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ABSTRACT

CHOKING UNDER PRESSURE: MULTIPLE ROUTES TO SKILL FAILURE

by Marci Sammons DeCaro

Choking under pressure has largely been explained by two different classes of theories. Distraction theories propose that pressure-induced failure occurs because attention needed to perform the task at hand is co-opted by task-irrelevant thoughts and worries. Explicit monitoring theories claim essentially the opposite – that pressure prompts individuals to attend closely to skill processes in a manner that disrupts execution. Although both mechanisms of choking have been shown to occur in certain contexts, it is unclear when distraction and/or explicit monitoring will ultimately impact performance. We propose that aspects of the pressure situation itself can lead to distraction and/or explicit monitoring, differentially harming skills that rely more (or less) on working memory and attentional control. Using category learning as a test bed, in three experiments we show that performance-contingent outcome pressures hurt rule-based category learning heavily dependent on attentional control. In contrast, pressure involving monitoring by others impairs information-integration category learning thought to run best without heavy demands on attentional control (Experiments 1-2). In Experiment 3, we leverage our knowledge about how specific types of pressure impact performance to design interventions to eliminate choking. Skill failure (and success) under pressure depends on the type of pressure one is under *and* the control structures of the task being performed.

CHOKING UNDER PRESSURE:
MULTIPLE ROUTES TO SKILL FAILURE

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Introduction

People often find themselves in high-stakes situations where performing their best carries implications for future opportunities and success. Whether it is a high school student taking the SAT, a golfer playing to make the cut for the PGA tour, or a violinist auditioning for an orchestra, high-level performance in important situations is crucial for advancement in most facets of life. These types of high-stakes situations are thus typically accompanied by *performance pressure*, an anxious desire to perform as well as possible in a personally-important situation (Baumeister, 1984; Hardy, Mullens, & Jones, 1996; Beilock & Carr, 2001). Unfortunately, in both real-world (e.g., Dandy, Brewer, & Tottman, 2001; Davis & Harvey, 2006; Dohmen, 2008; Forgas et al., 1980; Heaton & Sigall, 1989; Paulus et al., 1972) and laboratory situations (e.g., Beilock, 2008; Beilock & Gray, 2007), this pressure to attain performance success often causes people to perform below their actual abilities. The term *choking under pressure* describes this phenomenon. Choking is not just poor performance. Rather, it is performing more poorly than expected, given one's skill level, in situations where performance pressure is at a maximum (Beilock & Gray, 2007).

Understanding why choking occurs is important for devising training regimens to alleviate it. Yet investigations into unwanted skill failure can do a lot more. Understanding skill failure and success under pressure may shed light on the similarities and differences in the cognitive control structures underlying a diverse set of skills, ranging from math problem solving to golf putting. And by uncovering the mechanisms governing choking, we can also generate new understanding of how emotional and motivational factors combine with memory and attention processes to impact skill learning and performance.

Mechanisms of Choking

Why does poor performance sometimes occur in high-pressure situations? Two different theories have been proposed to answer this question. *Distraction theories,* originating from work in academic testing situations, propose that high-pressure situations harm performance by diverting individuals' attention to task-irrelevant thoughts, such as worries about the situation and its consequences (Beilock & Carr, 2001; Beilock, Kulp, Holt, & Carr, 2004; Lewis & Linder, 1997). Pressure essentially creates a dual-task environment in which situation-related worries compete with the attention needed to execute the task at hand.

Attention is a key component of *working memory* (Engle, 2002), a short-term memory system responsible for actively maintaining a limited amount of task-relevant information while inhibiting irrelevant information (Engle, 2002; Miyake & Shah, 1999). According to distraction theories, because high-pressure situations co-opt attentional resources, tasks that rely heavily on working memory should be most negatively impacted under pressure. This is exactly what has been found with working memory-demanding tasks such as mathematical problem solving (Beilock et al., 2004; Beilock & Carr, 2005; Beilock & DeCaro, 2007), intellectual reasoning (Gimmig, Huguit, & Pascal, 2006), and rule-governed category learning (Markman, Maddox, & Worthy, 2006). For example, Beilock, Kulp, et al. (2004) demonstrated that math problems heavily dependent on working memory (i.e., requiring the on-line maintenance and manipulation of intermediate problem steps) were solved less accurately in a high-pressure test compared to a low-pressure test. In contrast, math problems that were highly practiced and thus could be directly retrieved from long-term memory (Logan, 1988), circumventing demanding computations in working memory, were performed just as well in low- and high-pressure situations.

Although the above-mentioned work suggests that pressure induces choking by distracting attention away from skill execution, a very different class of theories has also been put forth to explain unwanted skill failure. *Explicit monitoring* or skill-focus theories suggest that pressure increases self-consciousness about performing correctly, which in turn leads performers to focus their attention on skill execution in order to ensure an optimal outcome (Beilock & Carr, 2001). Explicit attention to step-by-step processes is thought to disrupt the learning and execution of proceduralized processes that normally run outside of conscious awareness (Beilock, Bertenthal, McCoy, & Carr, 2004; Beilock & Carr, 2001; Kimble & Perlmuter, 1970; Langer & Imber, 1979; Masters, 1992).

Support for explicit monitoring theories is found primarily in high-level sensorimotor skills ranging from golf putting (Beilock & Carr, 2001; Lewis & Linder, 1997; Masters, 1992), to hockey dribbling (Jackson, Ashford, & Norsworthy, 2006), to baseball batting (Gray, 2004). For instance, Gray (2004) examined how expert baseball players batted in a baseball simulator in both low-pressure and high-pressure conditions. Gray found an increase in batting errors and movement variability under high pressure, relative to the low-pressure situation. Notably, this pressure-induced batting failure was accompanied by improvement in the players’ ability to judge the direction their bat was moving during skill execution. Specifically, when batters were asked to judge whether their bat was traveling upward or downward at the moment an intermittent tone sounded, these judgments were more accurate under pressure. These results suggest that, under pressure, the batters focused more explicitly on the components of the batting skill, disrupting proceduralized batting processes.

As can be seen, theories of choking under pressure pose very different mechanisms of skill failure. Whereas distraction theories suggest that pressure harms performance by shifting attention and working memory resources *away from* execution, explicit monitoring theories suggest that pressure shifts too much attention *towards* skill processes. How can pressure do both? One possibility could be that pressure co-opts working memory when individuals are performing demanding cognitive tasks, whereas it induces attention to skill processes during motor skill execution. But then why would high-pressure situations exert different effects depending on whether one is holding a pencil or a baseball bat in his or her hand?

We believe the answer to the above question lies in the pressure situation itself. Pressure situations may actually involve multiple components and thus exert multiple effects – leading to distracting thoughts, explicit monitoring, or even both, depending on specific elements of the stress imposed. Whether or not performance will fail, and how this failure will come about, will depend on the control structures governing the task being performed *and* aspects of the pressure situation itself. To explore this idea, it is necessary to take a closer look at real-world pressures and the laboratory situations designed to mimic them.

The Pressure Situation

Although most investigations of performance under pressure have largely ignored the make-up of the pressure situation itself, real-world pressure situations (and the laboratory pressure manipulations that imitate them) have multiple elements. Individuals might be watched by a teacher, audience, or video camera; people may try to obtain a personally-important title, scholarship, or monetary reward; or people may be out for a high test score. Even though these distinct elements of a high-pressure situation may elicit feelings of pressure and anxiety, a closer look reveals subtle differences among them.

