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CHAPTER 19

Why Do Athletes Choke under Pressure?

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Picture it: A PGA (Professional Golfers' Association) tour player is on the final hole of a major tournament. All he needs to do to win the tournament is sink a simple 5-foot putt on a flat, straight green. This is a putt he has sunk so many times in practice he has lost count. This is a putt he knows, he understands, he can execute without a second thought. But, on this day, on this putt, there are other thoughts. He notices the crowd, the leader board, and thinks about how many people are counting on him to make the shot and win the tournament. He thinks about all those individuals, including himself, who expect him to finish at the top. Thus, this putt is not exactly the same as all of the simple 5-foot putts he has taken in practice. And when he steps up to the ball, performs his preshot routine, and executes his shot it becomes apparent how different this pressure-filled putt actually is. Our golfer does the unthinkable, the unexpected, and the unwarranted given his ability: He misses the putt, he loses the tournament, he *chokes under the pressure*.

We have all heard the term "choking" before. In the sports arena, we talk about the "bricks" in basketball, when the game-winning free throw manifests itself as an air ball, or we speak of the "yips" in golf, when an easy putt to win the tournament stops short. In more academic domains, we refer to "cracking" in important test-taking situations, when a test score much lower than expected results in a failing course grade or prevents the all-important college admission. But what exactly do these terms mean, and, more important, why do less-than-optimal performances

occur—especially when the incentives to perform at one's best are at a maximum?

In this chapter, we describe the research to date conducted on the phenomenon of choking under pressure. We begin by defining what we mean by "choking under pressure." We also highlight the circumstances under which choking is most likely to occur. Subsequent sections detail how the choking phenomenon is studied and the mechanisms believed to govern performance failure under pressure. Once we have established what choking is and why it occurs, we examine individual difference variables that may serve to exacerbate the choking phenomenon (e.g., self-consciousness, trait anxiety). Finally, we highlight research attempting to alleviate choking and present future directions for this exciting line of work. Choking under pressure has received a lot of attention in recent years—attention from researchers, practitioners, coaches, and players themselves. It is our hope that this chapter will serve as both a review of the choking work that exists and a catalyst for what is yet to come.

CHOKING UNDER PRESSURE: WHAT IT IS AND WHAT IT IS NOT

The desire to perform as well as possible in situations with a high degree of personally felt importance is thought to create *performance pressure* (Baumeister, 1984; Hardy, Mullen, & Jones, 1996). Paradoxically, 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. Choking is defined as performing more poorly than expected given one's skill level and is thought to

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occur across many diverse task domains where incentives for optimal performance are at a maximum (Beilock & Carr, 2001; Lewis & Linder, 1997; Masters, 1992).

Choking under pressure is not just poor performance. Rather, choking is suboptimal performance—worse performance than expected given what a performer is capable of doing and what this performer has achieved in the past. This less-than-optimal performance does not reflect a random fluctuation in skill level (we all have performance ups and downs), but rather occurs in response to a high-pressure situation. Inherent in this definition is the notion that choking is a relatively discrete performance state. By this we mean that choking has a noticeable beginning and end that corresponds to what the performer interprets as a high-pressure situation. A baseball player in a slump may be performing poorly and at a lower level than what he has demonstrated he can accomplish in the past, but to the extent that this prolonged period of poor performance does not have a high-pressure situation as a catalyst, we would not consider this to be an example of choking.

In particular, extended periods of below-average performance (relative to one's usual performance level) are thought to constitute performance slumps (Grove, 2004). The main difference between performance slumps and choking is that the latter is initiated by perceived feelings of performance pressure, and the suboptimal performance that results in response to pressure is attenuated when the source of this pressure subsides. A slump, on the other hand, is characterized by an inability (in most cases) to pinpoint a specific cause of extended poor performance (Grove, 2004; Prapavassis, Grove, Maddison, & Zillmann, 2003).

