an avoidance of situations that involve numerical processing (Krinzinger, Kaufmann, & Willmes, 2009). There are two general interpretations for why higher math anxiety is associated with poor math achievement. The first suggests that highly math anxious students are simply less competent in math to begin with, which leads them to experience a higher degree of stress in this domain (Fennema, 1989). From this account, math anxiety is the *result* of poor proficiency in math and not the *cause* of performance failure. This interpretation is rooted in some truth, since math anxious individuals are typically less motivated in math-related situations than non-math-anxious individuals (Ashcraft & Kirk, 2001) and math anxiety is associated with lower math competence as well as with an avoidance of math classes in general (Hembree, 1990).

However, researchers like Ashcraft and Kirk (2001) contend that math anxiety itself can cause deficits in math problem solving, which can eventually lead to poor math outcomes (Hopko, Ashcraft, Gute, Ruggiero, & Lewis, 1998). Support for this view comes from previous work (Hembree, 1990; see also Kamann & Wong, 1993) showing that counseling interventions designed to treat math anxiety itself (but do not provide math instruction or practice in mathematics) actually increase the posttreatment math achievement scores of math anxious individuals. If math anxiety were simply the by-product of poor math competence, then we would not expect math anxious students receiving anxiety-specific counseling to perform at the level of their low math anxious peers.

Also, other work by Faust, Ashcraft, and Fleck (1996) has shown that while math anxiety can impact how students perform on a timed test with difficult math problems (high-load testing condition), the negative consequences of math anxiety disappear when students are tested in an untimed paper and pencil test (a low-load testing condition). Since paper and pencil tests allow students to reduce the cognitive load associated with math problem solving, this work would suggest that math anxiety may have an online cognitive consequence, which supplements a reduced math competency interpretation of math anxiety.

4.1. A working memory interpretation

By online, we mean that math anxiety has an impact on the *execution* of math problem solving. Specifically, math problem solving situations are thought to encourage an anxiety response among math anxious individuals that disrupts the cognitive processes responsible for math problem solving—namely, WM. Some of the earliest work supporting an online account

found that students with high math anxiety took much longer to respond to arithmetic problems with a carry versus no-carry operations than those with low math anxiety (Ashcraft & Faust, 1994; Faust et al., 1996). This is significant because performing a carry operation highly depends on WM (Geary & Widaman, 1992), which led researchers to speculate that math anxiety may be disrupting processes responsible for maintaining superior performance during cognitively demanding math problems.

In a more direct test of this claim, Ashcraft and Kirk (2001) asked a group of college students to solve a series of fairly easy arithmetic problems that varied based on whether they required a carry operation (e.g., $25 + 17$) or not (e.g., $23 + 11$). Ashcraft and Kirk reasoned that if math anxiety impacts WM processing, then this should be particularly true of problems that require additional mental workload (e.g., arithmetic with a carry operation). However, to really implicate WM as the source of math anxiety failure, they asked students to concurrently solve a secondary task that taxes WM. This secondary task required students to memorize either two (low load) or six (high load) letters as they solved math problems. Their results showed that among students assigned to the two-letter load condition, those with high versus low math anxiety did not differ in amount of errors committed when trying to solve the math problems. This was true in both problems that required carry operation and those that did not. However, among students in the six-letter load condition, those with high math anxiety committed significantly more errors than those with low math anxiety, but these effects were limited to problems with a carry operation.

These results provided strong evidence that while math anxiety may be related to math avoidance in general, it also seems to influence the online execution of math problem solving. Furthermore, math anxiety does not seem to prevent efficient problem solving in all forms of math but is instead particularly detrimental to problems that rely heavily on WM resources (Ashcraft & Kirk, 2001; Faust et al., 1996).

4.2. Math anxiety development

While most studies have concentrated on examining math anxiety in late high school and college populations, there is some work demonstrating that math anxiety is present among both middle (Meece, Wigfield, & Eccles, 1990; Wigfield & Meece, 1988) and primary school students (Krinzinger et al., 2009). For example, Wigfield and Meece asked students as young as sixth grade to fill out a math anxiety questionnaire and an attitude questionnaire that assess students' expectations for success and perceived ability in math. They found that higher math anxiety was associated with reduced perceptions of ability and future expectations of success in mathematics. A similar pattern of results was found in a

different study with fourth graders whose math anxiety was shown to be negatively related to mathematics grades and academic ability in math (Chiu & Henry, 1990). Indeed, math anxiety can be *experienced* at every age during schooling (Bush, 1991; Krinzinger et al., 2009; Meece et al., 1990; Suinn, Taylor, & Edwards, 1988; Wigfield & Meece, 1988). This is because math anxiety is thought to originate early in schooling.