For instance, the pressure of being watched by others – which we will refer to as *monitoring-pressure* – may increase attention to skill processes and procedures, particularly when one's performance processes are evaluated in some manner. This notion is supported by work in social psychology showing that the presence of an audience, video camera, or mirror increases self-consciousness or self-awareness (e.g., Carver & Scheier, 1978; Davis & Brock, 1975; Duval & Wicklund, 1972; Geller & Shaver, 1976). To our knowledge, some aspect of performance monitoring appears to be involved across all the pressure scenarios linked to high-level sensorimotor skill deficits in the literature. Some studies increase pressure by videotaping participants while performing a skill (e.g., Jackson et al., 2006). Others involve another person, such as a confederate participant, expert, or a larger audience, watching performance (e.g., Baumeister, 1984, Exp. 4; Forgas et al., 1980; Liao & Masters, 1992; Masters, 1992). Still others, even though nominally invoking pressure through some other means, involve an experimenter watching and measuring performance in some way (e.g., Baumeister, 1984, Exp. 6; Beilock & Carr, 2001; Gray, 2004; Lewis & Linder, 1997).

On the other hand, pressure induced by offering an incentive if a certain outcome is achieved – which we will refer to as *outcome-pressure* – may serve to shift performers' focus of attention more to worries about the situation and its consequences rather than to step-by-step control. A greater metacognitive awareness of the performance situation may lead people to simulate different outcome possibilities or think about how they are measuring up during performance (e.g., "I haven't even gotten one right so far;" Sarason, 1972, p. 411), diverting attention away from the performance process itself. For the majority of those studies supporting distraction theory, this outcome-based incentive entails a monetary reward if an individual attains a goal level of performance, usually an improvement of some percent from baseline performance (Beilock et al., 2004; Beilock & Carr, 2005; Beilock & DeCaro, 2007; Markman, et al., 2006). It is not likely necessary that the outcome of concern be monetary, however – something as simple as a seemingly important test outcome may invoke similar types of distractions. Gimmig et al. (2006) demonstrated performance decrements after telling a group of students specializing in mathematics and science that their score on a test (i.e., Raven's Progressive Matrices) measured analytic reasoning associated with overall success in math and science.

A given pressure situation may therefore differentially emphasize outcome- or monitoring-pressures: an important performance outcome may be highlighted (perhaps via incentives to achieve a certain score; e.g., Gimmig et al., 2006) or performance may be observed by others (e.g., Jackson et al., 2006). And in many high-pressure situations aspects of both outcome- and monitoring-pressures may be present (e.g., Beilock, Kulp, et al., 2004; Beilock & Carr, 2005; Beilock & DeCaro, 2007; Gray, 2004; Hardy, Mullen, & Jones, 1996), simultaneously disrupting working memory availability and directing attention in ways that are counterproductive. Thus, pressure may lead to choking in multiple ways, depending in large part on features of the performance environment itself.

We are aware of no previous research that has attempted to tease apart the pressure situation to explore whether multiple pressure elements exert systematically different effects on performance. However, a close examination of one recent study offers some preliminary support for our ideas. Markman, Maddox, and Worthy (2006) investigated performance under pressure on category learning tasks that differ in their reliance on attentional control. For *rule-based category learning* tasks, individuals must discover an easily verbalizable rule in order to categorize stimuli into two groups (e.g., all items with a particular feature belong to Category A). Doing so involves explicitly testing various hypotheses about category membership and therefore relies on working memory and executive attention – similar to many of the demanding cognitive tasks (e.g., math problem solving) explored in the choking literature to date (DeCaro, Thomas, & Beilock, 2008; Waldron & Ashby, 2001; Zeithamova & Maddox, 2006). *Information-integration category learning* tasks, on the other hand, rely on the integration of multiple stimulus dimensions at a pre-decisional stage. Categories are similarity-based, and categorization is thought to rely on procedural learning (i.e., accumulating stimulus-response associations) that occurs largely outside of attentional control. This task representation is said to be similar to that of the complex sensorimotor skills (e.g., golf putting) studied under pressure (Maddox & Ashby, 2004).

In their work, Markman et al. (2006) looked at both rule-based and information-integration category learning under pressure. Similar to other studies examining attention-demanding task performance under pressure, the authors found that rule-based category learning was worse under high-pressure compared to low-pressure conditions. However, the opposite was found for information-integration category learning – performance was actually better under high-pressure than low-pressure conditions. These findings can be readily explained with the distraction theory of choking: Pressure consumed the working memory and attention needed for hypothesis testing, which in turn harmed rule-based category learning. In contrast, information-integration category learning, relying instead on similarity-based responses elicited by the procedural learning system, benefited when attention was diverted from performance (for related work in complex sensorimotor skills, see Beilock et al., 2002).

In light of explicit monitoring theories, however, the latter findings are strikingly unexpected: Why doesn't information-integration category learning fail, via pressure-induced explicit monitoring of performance? According to our above hypothesis concerning multiple types of pressure, the answer can be found in the pressure situation itself – Markman et al. (2006) only employed an outcome-based incentive scenario. Individuals were told that, by exceeding a performance criterion, they could earn money for both themselves and a partner. There was no aspect of monitoring-pressure (e.g., social evaluation, video camera) that we propose would lead to explicit monitoring. Had monitoring-pressure been present, we anticipate that information-integration category learning would falter.

If this performance pattern was found, it would not only provide evidence for multiple routes to skill failure under pressure, but it would also suggest that the impact of pressure (i.e., distraction versus explicit monitoring) does not fall along cognitive versus motor lines per se. Rather, whether performance will suffer depends on aspects of the performance situation and the control structures (i.e., attention-demanding versus not) of the task being performed. We explore these ideas in the current work.

Current Experiments

Across three experiments, we examine whether different types of pressures exert distinct effects and, moreover, whether these pressures carry different implications for skill success and failure based on the control structure of the task being performed. We start in Experiment 1 by showing that categorization tasks similar to the ones used by Markman et al. (2006) can differentially fall prey to distraction and explicit monitoring. In Experiment 2 we examine whether outcome-pressure hurts rule-based categorization in line with distraction theories of pressure (as did Markman et al., 2006) and monitoring-pressure hurts information integration-integration categorization in accordance with explicit monitoring theories of pressure (similar to work in proceduralized sensorimotor skills). Finally, in Experiment 3 we leverage findings of the first two experiments to examine how pressure-induced performance decrements can be alleviated in both types of categorization tasks.

Experiment 1

Individuals completed both rule-based and information-integration category learning tasks in a baseline single-task condition followed by one of two types of secondary task conditions: (1) a distracting secondary task designed to divert attention away from category learning, or (2) an explicit monitoring secondary task intended to prompt attention to the step-by-step components of learning.

If rule-based category learning relies on attention and working memory in order to discover and maintain different hypotheses about category membership (Waldron & Ashby, 2001), then it should take longer to learn this type of category structure when simultaneously performing a distracting versus explicit monitoring secondary task. The opposite should occur for information-integration category learning, where optimal performance is not thought to occur via attention-demanding hypothesis testing but by processes that make little demand on attention and working memory (Maddox & Ashby, 2004). Learning this type of category structure should be unaffected by a distracting secondary task but impaired when performing an explicit monitoring secondary task. Such findings would set the stage in Experiment 2 to test whether there are systematically different types of pressures and to explore how these pressures might exert their impact.

Method

Participants

Undergraduate students (N=103) at a large U.S. Midwestern university served as participants (age: M=19.1 years, SD=2.7 years). Participants had no reported color blindness. Individuals were randomly assigned to a distracting secondary task condition (N=46) or an explicit monitoring secondary task condition (N=57).