This does not mean that the cognitive mechanisms responsible for a performance slump (e.g., a baseball infielder who made only 10 fielding errors all of last season but has made 8 errors in the past month) and an instance of choking (e.g., an infielder who feels a high degree of pressure and muffs an easy play that allows the winning run to score) are not similar; rather, this just sets limits on what we define as choking and what we explore in this chapter. Nonetheless, to the extent that similar cognitive mechanisms may govern different types of performance failures, an exploration of the choking-under-pressure phenomenon can open a new window into the processes responsible for less-than-optimal execution, whether pressure-induced or not.

Choking is thus poor performance in response to what an individual perceives as an important and stress-filled situation. Here we define choking behaviorally in terms of performance outcomes. This does not mean that pressure

cannot manifest itself physiologically in terms of heightened levels of arousal or drive (Spence & Spence, 1966), or cognitively in terms of heightened levels of worry or anxiety (Beilock, Kulp, Holt, & Carr, 2004; Wine, 1971). Physiological arousal and anxiety may accompany choking, and dispositional trait anxiety may make an individual more prone to performance failure under pressure (see "Individual Differences" section). However, we believe that heightened levels of perceived pressure accompanied by a suboptimal performance level are necessary and sufficient criteria to classify the performance as an example of choking under pressure. This definition of performance failure (a) makes it easier to diagnose choking (as one must demonstrate only a link between perceived pressure and performance, rather than additional links with anxiety, physiological arousal, and worry); (b) provides a parsimonious definition that can be applied quite easily to a variety of situations; (c) gets around problems associated with the known difficulty of introspecting on one's level of anxiety (Nisbett & Wilson, 1977) and inherent variability associated with physiological measurements of arousal (Baumeister & Showers, 1986); and (d) is as limited as possible in terms of the assumptions it makes regarding the cognitive or physiological criteria necessary to classify an instance of performance as an example of choking. This last point is extremely important, as there should not be theoretical assumptions about the correlates of choking inherent in its definition.

HOW IS CHOKING UNDER PRESSURE STUDIED?

Now that we have established what we believe choking under pressure is, and what it is not, we can move on to the important question of how it is studied. Although we often refer to real-world examples of performance failure under pressure (e.g., the professional golfer missing a final shot to win the tournament, the field goal kicker missing the extra point to win the game), a significant amount of research on choking under pressure has examined the phenomenon in laboratory settings rather than in actual game situations.

What are the benefits of studying choking under pressure in the laboratory? First, this environment provides a controlled setting with which to examine performance failure. The amount of pressure can be manipulated, and players' perceptions of pressure, and their subsequent performance, can be measured. This not only allows one to

directly correlate perceived pressure and performance, but it provides a nice test bed to examine the impact of other variables (e.g., skill level of the performer, task difficulty) on the pressure-performance relationship.

Obviously, however, the benefit of control in the laboratory is accompanied by problems of ecological validity: the extent to which a pressure situation created in the lab (and resultant performance failure) is really reflective of real-world occurrences. One way to counter this problem is to create an environment that contains multiple sources of pressure commonly seen in the real world. We have accomplished this in our work (e.g., Beilock & Carr, 2001; Gray, 2004) by administering pressure scenarios that involve monetary incentives, peer pressure, and social evaluation components. In athletics, performance is often judged by coaches, fans, and teammates (i.e., social evaluation); there are monetary consequences for winning and losing (i.e., monetary incentives); and team success is dependent on the performance of individual athletes, which may generate peer pressure to perform at an optimal level. It is an empirical question as to exactly how these different sources of pressure exert their influence. However, our goal in the laboratory is to capture the real-world phenomenon of choking, thus we incorporate as many components of pressure as possible.

Other researchers have induced choking in laboratory settings by merely making salient the concept of pressure-induced skill failure, something that is likely to occur in important competition situations. For example, Leith (1988) found that individuals shooting free throws who were made aware of the fact that "some people have the tendency to choke at the free throw line" performed worse than those who had not received this information.