One issue that is less clear, however, is whether math anxiety is actually related to math achievement early in elementary school. For instance, Krinzinger et al. (2009) found that young children do indeed possess math anxiety that is negatively associated with how much they like doing math, but they did not find an association between math anxiety and calculation ability. These findings should be alarming nonetheless as levels of math anxiety do not remain stable across schooling but increase with age (Brush, 1981; Meece, 1981). Therefore, even though it is unclear whether math anxiety is associated with math achievement early in elementary school, it seems highly likely that math anxiety will eventually emerge as a source of math difficulty in a child's academic career. Moreover, as children advance in schooling, math anxiety can begin to deter students from taking advanced elective courses in mathematics that would better prepare them for a college career.

Understanding the early emergence of math anxiety is critical as early interventions may be able to deter a pattern of math avoidance and change children's attitudes toward math during an age when children's attitudes are malleable (Tobias, 1995; Townsend & Wilton, 2003). For this reason, we conducted our own investigation of math anxiety among first and second grade children (Ramirez, Gunderson, Levine, & Beilock, 2009). As with previous research, we were interested in investigating if math anxiety is related to young children's math achievement. However, we also wanted to investigate this relationship as a function of the WM, which, similar to the choking and ST phenomena, seems critical in understanding performance.

We first constructed an age appropriate measure of math anxiety (Child Math Anxiety Questionnaire (CMAQ)), which we adapted from a previously published measure for middle school children (MARS-E—Suinn et al., 1988) (see Figure 2).

We began by measuring children's math anxiety. A few days later, we returned to test children's WM using the total digit span task that is a composite of the forward and backward span tests of the *Wechsler Intelligence Scale for Children*—third edition (WISC-III) (Wechsler, 1991). We also tested children's math achievement and reading achievement using the *Woodcock-Johnson III Applied Problems Subtest* (Woodcock, McGrew, & Mather, 2001).

Replicating past work with adults (Beilock & Carr, 2005), we found that math anxiety was indeed negatively related to math achievement, but only for those children with high WM (Highs). Importantly, we

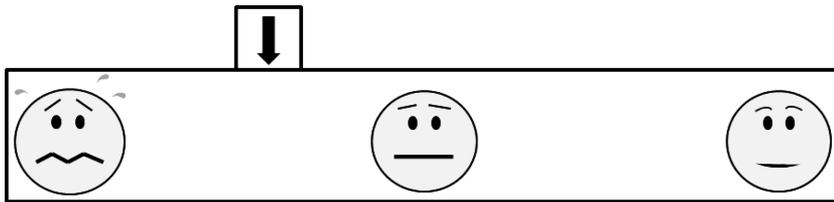


Figure 2 A representation of the smiley scale slider that was used to measure children's responses to the CMAQ (Ramírez et al., 2009).

found that our measure of math anxiety was not related to reading achievement.

One way to understand our results is to recognize that problem solving strategies are quite different among children with high versus low WM (Barrouillet & Lépine, 2005; Geary, Hoard, Byrd-Craven, & DeSoto, 2004; Imbo & Vandierendonck, 2007) and that strategies that are advantageous in nonanxious populations can backfire on anxious ones. For example, low WM children typically rely on less sophisticated strategies such as finger and verbal counting, while high WM children show a greater reliance on more sophisticated strategies such as direct retrieval (Barrouillet & Lépine, 2005). However, retrieval strategies are not consistently used until the fourth grade upward (Ashcraft, 1982; Geary et al., 2004) when children have had the experience of using the repeated algorithms that build up strong problem–answer associations in memory (Siegler & Shrager, 1984). Prior to the fourth grade, children who use a retrieval strategy are often more successful than those who do not, but they must use this strategy in the face of ongoing interference from competing answers (Barrouillet & Lépine, 2005).

Hence, it is possible that math anxiety impacts the efficacy with which high WMs (or Highs) use retrieval strategies. Math anxiety may make high WM children more prone to retrieval interference, resulting in slower, less efficient, and error-prone retrieval processes (Barrouillet & Lépine, 2005). Math anxiety may also encourage high WMs to adopt unsuccessful backup strategies for retrieval, such as guessing (Beilock & DeCaro, 2007). Of course, since we did not ask children to report their problem solving strategies, this is speculation at present. However, as mentioned above, our previous work with adults examining the impact of performance pressure on the problem solving strategies of high versus low WM students supports this interpretation (Beilock & Carr, 2005; Beilock & DeCaro, 2007).