Procedure

After giving informed consent, participants completed the category learning task individually on the computer (see below for details). Individuals were instructed to place each stimulus into either category A or category B by pressing one of two marked keys on the computer keyboard. Following each categorization selection, immediate feedback was displayed, with the words “correct” or “incorrect” appearing directly below the stimulus, until the individual pressed the spacebar to continue to the next trial. The screen then went blank for a 1500 ms inter-trial interval. Once participants reached a learning criterion of 8 correct categorization trials in a row or a 200 trial maximum, they exited that particular category structure (Waldron & Ashby, 2001). They were then given a rest period during which they were informed they would be given a new category structure. Only individuals who successfully reached this learning criterion prior to the 200 trial maximum in the single-task baseline block (see below) were included in the current work. This allowed us to examine the impact of the experimental manipulations on performance for only those individuals who demonstrated that they were able to perform these types of categorization tasks in the first place.

All participants performed the same four category structures, separated into two blocks. Within each block, individuals saw two different types of category structures – one rule-based category (R) and one information-integration category (I) (see below). Thus, four global orders were possible (i.e., RI RI, IR IR, RI IR, IR RI) and counterbalanced across participants. The specific category structure (e.g., which rule-based task came first) and the order of trials within each category structure were randomized across participants as well.

The first block served as a single-task baseline. Before the second block, participants read instructions for either the distraction or explicit monitoring secondary tasks, depending on their assigned condition. Then the second block was performed concurrently with one of the two secondary tasks. After the second block was complete, individuals completed a series of questionnaires, were thanked, and debriefed.

Category Learning Task. Stimuli were adapted from Waldron and Ashby (2001). Each was a square with one or two symbols embedded within it. Sixteen stimuli were constructed by taking the factorial combination of 4 dimensions, 2 levels each: square/background color (yellow or blue), embedded symbol shape (circle or square), symbol color (red or green), and number of embedded symbols (1 or 2). The four category structures each used all 16 stimuli but differed in the mapping from stimuli to responses.

Rule-based categories had one relevant dimension, affording an easily verbalizable rule (e.g., "If the embedded symbol is red, choose category A; if the symbol is green, choose category B"). Because previous studies (e.g., Waldron & Ashby, 2001) found no differences in performance depending on the dimension selected to be relevant, symbol color was randomly chosen as the relevant dimension for one rule-based structure and symbol shape for the other.

Information-integration categories involved 3 dimensions. One dimension was randomly selected to be irrelevant (background color for one information-integration structure and number of embedded symbols for the other). The three remaining relevant dimensions were labeled X, Y, and Z, and each binary value of these 3 dimensions was randomly assigned either a -1 or a +1 (e.g., a green symbol = -1 and a red symbol = +1). Stimuli were then categorized according to the following rule: If value(X) + value(Y) + value(Z) > 0, classify as category A, otherwise classify as category B (Waldron & Ashby, 2001). Information-integration categories generally cannot be usefully described by simple verbal rules (Ashby et al., 1998). Rather, multiple dimensional values must be integrated at a pre-decisional stage, presumably without access to conscious awareness (Ashby & Maddox, 2005).

Secondary tasks. A letter monitoring task served as the *distracting secondary task*. At the beginning of each trial, a 200 ms fixation point (a plus sign in the center of the screen) was replaced by a randomly selected alphanumeric letter appearing for 2000 ms. Individuals were instructed to press the spacebar if the displayed letter was an "S." If the letter was not an "S," they were instructed to do nothing (i.e., a go/no-go task). The letter "S" was shown more often than any other individual letter (37.5% of the time if all 200 trials were completed).

After either the spacebar was pressed or the 2000 ms time interval had passed, the word "correct" or "incorrect" replaced the letter stimulus for 1000 ms, providing immediate feedback for the secondary task. Feedback was used in order to emphasize the importance of the letter monitoring task for the participant. Following, the screen went blank for 1000 ms and the categorization trial resumed as described above. Only participants who maintained 90% accuracy on the letter monitoring task were included as participants.

A confidence judgment task served as the *explicit monitoring secondary task.* This task was intended to induce individuals to explicitly monitor the component steps of the categorization process – how they went about deciding the stimuli should go in a particular category. At the beginning of each trial, participants were shown a categorization stimulus along with a confidence rating prompt. They were asked to first think about how they were going to categorize the stimulus and then rate how confident they were in their category selection, by typing the number corresponding to their confidence rating on a scale ranging from 1 (not at all confident) to 7 (extremely confident). After selecting their confidence rating, the prompt disappeared and individuals categorized the stimulus as usual.

Questionnaires. Following the category learning task, participants rated how important they felt it was to perform at a high level during the last two sets of category learning tasks (i.e., the secondary task block), on a scale ranging from 1 (not at all important) to 7 (extremely important). We only included participants who responded at the midpoint or higher in our analyses. Because performance pressure, by definition, only occurs when individuals feel it is important to perform their best (Baumeister, 1984), reporting at least moderate task importance is often used as a criterion for study participation in experiments exploring the choking phenomenon (Beilock & Gray, 2007). Because we implement this criterion in Experiments 2 and 3 where pressure is explicitly manipulated, for consistency we implement it in Experiment 1 as well. Following, individuals completed a brief demographics questionnaire.

Results and Discussion

Of primary interest was how many categorization trials individuals performed before reaching the learning criterion of 8 correct categorization trials in a row. Trials to criterion were log transformed due to a positive skew in the distribution (Tabachnick & Fidel, 1996) common for category learning tasks (e.g., Waldron & Ashby, 2001; DeCaro et al., 2008). Because we were interested in understanding how adding a secondary task changes category learning performance, our dependent variable was a difference score created by subtracting block 1 (single-task baseline) log-transformed trials to criterion from block 2 (secondary task block) log-transformed trials to criterion. This was done separately for the rule-based and information-integration category structures in order to examine the impact of the secondary tasks on each type of category structure. Thus, higher scores on this difference measure indicate worse category learning performance (i.e., taking more trials to learn the categories) during the secondary task block compared to the single-task baseline.

These difference scores were submitted to a 2 (category structure: rule-based, information-integration) x 2 (secondary task type: distraction, explicit monitoring) ANOVA, with the last factor between subjects. There was no main effect of category structure or secondary task condition, $Fs<1$. However, a significant category structure x secondary task condition interaction obtained, $F(1,101)=4.78$, $p=.03$, $MSE=.26$.

To understand this interaction, we examined the impact of each secondary task separately. As can be seen in Figure 1, when performing the distracting secondary task, the difference in rule-based category learning from the baseline to secondary task block was significantly larger than zero ($M=.17$, $SE=.07$), $t(45)=2.21$, $p=.03$. Rule-based category learning, heavily reliant on attention and working memory for optimal performance, was worse when individuals were distracted. These results are consistent with previous research using an attention-demanding dual task during rule-based category learning (i.e., Waldron & Ashby, 2001; Zeithamova & Maddox, 2006). Simultaneously performing two attention-demanding tasks typically leads to worse performance than if either task was performed alone (Baddeley, 1999). In contrast, rule-based category learning was not impacted in the explicit monitoring secondary task condition – the difference between baseline and explicit monitoring rule-based learning blocks was essentially zero ($M=-.03$, $SE=.07$), $t(56)=-.48$. Asking individuals to think explicitly about each rule-based categorization judgment and rate their confidence in their selection did not impact performance.