Not only is it crucial for laboratory studies to attempt to mimic the types of pressure situations found in the real world, but recent work has highlighted the importance of taking a number of manipulation checks to ensure that the instantiated pressure scenario produced its desired effects (e.g., increased perceptions of pressure). For example, following pressure manipulations, individuals are often asked about their levels of state anxiety (e.g., via the State-Trait Anxiety Inventory; Spielberger, Gorsuch, & Lushene, 1970), how important they felt it was to perform at a high level in the pressure situation, how much pressure they felt, and to report the thoughts and worries they experienced while performing under pressure (see Beilock & Carr, 2005; Beilock, Kulp, et al., 2004; Tenenbaum, Reeves, & Acharya, 2005; Wang, Marchant, Morris, & Gibbs, 2004).

Recent work has demonstrated across a number of different tasks that, under pressure, individuals do perceive the task at hand to be important; moreover, the extent of pressure-induced performance decrements is often correlated with perceived performance pressure and state anxiety (Beilock, Kulp, et al., 2004; Wang et al., 2004).

Importing choking research into a more controlled laboratory setting is beneficial because it allows one to directly examine the relationship between what is being manipulated (i.e., pressure) and what is being measured (i.e., performance, perceived feelings of pressure). Moreover, if individuals are randomly assigned to no-pressure and pressure groups, laboratory studies decrease the likelihood that individual differences in performance history or trait variables, such as anxiety, will influence the results. However, it is important to remember that the purpose of laboratory studies is to shed light on the real-world choking phenomenon. Thus, one must also demonstrate that choking occurs outside the laboratory.

In an attempt to explore real-world instances of pressure-induced failure, Baumeister and Steinhilber (1984) examined the performance of teams in the Baseball World Series and the National Basketball Association (NBA) finals. The authors hypothesized that heightened self-attention caused by the prospect of success ironically may hamper skill execution (resulting in choking under pressure). Using archival data of athletic performance in these contests, Baumeister and Steinhilber postulated that self-attention would be greater in situations that garnered significant audience support (when a team is playing at home in front of their loyal fans).

Early versus late games of the World Series and NBA finals were compared. In both basketball and baseball, the home team tended to win the first two games but lose the last (and decisive) game in these series. The authors concluded that this difference between performances in the early versus late games represented an example of the "home choke" in the later games, when the pressure was on to win the championship. In support of the notion that the home team was doing worse (rather than the visiting team performing better) in these games, Baumeister and Steinhilber (1984) reported data in baseball demonstrating that the incidence of fielding errors for the home team increased in the final games. Moreover, in basketball, although the home and visiting team performed at a similar level in free throw shooting in the early games, the visiting team outshot the home team in the late games. Thus, the presence of a supportive home crowd may cause the home

team to perform more poorly than expected when on the brink of a championship (for a recent review of the impact of supportive audiences on performance, see Wallas, Baumeister, & Vohs, 2005).

Although the notion of the home choke is intriguing, there have been counters to this idea suggesting that professional athletes in their home territory do not show signs of choking when the pressure is on (Schlenker, Phillips, Boniecki, & Schlenker, 1995). Moreover, recent work examining whether choking under pressure occurs in professional golf (i.e., the PGA tour, Senior PGA Tour, and LPGA) suggests that contrary to popular opinion, those players leading going into the final round won the majority of the time (Clark, 2002a; see also Clark, 2002b). That is, the leaders did not play worse than the nonleaders in the final and pressure-filled situation, as Baumeister and Steinhilber's (1984) data might suggest. However, when interpreting the results of archival data analysis, it is important to have a clear picture of the data being considered and the analyses being performed. Clark's (2002a) analysis of choking, for example, involved comparisons of final-round scores across different golfers. No within-golfer comparisons were performed. Because choking is defined as performing more poorly than expected in a high-pressure condition (i.e., a deviation from one's average or expected performance), another approach to diagnosing choking is to perform a within-golfer comparison. That is, one might compare a golfer's initial-round score (or an average over a few initial or nonpressure rounds) with his or her final-round "pressure" score. Golfers with a higher score in the final round than in their initial rounds could be thought of as choking. It may be that comparing across golfers obscures such differences because two golfers could have the same final-round score, yet one is performing better than his or her average, and one is performing worse.