4.3. What gives rise to math anxiety?

Having shown that math anxiety is not only present at a young age (Krinzinger et al., 2009) but is also associated with poor performance in

math (Ramirez et al., 2009), it seems imperative to examine the developmental origins of math anxiety and negative math attitudes. This is because children do not just pick up attitudes from thin air. Negative attitudes toward mathematics are likely driven by cultural and educational factors that have a long-term and consistent presence in a child's academic and emotional development (Tiedemann, 2000b; Yee & Eccles, 1988).

Take, for instance, the influence that a parent's own attitude has on their children's performance. Parental attitudes have been shown to predict student's math attitudes much better than their children's own past math achievement (Eccles, et al., 1990; Midgley, Feldlaufer, & Eccles, 1989; Simpkins, Davis-Kean, & Eccles, 2006; Yee & Eccles, 1988). While parents are a consistent influence in a child's life, teachers and the classroom environment also likely play an important role in shaping how a child approaches math. Indeed, when math anxious students are asked to speculate on the source of their math anxiety, they typically link their fear of math to a particular elementary teacher who responded angrily when he/she asked for help, seemed insensitive toward their struggle with math (Jackson & Leffingwell, 1999), or who embarrassed them in front of their peers for not being able to complete a math problem (Chapline, 1980; Chavez & Widmer, 1982; Wood, 1988). Fiore (1999) referred to this teacher response as math abuse (as cited by Brady & Bowd, 2005). It is easy to imagine why math abuse would cause students to develop math anxiety at a young age. What is not so clear is the source of such abuse and insensitivity.

One explanation is that early elementary school teachers are themselves anxious about math and that these negative feelings about math are passed onto their students (Beilock et al., 2010; Harper & Daane, 1998; Jackson & Leffingwell, 1999; Vinson, 2001; Wood, 1988). This explanation seems rational in light of the research findings suggesting that elementary education majors (who will become elementary teachers) have the highest levels of math anxiety of any college major (Hembree, 1990; Kelly & Tomhave, 1985; Nisbet, 1991; Trujillo & Hadfield, 1999; Watson, 1987). As discussed in the ST section, in a recently published study, we showed that teachers may pass on their math insecurities to their students (Beilock et al., 2010).

Of course, it is likely that there exist a variety of pedagogical methods by which teachers can transmit their math anxiety. After all, past studies have shown that math anxiety is positively related to feelings of apprehension at the prospect of teaching math (Brady & Bowd, 2005) and negatively related to teachers' perception of their ability to teach math effectively (Swars, Daane, & Giesen, 2010; Wentz, 2000). This might help explain why elementary school teachers who score high on a measure of mathematics anxiety have been found to spend less time planning mathematics lessons and use mathematics instruction time for non-mathematics-related activities more often than their less math anxious colleagues (Swetman, Munday, & Windham, 1993).

Feelings of apprehension about teaching math may also force teachers to entertain alternative answers to a lesser degree (Ball, 1990), spend less time in continued question and discussion after receiving a correct answer from a student (defined as *extended discourse*; Schleppenbach, Perry, Miller, Sims, & Fang, 2007), be more focused on expected responses and less likely to attend to student questions (Stigler, Fernandez, & Yoshida, 1996), and have high expectations of success but do little to provide motivational support (Turner et al., 2001). Avoidance strategies like those outlined above are a quite common experience among math anxious individuals (Brady & Bowd, 2005; Jackson & Leffingwell, 1999). In fact, in one case, a student reported that the teacher gave him or her a passing grade “on the condition that they refrain from taking further mathematics courses” (Brady & Bowd, 2005, p. 34). Such avoidance strategies at the hands of math anxious teachers can wreck havoc on a student’s math competency and lead students to experience stress in future situations that involve math. It is no wonder that math avoidance is a hallmark of students with math anxiety (Ashcraft & Kirk, 2001; Hembree, 1990).

Though the impact of math anxiety can be far reaching, the silver lining in the research outlined above is that it allows researchers to identify the precise ways in which teachers and others may pass on their insecurities about math to children. Such knowledge is imperative for the development of effective strategies that will help teachers, students and others stave off the negative effects of math anxiety.



5. BRINGING IT ALL TOGETHER TO ALLEVIATE SUBOPTIMAL PERFORMANCE IN THE CLASSROOM

Having outlined the mechanisms and consequences associated with poor performance in high-pressure situations, math anxiety, and ST, one big question remains: What can we do with this knowledge to thwart poor performance?