In terms of information-integration category learning, the difference from the single-task baseline to the explicit monitoring secondary task block was significantly greater than zero ($M=.17$, $SE=.07$), $t(56)=2.47$, $p<.02$. Information-integration category learning was worse when individuals were asked to make confidence judgments by explicitly attending to the steps of the categorization process. Such findings are consistent with those of Maddox and colleagues (2008), who demonstrated that additional feedback that draws attention to explicit aspects of categorization can impair information-integration category learning. These results also resemble findings in complex sensorimotor skills (Wulf, 2007). Secondary tasks requiring individuals to monitor the processes of performance (e.g., attending to the hands or feet) disrupt skilled hockey (Jackson et al., 2006), soccer dribbling (Beilock et al., 2002), and baseball batting (Gray, 2004). Finally, the distracting letter monitoring task had no impact on information-integration category learning ($M=.06$, $SE=.08$), $t(45)=.78$. This is consistent with work with proceduralized sensorimotor skills as well. Performing a secondary tone monitoring task during hockey or soccer dribbling does not negatively impact well-learned skill execution (Beilock et al., 2002; Jackson et al., 2006).

In conclusion, rule-based category learning was harmed when individuals were required to perform a distracting secondary task. In contrast, information-integration category learning was harmed when individuals performed a task that prompted attention to execution. These results set the stage to test whether different high-pressure conditions elicit effects analogous to the distracting and explicit monitoring secondary tasks. In Experiment 2 we examine the effects of outcome-pressure versus monitoring-pressure on rule-based and information-integration category learning. If outcome-pressure co-opts attention and working memory, then we should find the same performance pattern as the distracting secondary task condition in Experiment 1. And to the extent that monitoring-pressure increases explicit monitoring, category learning results should parallel those seen in the explicit monitoring secondary task condition in Experiment 1.

Experiment 2

Individuals learned rule-based and information-integration categories under a low-pressure baseline condition followed by a low-pressure control condition or one of two high-pressure conditions designed to increase the personally-felt importance of a high level of performance. In the outcome-pressure condition, individuals were told that a 20% performance improvement from baseline would earn both themselves and a partner a monetary reward. In the monitoring-pressure condition, participants were watched and videotaped during the category learning task and told that the footage would be viewed by other students and researchers.

Because the high-pressure conditions always occurred after the low-pressure baseline, the control condition was employed to ensure that the rule-based and information-integration category learning tasks were free of any differential practice effects. We did not expect any differences between baseline and control condition performance. We predicted outcome-pressure would lead individuals to worry or ruminate about the consequences of their performance, distracting them from the task at hand. To the extent that attention is distracted under this pressure type, rule-based category learning should be worse than baseline, but information-integration category learning should be no different from baseline. In contrast, we expected the monitoring-pressure situation, in which individuals' online performance is watched and evaluated, to lead individuals to focus essentially on what others are watching – the step-by-step task processes they are performing. This explicit monitoring should impair information-integration category learning but have no effect on rule-based learning relative to baseline performance.

Method

Participants

Undergraduate students (N=130) at the same university as Experiment 1 participated in Experiment 2 (age in years: M=19.13, SD=1.12). Participants had no reported color blindness. Individuals were randomly assigned to a low-pressure control condition (N=47), an outcome-pressure condition (N=43), or a monitoring-pressure condition (N=40).

Procedure

The procedure was exactly the same as in Experiment 1, except the last 2 category structures (block 2) were performed under one of three types of pressure conditions rather than secondary tasks.

Low-Pressure Control Condition. After block 1 was completed, the experimenter returned to the testing room and explained to participants in the low-pressure control group that they would continue to perform a category learning task and instructed them to try to do their best. The experimenter then left the room and participants completed the last block of the category learning task.

Outcome-Pressure Condition. Participants in the outcome-pressure condition were given a high-pressure scenario before continuing to block 2. Specifically, the experimenter explained that the computer had been calculating a score based on the participant's categorization accuracy in the first block, and a 20% improvement in this score during the next sets of categories would earn the participant an additional $10 at the end of the study. The experimenter explained, however, that the study was actually about teamwork, and both the participant and a "partner" must improve their scores in order to earn the money. The partner, participants were told, had already completed the experiment and improved his or her score, leaving it up to the present participant to do well in order for both individuals to be rewarded. Of course, if their categorization accuracy did not improve, they were told, then neither the participant nor his or her partner would receive the bonus. After explaining the stakes, the experimenter left the room and the participant completed block 2. At the end of the experiment, participants were fully debriefed, including the fact that their partner was actually fictitious, and participants were given the money regardless of their performance. Only individuals who did not state outright that they thought the pressure scenario was false were included as participants.

Monitoring-Pressure Condition. Before beginning block 2, the experimenter informed participants in the monitoring-pressure condition that their performance during the next sets of categories would be videotaped, for students and professors at the university to watch how people perform this skill. In addition, participants were told that the footage may also be used in a film about the basic skills of category learning funded for nationwide distribution to researchers and psychology classes. The experimenter set up the camera about 1 m to the left of the participant, so that the participant and the computer screen were in view, and stayed behind the camera watching individuals' performance during the category learning task. When block 2 was completed, the experimenter turned off the camera and faced it away from the participant. After the experiment was completed, participants were fully debriefed concerning the purpose of the study and reassured that in fact no one would be watching the tapes of their performance.

Questionnaires. As in Experiment 1, all individuals completed a question regarding how important it was to them to perform at a high level on the last two sets of category learning tasks. Next, individuals rated how much pressure they felt to perform at a high level, ranging from 1 (very little performance pressure) to 7 (extreme performance pressure), followed by a brief demographics questionnaire.

Results and Discussion

Ratings of performance pressure were significantly higher for individuals in the outcome-pressure ($M=4.95$, $SE=.20$) and monitoring-pressure ($M=5.15$, $SE=.15$) conditions, compared to the low-pressure control group ($M=4.29$, $SE=.20$), $t(89)=2.31$, $p=.02$, and $t(86)=3.27$, $p<.01$, respectively. The outcome-pressure and monitoring-pressure groups did not differ in their pressure reports, $t(81)=.76$. Thus, both pressure conditions served to elevate feelings of performance pressure, to comparable levels, above that of the low-pressure control group.

The dependent measure was again the number of trials taken to learn the categories to the criterion of 8 correct trials in a row, log transformed. A difference score was obtained by subtracting block 1 (low-pressure baseline) trials to criterion from block 2 (high-pressure or control block) trials to criterion. This was done separately for the rule-based and information-integration category structures in order to examine the relative impact of the pressure conditions on each type of category structure. Again, higher scores indicate worse category learning performance (i.e., taking more trials to learn to criterion) during block 2 relative to the low-pressure baseline.

This difference score was examined as a function of category structure and pressure condition. A 2 (category structure: rule-based, information-integration) x 3 (pressure condition: low-pressure control, outcome-pressure, monitoring-pressure) mixed ANOVA revealed no main effects of category structure, $F<1$, or pressure condition, $F<1$. However, a significant category structure x pressure condition interaction was found, $F(2,127)=4.75$, $p=.01$, $MSE=.21$.

As shown in Figure 2, the low-pressure control condition did not alter either rule-based ($M=.04$, $SE=.05$), $t(46)=1.14$, ns, or information-integration ($M=.03$, $SE=.08$), $t(27)=.51$, category learning in block 2 – the difference scores were essentially zero. However, the difference score for rule-based category learning was significantly greater than zero during outcome-pressure ($M=.16$, $SE=.06$), $t(42)=2.93$, $p<.01$, but not during monitoring-pressure ($M=.03$, $SE=.06$), $t(39)=.40$. Outcome pressure was created by informing individuals that a monetary reward, for both themselves and another person, was contingent on their performance. Given that rule-based category learning only suffered in this pressure condition, and that in Experiment 1 only a distracting secondary task hurt rule-based category learning, these findings suggest that attention was diverted during the outcome-pressure condition. This result is consistent with the distraction theory of choking under pressure.