Thus, there is a debate concerning the frequency with which high-level athletes choke in real-world situations. It may be the case that choking studies in the lab lead us to overestimate the extent to which the phenomenon occurs in real life. However, the types of pressure created in the lab are likely multiplied many times over in real-world settings. Using this logic, instances of choking in laboratory settings should only be amplified in the real world (Wang et al., 2004). On the other hand, one might argue that real-world instances of choking are overestimated, as, by definition, they occur in response to an important or novel situation, which increases the likelihood that such an event will be remembered. However, to the extent that such paradoxical performance decrements can occur at all in situa-

tions where individuals are motivated to perform their best, understanding the processes underlying this phenomenon is very important.

MECHANISMS OF CHOKING UNDER PRESSURE

Although documenting instances of choking under pressure (in both laboratory and real-world settings) provides insight into the conditions under which this type of skill failure occurs, it is an understanding of the mechanisms underlying pressure-induced failure (i.e., the psychological, physiological, and biomechanical processes associated with less-than-optimal performance) that will truly advance our knowledge of the choking phenomenon. Moreover, a clear picture of choking processes sets the stage for the development of training regimens designed to alleviate these unwanted performance failures.

A number of theories have been proposed to account for choking under pressure. We have divided these theories into three categories: drive theories, attentional theories, and biomechanical theories. Although drive theories are consistent with pressure-induced skill decrements in some situations, they are generally limited in usefulness in that they do not provide a mechanistic explanation for why such performance failures occur. In this section, we focus more attention on attentional theories (no pun intended), as these theories attempt to describe how one's cognitive representation of a skill changes under heightened pressure conditions. Finally, we turn to biomechanical theories of choking. These theories provide hypotheses about how the biomechanical components directly implement one's skill change in response to pressure. It is important to note that the attentional and biomechanical theories described here should not be thought of as competing alternatives. Rather, it may be that pressure produces attentional changes, which in turn result in changes in the biomechanical implementation of one's skill, ultimately leading to performance decrements. By examining how pressure exerts its impact on multiple levels, we gain a better understanding of how exactly high levels of pressure result in low levels of performance.

Drive Theories

According to general drive theory models, an individual's performance level is determined by his or her current level of arousal, or "drive" (Spence & Spence, 1966). 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 more descriptive than prescriptive. That is, drive theories link arousal and performance, but they do not explain *how* arousal exerts its impact. Second, in 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, as will be seen, there are situations in which certain drive theories have trouble accounting for observed behavior.

Yerkes-Dodson Effect

The Yerkes-Dodson (1908) effect, often termed the inverted-U theory, refers to the idea that as arousal increases, so does performance, but only to a certain point. In essence, performance is optimal at intermediate levels of arousal. Too little arousal, and the basketball player will not have the tools necessary to make the shot. Too much arousal, and again the shot will be missed. In the context of such theories, arousal has often been conceptualized as a physiological state (e.g., in terms of heart rate, blood pressure). The inverted-U hypothesis can, in general, account for performance failure under high-pressure situations. But, as mentioned earlier, such a theory is merely descriptive in nature in that it postulates a connection between arousal and performance but does not explain how different levels of arousal serve to alter skill execution processes.

Easterbrook's (1959) cue utilization hypothesis is one variant of the inverted-U that has attempted to apply a mechanistic explanation to the arousal-performance relationship. Easterbrook argues that increasing arousal reduces the range of cues used in a task. At low levels of arousal, the basketball player's attention may be too broad, encompassing both play on the court and her mom in the stands. At high levels of arousal, our player may be attending too narrowly to the player she intends to pass the ball to and, as a result, fails to notice the opponent about to steal her pass. Thus, Easterbrook's hypothesis suggests that arousal exerts its impact on performance by changing the player's selection of stimuli in the environment to attend to.