5.1. Interventions reducing the burden of high-pressure situations and math anxiety

We and others have targeted worries associated with stressful situations as one way to alleviate poor performance (DeCaro et al., 2010; Kamann & Wong, 1993; Park, Ramirez, & Beilock, 2011; Ramirez & Beilock, 2011). We reasoned that if worries about the situation and its consequences co-opt the WM needed for task performance, then interventions that serve to alleviate such worries may help boost performance.

To do this, we (Ramirez & Beilock, 2011) turned to an effective therapeutic technique in the clinical literature termed expressive writing

in which individuals are asked to repeatedly write about a traumatic or emotional experience over the course of many weeks. Expressive writing has been shown to work as a powerful technique for improving physical and psychological health (Smyth, 1998). More importantly, previous research has also shown that expressive writing can be quite effective at decreasing ruminations and increasing WM (Joormann & Tran, 2009; Klein & Boals, 2001). Hence, we reasoned that if expressive writing is an effective technique for reducing worries in a clinical domain, then giving students the opportunity to express their thoughts prior to a math exam might alleviate worries and prevent choking under pressure.

To test this, we asked students across two laboratory studies to complete a baseline math test in a low-pressure situation. After completing this initial math pretest, students were given a set of instructions designed to put them in a high-pressure environment. As mentioned earlier in the chapter (Beilock & Carr, 2005), the high-pressure scenario consisted of a monetary incentive, peer pressure, and social evaluation. Students then took another math test. However, before this second pressure-filled math test, students were asked to either expressively write, write about their previous day in an unemotional manner, or sit quietly (control group) for 10 min.

Students who were asked to expressively write were told to “write as openly as possible about their thoughts and feelings regarding the math problems they were about to perform,” while those who were asked to write about an unrelated event were told to “write about their previous day in an unemotional, factual manner.” Control students were simply told to sit quietly, while the experimenter retrieved some materials that would be used in a later portion of the experiment. After the 10-min period, we asked all the students to complete the pressure-filled math posttest.

We found that students who wrote about their previous day in an unemotional manner *or* sat quietly for 10 min “choked” under pressure—that is, their accuracy in the posttest was significantly lower than their accuracy in the pretest. However, the students who were allowed to express their thoughts and concerns actually improved their performance in the posttest relative to the pretest.

If it is indeed true that expressive writing can aid students by reducing the impact of worries on performance, then students who are most prone to worry during math exams (math anxious students) and exams in general (test anxious students) should benefit the most from expressive writing. We investigated this in a series of follow-up studies. Specifically, we invited individuals with both high and low math anxiety to complete a math test (Park, Ramirez, & Beilock, 2011). We found that among students who sat quietly for 10 min before a math exam, those with high

math anxiety performed significantly worse than students with low math anxiety. However, among students who engaged in our expressive writing manipulation for a 10-min period, those with high math anxiety performed comparable to those students with low math anxiety.

We have also taken our intervention into the school setting where, in two separate studies, we measured students test anxiety 6 weeks prior to their final biology exam (Ramirez & Beilock, 2011). Ten minutes prior to their final biology exam, we asked students to either expressively write or sit quietly. Our results showed that while test anxiety was negatively related to final exam performance among control students (who did not write), this association was not present among those who expressively wrote prior to taking their final exam. These results suggest that expressive writing can help stave off the effects of both math anxiety and general test anxiety.

Yet another way to thwart the negative impact of performance worries is to encourage students to talk out loud their problem solving procedure as they complete a difficult math exam. We (DeCaro et al., 2010) reasoned that explicitly directing WM resources toward the step-by-step execution of the math problems can prevent negative worries from disrupting the WM that is key to solving difficult math problems.

To test this, students were given a math pretest in a low-pressure practice situation. Students then completed a math posttest after being given our high-pressure scenario. Prior to the posttest, students were asked to either solve the problems quietly or say out loud their problem solving procedure. As predicted, students who were instructed to work on the problems quietly performed worse in the posttest relative to the pretest. But students who talked through the problem steps performed at the same level in the posttest as they did in the pretest.

Thus, stopping the ruminative process by means of writing or redirecting the WM to problem procedures seem to be quite effective at ensuring that stressful situations do not impact academic test performance. While some of these interventions have not been directly tested among math anxious students or those experiencing ST, given the similarities in the mechanisms of failure across these varied phenomena, we speculate that these interventions will prove useful in a variety of situations.