The opposite pattern was found for information-integration category learning, which was unaffected by outcome-pressure ($M=-.11$, $SE=.08$), $t(42)=-1.20$, $p=.24$, but was significantly worse during monitoring-pressure ($M=.19$, $SE=.08$), $t(39)=2.51$, $p<.02$. In the monitoring-pressure condition, individuals were watched by an experimenter who videotaped their performance, nominally so that others could watch how people learn new categories. Information-integration category learning was only hurt by this type of pressure, and the findings were analogous to those of the explicit monitoring secondary task condition in Experiment 1. These findings are consistent with the explicit monitoring theory of choking under pressure. It appears that, under the watchful eye of others, individuals focus more explicitly on the steps of the skill being performed. This skill monitoring disrupts performance that operates best outside of explicit attentional control.

As can be seen, different types of tasks failed – and thrived – under different types of pressure situations. These findings underscore the idea that high-pressure situations can be composed of various elements that impact attentional control in multiple ways. Revealing predictable relationships between pressure types and performance, based on theories of attentional control, not only allows us to integrate disparate theories of choking, but it also enables us to develop systematic ways to aid performance under pressure. We did so in Experiment 3 by combining the secondary task and pressure conditions used in Experiments 1 and 2.

Experiment 3

In Experiment 3, we set up those pressure situations that had proven detrimental in Experiment 2: Rule-based category learning was performed under outcome-pressure, and information-integration category learning was performed under monitoring-pressure. During these pressure conditions, individuals also performed distracting and explicit monitoring secondary tasks, in separate learning blocks. If both outcome-pressure and a distracting secondary task serve to divert attention from performance, then rule-based category learning should be impaired when both of these conditions are combined. But if an explicit monitoring secondary task prompts people to attend closely to the steps of rule-based categorization, then the negative impact of outcome-pressure (e.g., distractions) may be counteracted. On the other hand, if both monitoring-pressure and an explicit monitoring secondary task act to enhance attention towards a task, then information-integration category learning should be harmed when these conditions occur simultaneously. But a distracting secondary task, continually diverting attention away from task processes, may keep monitoring-pressure from taking its toll on information-integration categorization.

Method

Participants

Undergraduate students (N=37) at the same university as Experiments 1 and 2 served as participants (age in years: M=18.97, SD=.73). Participants had no reported color blindness. Individuals were randomly assigned to either the outcome-pressure/rule-based category learning condition (N=15) or the monitoring-pressure/information-integration category learning condition (N=22).

Procedure

Participants were introduced to the same category learning task as in Experiments 1 and 2, with a few exceptions. In the current experiment, each participant completed either three rule-based or three information-integration category structures. Recall that the stimuli consisted of four total dimensions: symbol color, symbol shape, background color, and number of embedded symbols. For each rule-based structure, the salient dimension for each set in Experiment 3 was randomly determined, without replacement, from these four possibilities. For each information-integration structure, the irrelevant dimension was randomly selected from the four total dimensions.

Participants first completed a low-pressure, single-task baseline block, followed by two high-pressure blocks. The two high-pressure conditions were exactly the same as in Experiment 2. In the outcome-pressure condition, participants were informed by the experimenter that they could earn $10 for themselves and a partner if they improved their categorization accuracy by 20%. Participants in the monitoring-pressure condition were monitored by the experimenter, who stood behind a video camera under the auspices that the film could be watched by students and professors at their university and across the country. Each block performed under high pressure was also performed concurrently with one of the two secondary tasks used in Experiment 1: a distracting and an explicit monitoring secondary task, in counterbalanced order. As in Experiment 1, the distracting task was a letter monitoring task, in which participants viewed a letter between every categorization trial and pressed the spacebar on the computer keyboard if the letter was an "S." The explicit monitoring task was a confidence rating task, in which individuals were asked to rate how confident they were that the category they were about to select was correct on a 7-point scale ranging from 1 (not at all confident) to 7 (very confident).

Following the categorization task, participants were given the same importance, pressure, and demographics questionnaires as in Experiment 2. Following, they were thanked and debriefed.

Results and Discussion

As in Experiment 2, participants rated their feelings of performance pressure as equivalent between the two high-pressure groups: outcome-pressure ($M=5.07$, $SE=.41$), monitoring-pressure ($M=4.96$, $SE=.31$), $F<1$.

The number of trials taken to learn rule-based and information-integration categories to criterion (8 correct in a row) was measured for each block, log transformed, and difference scores were computed by subtracting each high-pressure block score from the low-pressure block baseline. These scores were examined in a 2 (category structure/pressure condition: rule-based/outcome-pressure, information-integration/monitoring-pressure) x 2 (secondary task condition: distraction, explicit monitoring) mixed ANOVA, with secondary task condition within-subjects. This analysis revealed no main effects for category structure/pressure condition, $F<1$, or secondary task condition, $F<1$. But a category structure/pressure condition x secondary task condition interaction was found, $F(1,35)=7.22$, $p=.01$, $MSE=.09$.

As shown in Figure 3, rule-based categories were learned more slowly during a combination of outcome-based pressure and distracting secondary task conditions, relative to a low-pressure, single-task baseline – the difference score was significantly greater than zero ($M=.22$, $SE=.12$), $t(14)=2.35$, $p<.04$. Similarly, information-integration category learning was slowed during simultaneous monitoring-pressure and explicit monitoring secondary tasks relative to baseline performance ($M=.24$, $SE=.09$), $t(21)=2.20$, $p<.04$. These results are consistent with those of Experiment 1, in which we tested the effects of these secondary tasks, and Experiment 2, in which we examined these pressure types. Moreover, they corroborate the distracting and explicit monitoring natures of the outcome-pressure and monitoring-pressure conditions, respectively.

However, when rule-based category learning was performed with an explicit monitoring secondary task under outcome-pressure, it was no longer significantly impacted ($M=.10$, $SE=.11$), $t(14)=1.24$, ns. Instructing individuals to think about how they were going to categorize each stimulus appears to lead them to refocus their attention towards the processes of rule-based category learning, counteracting the distractions that arise from outcome-based pressure. Information-integration category learning, under monitoring-pressure, was similarly unimpaired when coupled with a distracting secondary task designed to redirect the focus of attention away from the online steps of performance ($M=-.01$, $SE=.10$), $t(21)=-.09$, ns. These findings enable us to further dissociate the attentional mechanisms at play in these secondary task and pressure types by demonstrating their opposing effects. Crossing situations that distract with those that enhance attention towards a skill seems to counteract the negative impact that would otherwise occur.

The latter findings offer promise for interventions aimed to alleviate performance pressure. When a performance situation tends to distract a performer from an attention-demanding task, perhaps a method to redirect attention back to the steps of performance will help. We see an example of this in a recent study by DeCaro, Rotar, Kendra, and Beilock (2008), in which individuals performed mental arithmetic under pressure. One group of participants was asked to talk out loud while solving the problems, with the intention that doing so would help them focus their attention onto the task steps. Another group solved problems under pressure as they normally would, without talking aloud. Those who talked themselves through the problem steps under pressure performed significantly better than those who did not. Moreover, their performance equaled that of individuals in low-pressure conditions. Articulating the problem steps aloud appears to enable one to redirect attention and working memory resources to the task rather than the outcome at stake.

On the other hand, when a performance situation leads individuals to focus explicitly on the component processes of a proceduralized skill, an intervention designed to mildly distract performers may prove beneficial. In accordance with our findings, Jackson and colleagues (2006) demonstrated that skilled field hockey players dribbled a ball more quickly and accurately during a high-pressure condition when also randomly generating a letter from the alphabet at the sound of an intermittent tone. Without this distraction, dribbling performance suffered under pressure. Perhaps by performing any of a number of similarly distracting tasks, a performer can successfully keep from over-thinking a skill when the stakes are high (Beilock & Carr, 2001; see also Lewis & Linder, 1997; Mullen & Hardy, 2000).