Another variant of the inverted-U is Hardy's (1996) sport adaptation of the cusp catastrophe model (CCM). The inverted-U and CCM are similar in that both predict that increases in arousal will facilitate performance to a certain degree. The two theories then diverge in their predictions regarding performance outcomes following optimal arousal (Gould & Krane, 1992). Once an optimal arousal-performance relationship is reached, the inverted-U predicts a monotonic decrease in performance associated with similar

increases in arousal levels. The CCM makes a different prediction. Specifically, CCM suggests that small increases in arousal following an optimal arousal-performance relationship can be catastrophic, leading to large drops in performance. And, once such catastrophic performance drops have occurred, CCM postulates that recovering to previously high performance levels is difficult. Moreover, whereas traditional inverted-U hypotheses conceptualize arousal in largely physiological terms, the CCM suggests that it is the interaction of physiological arousal and cognitive anxiety that serve to impact performance, as opposed to physiological arousal alone. Although a full review of CCM is outside the scope of this chapter (including the precise nature of the relationship between cognitive anxiety and physiological arousal and how these constructs combine to impact performance differently at different stages along each of their respective continuums), the CCM's recognition of sudden performance drops suggests that this model may account for the types of performance decrements characteristic of the choking-under-pressure phenomenon. Future research is thus warranted here. See Hardy, Woodman, and Carrington (2004) and Tenenbaum and Becker's (2005) methodological critique for a recent discussion of the CCM and its predictions.

Social Facilitation

Zajonc's (1965) theory of social facilitation is another version of drive theory that postulates a relationship between arousal and performance. Social facilitation captures the notion that as drive increases, so, too, will the likelihood that one's dominant response will be exhibited. Under heightened levels of drive (often created by the presence of an audience), social facilitation theory argues, novices are likely to exhibit poor performance (i.e., their dominant response), whereas experts should perform at a high level (i.e., their dominant response). Although theories of social facilitation are intuitively appealing, they have received mixed support in motor skill research (for a review, see Strauss, 2002). Furthermore, it is easy to think of real-world examples where these predictions fall short. Namely, if one's dominant response was always displayed in high-drive situations, then professional athletes should never choke under pressure. This is because their dominant response (which is presumably high-level performance) should always be exhibited under stressful conditions where drive is at a maximum. Thus, instances where highly skilled individuals exhibit poor performance appear to be at odds with the idea that increased drive leads to the exhibition of one's dominant skill response.

To address these contrasting notions, C. E. Kimble and Rezabek (1992) attempted to directly pit social facilitation and choking theories against each other by examining *Tetris* video game performance in the presence of an audience (which was designed to increase participants' level of drive or arousal). In terms of performance on a complex *Tetris* game, social facilitation theory would suggest that the good players should perform well in the presence of an audience (i.e., exhibiting their dominant response). In contrast, from a choking-under-pressure perspective, such players might perform more poorly under audience pressure in comparison to an unobserved situation. This is exactly what occurred. Highly skilled *Tetris* players performed worse in the presence of an audience in comparison to a nonaudience situation. Thus, the notion that one's dominant response will be exhibited in high-arousal or high-drive situations does not always hold when the pressure is on.

Attentional Theories

Attentional theories seek to describe the cognitive processes governing pressure-induced failure: how pressure changes the attentional mechanisms and memory structures supporting performance. In this light, it may have been more appropriate to include Easterbrook's (1959) attentional cue utilization theory here (Lewis & Linder, 1997). However, because this theory is based on the notion of arousal or drive, we chose to describe it earlier.

The various attentional theories of choking make somewhat different claims concerning how pressure impacts performance. Nonetheless, as will be clarified in the following several paragraphs, there may not be just one attentional mechanism by which pressure can exert its impact. Rather, it may be the case that the cognitive demands of the skill one is performing predict how (and if) it will be susceptible to failure. Such a conclusion obviously makes the answer to the question of *why* skills fail under pressure more complicated. At the same time, however, it provides a more unified framework for understanding the choking phenomenon across diverse task domains (i.e., from cognitive to motor skills) and skill levels (i.e., from novice to expert performance).

Distraction Theories

Distraction theories propose that pressure influences task performance by creating a distracting environment that compromises one's working memory capacity resources. Working memory is a short-term memory system that

maintains, in an active state, a limited amount of information with immediate relevance to the task at hand while preventing distractions from the environment and irrelevant thoughts (Kane & Engle, 2000). If the ability of working memory to maintain task focus is disrupted, performance may suffer. Distraction-based accounts of sub-optimal performance suggest that performance pressure shifts attentional focus to task-irrelevant cues, such as worries about the situation and its consequences. This shift of focus changes what was single-task performance into a dual-task situation in which controlling the task at hand and worrying about the situation compete for the limited working memory resources of the performer.