It is important to note that though our work specifically focused on protecting students from the harmful effects of performance-related worries, we would not advocate that these interventions are replacements for the more important task of changing the teaching practices and math anxiety of teachers and parents. This seems particularly important considering previous work that suggests that teachers can pass on their insecurities about math onto their students. Hence, reducing math anxiety at the teacher level should have a “trickle down” effect as well as positive impact on student learning.

The good news is that teachers are willing to set aside their fears regarding math to improve their knowledge and teaching practices (Trujillo & Hadfield, 1999) and there are a number of studies that suggest effective ways to treat math anxiety. Some studies have shown that interventions designed to treat the affective component of math anxiety (feelings of dread and nervous reactions) can be quite successful at reducing the math anxiety that adults experience—especially in education settings (Hendel & Davis, 1978; Hoy & Woolfolk, 1990). Variations of systematic desensitization treatments (i.e., walking patients through imagined encounters with stressors and providing patients with relaxation techniques) have also consistently been found to be effective at reducing math anxiety (Foss & Hadfield, 1993; Schneider & Nevid, 1993; Walter & Jeffrey, 1993; Zettle, 2003). Though the majority of these studies were conducted in adult populations, we speculate that these treatments could be applied toward treating math anxiety in children as well.

In addition, previous work suggests that exercises combining brief therapeutic interventions and math training may be the most effective at reducing math anxiety in teachers (Hembree, 1990). The benefits of such interventions should be particularly useful in helping math anxious teachers develop more confidence in their ability to teach math (Swars et al., 2010) which could thus change the instructional practices that make students math anxious (Battista, 1994; Chapline & Newman, 1984; Sovchik, Meconi, & Steiner, 1983; Troutman, 1978). For example, past work has shown that providing teachers with pedagogical workshops that encourage teachers to teach beyond simple algorithms and engage in extended discourse can change the attitude and problem solving approach that their own students hold toward mathematics (Simon & Schifter, 1993). Other work has shown that providing teachers with professional development centered on spatial knowledge and problem solving lessens teachers' spatial anxiety across the school year and improves their students' spatial learning (Krakowski, Ratliff, Levine, & Gomez, 2010). We speculate that these types of professional development activities are likely to work with math as well.

5.2. Interventions for reducing stereotype threat

Considering the wide interest that stereotype research has enjoyed, it should come as no surprise that a variety of recommendations for improving how students perform under ST have been put forth. Below we outline some interventions that are aimed specifically at reducing the impact of negative self-relevant stereotypes.

If highlighting an existing self-relevant stereotype is the catalyst to creating a ST environment, then eliminating the practice of reporting demographic information (e.g., personal information such as sex, racial identity, and SES) prior to a test should prevent students from dwelling on

negative expectations of success. Interestingly, this assumption has actually been tested by Danaher and Crandall (2008) who reanalyzed data collected by Stricker and Ward (2004) in which students were asked to report demographic information either before or after taking a standardized test. Using less conservative decision criteria, Danaher and Crandall were able to show that soliciting identity information at the conclusion rather than at the opening of a test reduced the difference in how men and women performed by 33%. Such a finding highlights the profound impact that existing negative stereotypes can have on high-stakes test performance.

However, for many students, such test-relevant interventions may be too late as they may enter the testing situation with a history of underperforming. It is for this reason that Cohen et al. (Cohen, Garcia, Apfel, & Master, 2006; Cohen, Garcia, Purdie-Vaughns, Apfel, & Brzustoski, 2009) were interested in finding an efficient way to increase the self-integrity of academically stigmatized students across the school year. To do this, Cohen et al. conducted two field studies where roughly half of the students were asked to affirm the values that were most important to them and write an essay that explained why these values were important to them (self-affirmation condition). The other half of students were asked to indicate their values they deemed least important to them and write an essay that expressed why those values might be important to others (control condition). This intervention was administered at the beginning of the school year and it took only 15 min to complete. The authors found that African-American students in the self-affirmation condition actually performed .3 grade points better during the semester than those in the control condition. These effects were not found among EA students.

Interestingly, these effects were also long lasting, as a follow-up study showed that the AA students assigned to the self-affirmation condition continued showing superior performance even 2 years after the initial study (Cohen et al., 2009). Since we have previously discussed how the consequences of ST are not limited to AA, it is important to point out that neither are the interventions that are meant to reduce ST. In subsequent studies using similar methodology, researchers have shown that self-affirmation exercises can reduce the gender gap in STEM disciplines as well (Miyaki et al., 2010). These results suggest that while ST may have far-reaching consequences on intellectual achievement, there exist simple strategies to reduce the psychological burden of negative societal stereotypes.