General Discussion

Pressure-induced performance decrements occur across a variety of skill domains under a diverse set of situations. However, not everyone fails under what might typically be considered a high-pressure situation. In the current work we examined when and for what reasons people might fail versus succeed under pressure. By examining tasks that differ in their reliance on attentional control under two different types of high-pressure situations, we found evidence that pressure can impair performance in multiple ways.

Pressure to attain a particular performance-based outcome harmed a skill that relies on working memory and attention, but not one that is less dependent on executive control. These findings suggest that outcome-pressure co-opts attention and working memory resources, perhaps with distracting worries or ruminations about performance and the outcome. Thus, the distraction mechanism of choking under pressure may be most likely to occur when attention-demanding tasks are performed under an attention-consuming pressure type, such as one that emphasizes an important score, grade, or monetary reward.

When a pressure situation involved performance monitoring (e.g., by another person and a video camera), a skill that operates best outside of explicit attentional control was disrupted. But a skill that benefits from explicit attention to performance steps was relatively unaffected. It appears that, when the pressure situation involves online evaluation of performance, individuals attend to their step-by-step skill execution, perhaps as they expect others are also doing. Thus, explicit monitoring theories of choking under pressure are also supported by our findings – under the pressure of being watched and evaluated by others, skills that optimally operate outside of close attentional control (e.g., procedural skills) suffer from a performer's enhanced attention to performance processes.

Given these findings, it appears that *both* distraction and explicit monitoring theories of choking under pressure are correct, and whether attention will be diverted from and/or enhanced towards the task stems in large part from characteristics of the pressure situation one is facing. Whether these pressure situations will then disrupt performance depends on the executive control structures required for the type of task being performed. Our findings offer an important step towards reconciling these seemingly disparate theories of choking. With the multiple mechanisms of performance failure more clearly delineated, we may not only better understand when and how choking under pressure may occur, but we may also better design interventions to alleviate the negative effects of pressure (Baumeister & Showers, 1986).

In Experiment 3 we revealed one way to mitigate the negative impact of pressure, by setting up secondary tasks that counteract pressure's harmful impact on attentional control. We asked individuals under outcome-pressure to complete rule-based category learning concurrently with a secondary task involving explicit monitoring. Whereas outcome-pressure seems to divert attention and working memory away from performance, frequently prompting people to think explicitly about the processes they are using to perform the skill inoculated them against the ill effects of stress. The opposite intervention helped in a monitoring-pressure situation. Mildly distracting people during performance made information-integration category learning immune to pressure's negative effects. This type of distraction may have kept individuals from over-thinking a skill that operates best outside of explicit control.

It should be noted that we recently showed that the information-integration category learning task used in the current study can be successfully approached by using a proceduralized learning strategy, but also, under certain conditions, by using a simple rule (DeCaro et al., 2009; Tharp & Pickering, 2009). Regardless of whether or not the current information-integration category learning task is ultimately completed via a procedural learning mechanism or a simpler rule-based strategy however, a less attention-demanding approach is still better for ultimate learning in our task. Our findings across the three experiments presented here provide support for this idea given that the information-integration task was not impacted by attention-demanding secondary tasks or outcome-pressure situations, but was adversely impacted by situations that prompted attention to execution. This makes our information-integration category learning task a nice contrast to our rule-based task. Together, these category learning structures provide an appropriate test bed for examining the multiple effects of pressure.

Classifying Performance Situations

The current work demonstrates that the performance environment can influence how a skill is performed. Moreover, by better understanding when distraction and/or explicit monitoring may come about under stress, we are in a better situation to link performance under pressure to other high-stress situations where performance may go awry.

Multifaceted High-Pressure Situations. The two high-pressure situations studied in the current work were designed to isolate pressures concerning a performance outcome versus process, and had dissociable effects on performance. However, high-pressure situations can be composed of many elements, such as when an athlete vies for an important title (and possible monetary award) in front of a large audience. Indeed, participants across several studies have performed under the simultaneous pressures of earning a monetary reward for themselves and a partner while being watched by an experimenter. Under this combined pressure situation, participants both perform more poorly on attention-demanding math skills (Beilock, Kulp, et al., 2004; Beilock & Carr, 2005; Beilock & DeCaro, 2007) and perform worse at proceduralized golf putting and baseball batting skills (Beilock & Carr, 2001; Gray, 2004). If we are correct in attributing a distraction mechanism to outcome-based pressure but an explicit monitoring mechanism to the pressure of being watched and evaluated, then why do we see evidence for both effects when the two pressures occur simultaneously?

One possibility is that both types of pressure are actually impacting performance at the same time. For example, working memory capacity could be reduced in these situations, but what attention is still available may be explicitly devoted to step-by-step control. Thus, attention-demanding skills (e.g., difficult math problem solving) would suffer from the reduction in working memory capacity, whereas proceduralized skills (e.g., well-learned sensorimotor skills) would be impaired by the increase in explicit monitoring. Another possibility is that people are most affected by the aspect of the pressure situation that is most salient to them. If an individual is most concerned about earning high marks, for example, then he or she may suffer more from distraction than explicit monitoring, even if someone is watching. Although the current work has dissociated aspects of the pressure situation that differentially impact attentional control, whether, and how, these attentional mechanisms interact in multifaceted pressure situations remains an important empirical question.

Stereotype Threat. As with the high-pressure situations investigated in the current work, other situations in which a personally-important ability in a domain is questioned, such as conditions of stereotype threat, also often lead to performance decrements (Steele, 1997). Introducing a negative stereotype about one's social group impairs performance across a variety of domains, including proceduralized skills (e.g., Beilock et al., 2006; Chalabaev et al., 2008) and attention-demanding tasks (e.g., Beilock et al., 2007; Schmader & Johns, 2003). There is evidence for both distraction and explicit monitoring mechanisms of skill failure under stereotype threat, yet the literature is inconclusive regarding when each will impact performance (see Schmader, Johns, & Forbes, 2008; Steele, Spencer, & Aronson, 2002, for a review).

Drawing from the current findings, one might speculate that aspects of the stereotype threat situation may influence whether attention will be diverted from and/or enhanced towards skill performance. Stereotype threat is typically brought about in the laboratory by highlighting the diagnosticity of a test regarding one's aptitude in a domain or intelligence in general (Steele et al., 2002). On some occasions, performance is also measured and watched by another person (e.g., Beilock et al., 2006; Chalabaev et al., 2008). The emphasis on a performance outcome may lead attention and working memory to be disrupted during performance, whereas explicit monitoring may play a bigger role when a stereotype is made salient and then monitored by others. Thus, as in the current work, the mechanisms of skill failure in stereotype threat situations may also depend on aspects of the performance situation itself, in addition to the type of task being performed. Viewing stereotype threat in terms of the situational impact on attentional control may offer new insight into how (and when) stereotype threat will impact attentional control, but it may also reveal new interventions for counteracting this impact in threat-situations (e.g., setting up secondary tasks to optimally refocus attention).