The most notable arguments for the distraction hypothesis come from research involving academic test anxiety (Ashcraft & Kirk, 2001; Eysenck, 1979; Wine, 1971). Individuals who become highly anxious during test situations, and consequently perform at a suboptimal level, are thought to divide their attention between task-relevant and task-irrelevant thoughts more so than those who do not become overly anxious in high-pressure situations (Wine, 1971). Additional support for a distraction account of choking comes from recent work specifically examining the impact of performance pressure on cognitive task performance. Beilock, Kulp, et al. (2004) had individuals perform easy math problems as well as difficult problems (that placed heavy demands on working memory) in both low- and high-pressure situations. It was found that pressure does indeed cause individuals to worry. Moreover, only those math problems that were strongly reliant on the working memory resources that worries are thought to consume (i.e., the difficult problems) showed signs of failure under pressure.

Thus, there is evidence that pressure can compromise working memory resources, causing failure in tasks that rely heavily on this system. But not all tasks *do* rely heavily on working memory. Specifically, the types of high-level motor skills that have been the subject of the majority of choking research in sport (e.g., well-learned golf putting, baseball batting, soccer dribbling) are thought to become proceduralized with practice. Proceduralized skills do not require constant online attentional control and are in fact thought to run largely outside of working memory (e.g., Beilock, Carr, et al., 2002; Fitts & Posner, 1967; Proctor & Dutta, 1995). Such skills, then, should be relatively robust to conditions that consume working memory resources, as distraction theory proposes. However, these types of skills may be sensitive to other attention-induced disruptions under pressure. A second class of theories, generally

known as explicit monitoring theories, has been used to explain such failures.

Explicit Monitoring Theories

Explicit monitoring theories suggest that pressure situations raise self-consciousness and anxiety about performing correctly (Baumeister, 1984). This focus on the self is thought to prompt individuals to turn their attention inward to the specific processes of performance in an attempt to exert more explicit monitoring and control than would be applied in a nonpressure situation (Baumeister, 1984; Beilock & Carr, 2001; Lewis & Linder, 1997). Explicit attention to step-by-step skill processes and procedures is thought to disrupt well-learned or proceduralized performance processes that normally run largely outside of conscious awareness (Beilock, Bertenthal, McCoy, & Carr, 2004; G. A. Kimble & Perlmutter, 1970; Langer & Imber, 1979).

Masters's (1992) reinvestment theory suggests that the specific mechanism governing explicit monitoring is "dechunking." Pressure-induced attention to execution causes an integrated or proceduralized control structure that normally operates without interruptions to be broken back down into a sequence of smaller, independent units, similar to how the performance was organized early in learning. Once dechunked, each unit must be activated and run separately. Not only does this process slow performance, but it also creates an opportunity for error at each transition between units that was not present in the integrated control structure.

A number of recent studies have attempted to examine the attentional correlates of suboptimal performance under pressure in high-level sensorimotor skills using explicit monitoring theories as a guideline. Many of these studies do not involve pressure at all, but rather attempt to mimic the attentional demands that pressure might induce. The logic here is that if researchers can uncover the types of attentional manipulations that compromise performance, they can use this evidence to begin to infer how pressure might exert its impact.

Beilock, Carr, et al. (2002) directly manipulated the attentional focus of experienced soccer players performing a soccer-dribbling task. Experienced soccer players dribbled a soccer ball through a series of pylons while performing either a secondary auditory monitoring task (designed to distract attention away from execution, mimicking distraction theories' proposed choking mechanism) or a skill-focused task in which the dribblers monitored the side of the foot that most recently contacted the ball

(designed to draw attention to a component process of performance, mimicking explicit monitoring theories' proposed mechanism). Performing in a dual-task environment did not harm experienced soccer players' dribbling skill in comparison to a single-task practice condition used as a baseline. However, when the soccer players were instructed to attend to performance (i.e., monitoring the side of the foot that most recently contacted the ball), their dribbling skill deteriorated in comparison to both the dual-task condition and a single-task baseline. Consistent with explicit monitoring theories of choking, step-by-step attention to skill processes and procedures appears to harm well-learned performance (see Figure 19.1).