The work presented above suggests that the degree to which students are affected by ST can be reduced by moving the specific period when students report demographic information in a high-stakes exam (e.g., after the exam rather than before) and encouraging students to self-affirm their values at the beginning of the school year as a way of keeping negative societal expectations at bay. The impact of negative stereotypes can also be reduced by changing how students identify themselves.

Individuals have multiple social identities that are sometimes associated with competing expectations of success (Rydell, McConnell, & Beilock, 2009). One early study that attempted to investigate the effect of competing identities looked at Asian-American females who share a negatively stereotyped gender identity (“women”) and a positively stereotyped ethnic identity (“Asian”; Shih, Pittinsky, & Ambady, 1999). Shih et al. asked Asian-American female students to complete a math task after being asked to respond to a survey that was meant to highlight their gender identity, ethnic identity, or neither. Their results showed that while students performed poorly when their gender identity was highlighted, they performed moderately when no identity was highlighted and performed the best when their ethnic identity was highlighted. Encouraging students to look at themselves beyond their stigmatized status seems to hold promise in helping students maintain good performance. However, Shih’s study raises the question: What would happen if both identities were highlighted (as is often common in real-world academic contexts)?

We (Rydell et al., 2009) addressed this question in a study that explored whether we could deemphasize contextually threatening situations by highlighting positive identities concurrently. We found that while reminding female students of their gender before taking a math test can cause poor performance, reminding female students about their gender in combination with their status as high-achieving college students can disarm the negative consequences of ST. Indeed, other work has also shown that taking a more complex view of oneself (by creating an elaborate concept map of oneself) can encourage students to see themselves beyond stereotypes and ensure that students perform at their best (Gresky, Ten Eyck, Lord, & McIntyre, 2005).

Another route by which to influence ability beliefs and change how students perform under threat is to provide strong role models that run counter to stereotypes (Dasgupta & Asgari, 2004; McIntyre, Paulson, & Lord, 2003; McIntyre et al., 2005). For example, Marx and Roman (2002) showed that women perform just as well as men when a test is administered by a female proctor but not when a test is administered by a male proctor. Importantly, they also found that the students’ perceptions of how successful the female proctor was in mathematics impacted performance, such that female proctors had a more positive impact on women’s math performance if the students perceived these proctors to be highly competent in math.

A series of naturalistic experiments further demonstrate the power of strong role models. In one study, researchers wondered whether exposure to female professors in a math and science course might influence the STEM achievement of undergraduate women (Carrell, Page, & West, 2009). To test this, researchers tracked a group of men and women in the U.S. Air Force Academy who were randomly assigned to math and

science classes that varied only on one factor—the gender of the professor. Their results showed that professor's gender had a powerful effect on a number of outcome variables for female students, including class performance, likelihood of taking future courses in math and science, and likelihood of pursuing a degree in a STEM field (Carrell, Page & West, 2009). These results were not found among male students who, presumably, do not encounter negative societal expectations of success in math and science.

6. CONCLUSION

The way in which emotional factors combine with memory and attention processes to produce skilled performance is of fundamental importance to the understanding of human cognition. Yet, it is only recently that the interplay of emotion and cognitive control has received much attention in human performance research. Findings from this emerging area suggest that high-pressure or negative emotion-inducing situations can fundamentally alter skilled performance—preventing or inhibiting the recruitment of the appropriate cognitive resources necessary for optimal skill execution. Moreover, these types of unwanted skill failures are often most likely to occur for those with the most to lose. In terms of minorities (e.g., AA in the classroom) or underrepresented groups (e.g., women in math), for example, just being aware of a negative performance stereotype concerning how one's social group should perform can inhibit performance in stereotype-relevant skill domains.

In this chapter, we bring work together from cognitive psychology, social psychology, developmental psychology, and education in an attempt to understand the interplay of emotion and cognition in education, asking questions about how a variety of performance phenomena (from choking under pressure to ST to math anxiety) alter the cognitive processes that support performance—processes that under less emotion-inducing situations would be readily available for execution. Though the phenomena we describe in this chapter originate from different sources, they share common cognitive mechanisms by which poor performance occurs. Knowledge of how a diverse set of stressful academic situations impacts performance is imperative for designing effective performance environments that ensure that all students perform up to their potential in school.

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