Test Anxiety. Related work on test anxiety has suggested, like distraction theories of choking under pressure, that performance anxiety interferes with working memory processes critical for successful test performance (e.g., Ashcraft, 2002; Ashcraft & Kirk, 2001; Eysenck & Calvo, 1992; Hayes, Hirsch, & Mathews, 2008; Rapee, 1993; Wine, 1971). Test-anxious individuals have more worries and intrusive thoughts, particularly in situations with important contingencies, such as reward, test, or ego-involving situations (e.g., "This is an intelligence test"; Eysenck & Calvo, 1992, p. 421; Ikeda, Iwanaga, & Seiwa, 1996). The precise nature of these distractions is typically thought to be of worry over evaluation, self pre-occupation, and concern over the level of performance relative to that required (Eysenck & Calvo, 1992; Sarason, 1972). Such self-imposed pressure is much like the outcome-pressure in the current work – test-anxious individuals become distracted by the potential outcomes of performance, and are most negatively impacted on tests relying heavily on attention and working memory (e.g., inductive reasoning; Calvo, 1985). This body of literature can thus be easily connected with the present work, adding the idea that certain individual differences (i.e., test anxiety) may lead some individuals to be more sensitive to performance-based outcomes than others.

Social Facilitation-Inhibition. We have demonstrated with our monitoring-pressure condition that surveillance by an experimenter and a video camera (nominally to be viewed also by experts and peers), harms performance that operates best outside of attentional control, but not performance that relies on attention and working memory. A long line of literature on social facilitation-inhibition also speaks to the impact other individuals can have on performance (Blascovich et al., 1999; see Bond & Titus, 1983, for a review). Although this literature is probably best known for the improvement in performance seen when other individuals are present in a performance situation, a great deal of data also shows a decline in performance due to the presence of others. Several theories have been proposed to explain this phenomenon, in many ways paralleling the distraction versus explicit monitoring theory debate within the pressure literature (Baumeister & Showers, 1986). Although we demonstrate that monitoring pressure leads to explicit monitoring, it seems evident in the social facilitation-inhibition literature that attention can also be distracted due to others' presence. Future research may examine whether and how moderators discussed in the social facilitation-inhibition literature (e.g., evaluation potential, status of the observer) might elicit attention towards performance outcomes and/or the online processes of performance (Martens & Landers, 1972), and the impact of this attention mechanism on the type of task performed.

Regulatory Focus. Other work has linked the pressure and regulatory focus literatures, suggesting that individuals in high-pressure situations become sensitive to the potential for losses in the environment (i.e., prevention focus), as opposed to being in low-pressure situations where people are simply compensated for participating in the research study (i.e., promotion focus). Worthy, Markman, and Maddox (in press) posited that this regulatory focus would interact with the rewards structure of the task, where a gains rewards structure entails accumulating points for correct responses, and a losses rewards structure involves losing fewer points for correct compared to incorrect responses.

Worthy et al. (in press) found that rule-based category learning was best in regulatory fit conditions (i.e., high-pressure with a losses reward structure, low-pressure with a gains reward structure) and worse in regulatory mismatch conditions (i.e., high-pressure with a gains rewards structure, low-pressure with a losses reward structure). Information-integration category learning showed the opposite pattern (i.e., worse performance in fit than mismatch conditions). Worthy et al. suggest that regulatory fit may lead to “feeling right,” which increases confidence in performance, whereas regulatory mismatch decreases such confidence, potentially leading to anxiety that reduces working memory resources.

Worthy et al.’s (in press) findings coincide with some aspects of the current work, namely by showing that pressure can lead to failure or success with different types of tasks due to the availability of attentional resources during performance. Specifically, using Worthy et al.’s framework, one might presume that our outcome-pressure condition (the same pressure manipulation as Worthy et al.) induced a prevention-focus, interacting with our “gains” reward structure to invoke a regulatory mismatch. This regulatory mismatch co-opts attentional resources, consistent with the distraction theory of choking under pressure. However, our monitoring-pressure condition led to the opposite effect – increasing attention towards task performance.

Although Worthy et al. suggest that all high-pressure conditions lead to a prevention-focus, one way to reconcile these findings with Worthy et al.’s may be to conceptualize monitoring-pressure as leading to promotion-focus instead. Admittedly, the above classification seems a bit arbitrary, as someone given monitoring-pressure condition could just as easily wish to avoid a negative evaluation as they could desire to earn high regard by those watching. Similarly, outcome-pressure could prompt individuals to either attend to the potential monetary and social gains or to the potential losses. Notably, the stereotype threat literature is also inconsistent regarding whether stereotype threat leads to promotion- or prevention-focus (e.g., Chalabaev et al., 2008; Grimm et al., 2008; Keller & Dauenheimer, 2003; Seibt & Förster, 2004). Nonetheless, if prevention-focus is more likely to come about in situations that highlight a performance-contingent outcome, whereas monitoring-pressure is more likely to elicit promotion-focus, then the findings of the current experiments fit nicely with the work on regulatory fit under stress, adding the idea that explicit monitoring may occur in regulatory fit conditions whereas distraction may occur in regulatory mismatch situations.

As can be seen, research across several domains (e.g., stereotype threat, test anxiety, social facilitation, and regulatory focus) is consistent with the present findings. However, by focusing on underlying attentional mechanisms, we might cut across such domains to provide a more overarching theory of when performance will fail versus succeed under stressful situations. By denoting certain aspects of the pressure environment that may lead individuals to focus on the process of performance versus the outcome of performance, and the impact of such situational aspects on the attentional system, we may not only better predict when performance will fail but also provide interventions to help mitigate the possibility of choking. Such work thus has potential for training and education across such disparate domains as academic testing, high-pressure occupations, and competitive athletics.

Conclusion

The current work demonstrates that attention can be diverted and/or enhanced due to such factors as whether a personally-important performance-based incentive is at stake, or whether performance is evaluated or monitored by other people. Moreover, such changes in attentional control have implications for skills that rely more or less on this important cognitive resource. Thus, this work allows us to better understand choking and excelling under pressure across a wide variety of domains, from the student taking a math test to the expert on the playing field. Research in cognition has historically been content to cast aside the roles of motivation and emotion on performance—this work joins a recent body of literature seeking integrate these largely separate research domains (e.g., Beilock, 2008; J. Gray, 2004; Gray, Braver, & Raichle, 2002; Grimm et al., 2008).

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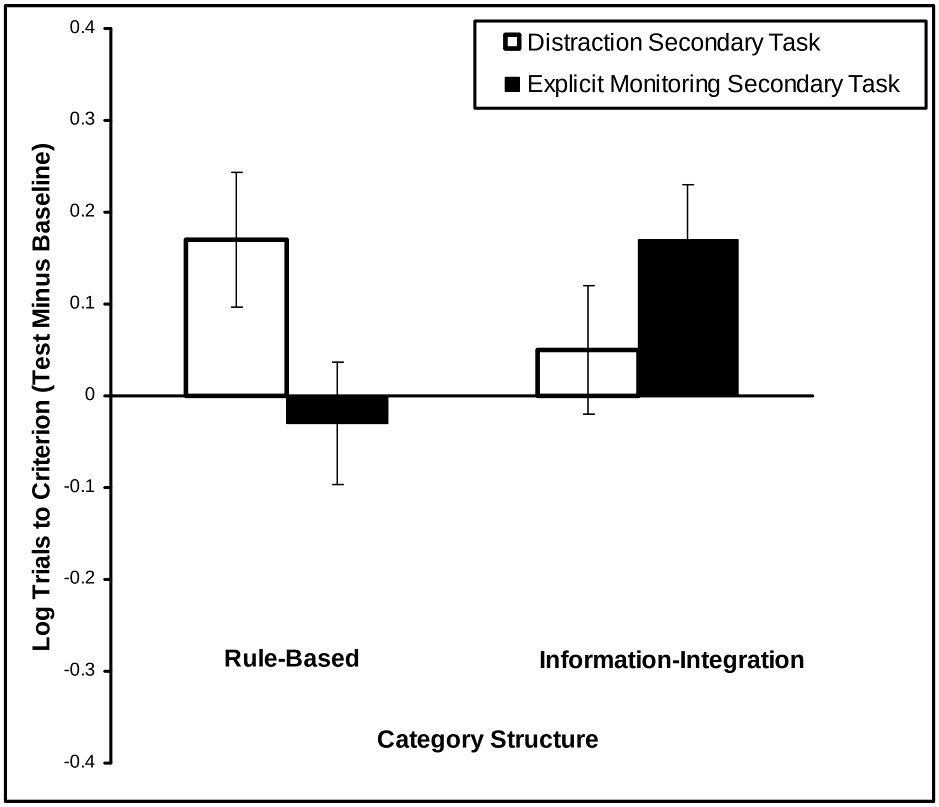
Figure Captions

Figure 1. Mean trials to criterion (log transformed) difference (test minus baseline) as a function of category structure and secondary task type. Error bars represent standard errors.

Figure 2. Mean trials to criterion (log transformed) difference (test minus baseline) as a function of category structure and pressure type. Error bars represent standard errors.

Figure 3. Mean trials to criterion (log transformed) difference (test minus baseline) as a function of secondary task type and category structure/pressure type (rule-based tasks were performed under outcome-pressure; information-integration tasks were performed under monitoring-pressure). Error bars represent standard errors.

Figure 1


Distraction Secondary Task
Explicit Monitoring Secondary Task
Log Trials to Criterion (Test Minus Baseline)
0.4
0.3
0.2
0.1
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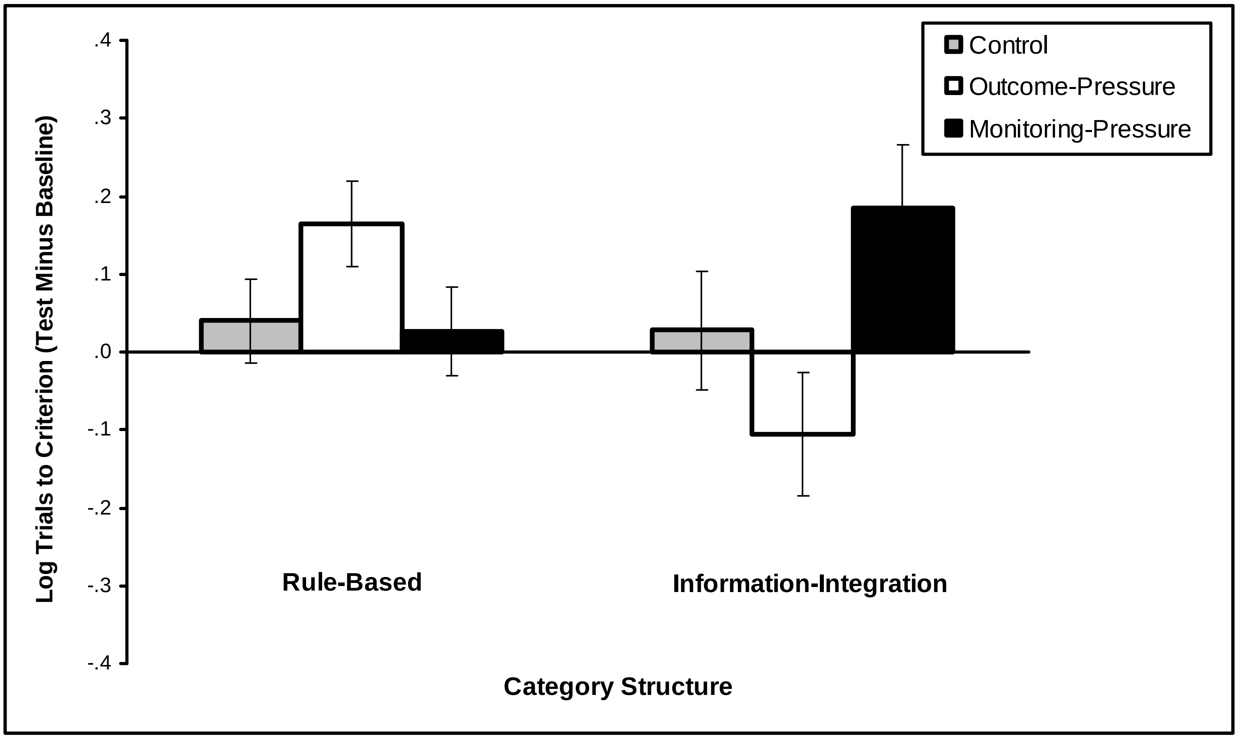
-0.1
-0.2
-0.3
-0.4
Rule-Based
Information-Integration
Category Structure

Figure 2



Control
Outcome-Pressure
Monitoring-Pressure
Log Trials to Criterion (Test Minus Baseline)
.4
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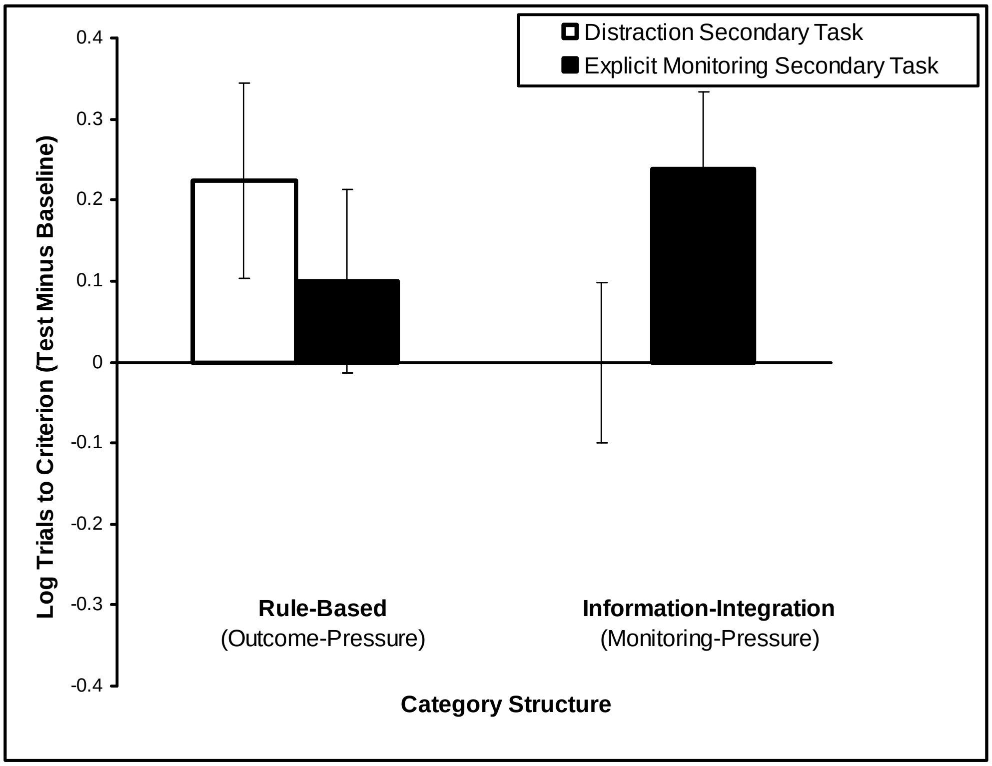
.1
.0
-.1
-.2
-.3
-.4
Rule-Based
Information-Integration
Category Structure

Figure 3


Distraction Secondary Task
Explicit Monitoring Secondary Task
Log Trials to Criterion (Test Minus Baseline)
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
Rule-Based
(Outcome-Pressure)
Information-Integration
(Monitoring-Pressure)
Category Structure