Gray (2004) reports analogous results in an investigation of baseball batting. Highly skilled Division I intercollegiate baseball players were asked to perform a hitting task while at the same time listening for a randomly presented tone to judge whether the tone was high or low in frequency. This external dual-task had little effect on the baseball players' temporal swing error. Because experienced batters are thought to not explicitly attend step-by-step to execution, attentional capacity was available to devote to secondary task demands (i.e., judging the frequency of the tone) without significantly disrupting primary skill execution. However, when

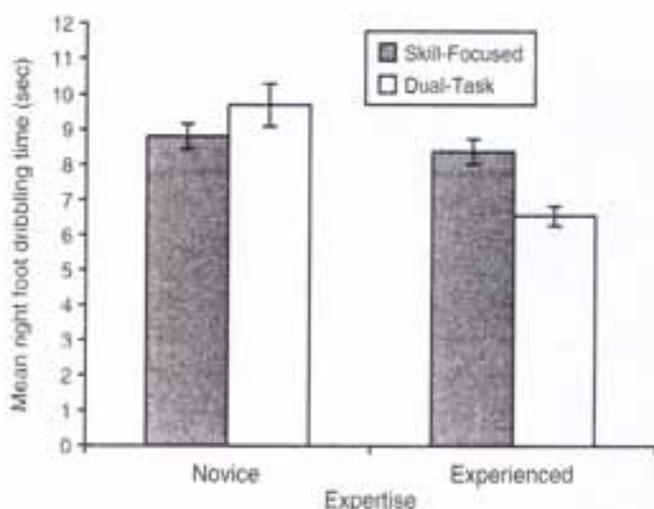


Figure 19.1 Mean right foot dribbling time(s) in the skill-focused and dual-task attention conditions for novice and experienced performers. Error bars represent standard errors. Source: "When Paying Attention Becomes Counterproductive: Impact of Divided versus Skill-Focused Attention on Novice and Experienced Performance of Sensorimotor Skills," by S. L. Beilock, T. H. Carr, C. MacMahon, and J. L. Starks, 2002, *Journal of Experimental Psychology: Applied*, 8, pp. 6-16. Copyright American Psychological Association. Reprinted with permission.

the same batters were required (in a skill-focused condition) to attend to a specific component of swing execution in a manner to which they are not accustomed, their performance suffered. In this skill-focused condition, baseball players heard a randomly presented tone and were instructed to indicate whether their bat was moving downward or upward at the instant the tone was presented. Kinematic swing analyses revealed that the observed performance failure was at least partially due to the fact that skill-focused attention interfered with the sequencing and timing of the different motor responses involved in swinging (Welch, Banks, Cook, & Draovitch, 1995), a finding consistent with Masters's (1992) notions of pressure-induced skill dechunking.

One might be concerned that the pattern of results just reported was merely due to different attentional demands in the external dual-task and skill-focused conditions (i.e., the skill-focused condition just required more attentional resources). However, there is evidence that this is not the case. Novice performers were also included in Gray's (2004) work and in Beilock, Carr, et al.'s (2002) work, and these novices showed the opposite pattern of results. For example, novices were harmed by the external dual-task but not the skill-focused condition in Beilock, Carr, et al.'s soccer dribbling study (see Figure 19.1). Unlike expert performance, novice performance is thought to require explicit attentional control (Beilock & Carr, 2001; Fitts & Posner, 1967; Proctor & Dutta, 1995). As a result, novices are hurt when attention is taken away from execution rather than by conditions that draw attention to performance. If the skill-focused condition had just required more attention in both Gray's and Beilock, Carr, et al.'s work, then novices should have been harmed by this condition as well, but they were not.

It should be noted that skill-focused attention may not always be detrimental to well-learned performances. For example, when the goal is to explicitly alter or change performance processes to achieve a different outcome rather than to maximize real-time performance, attention to performance may be beneficial. High-level performers will likely have to slow down and dechunk previous execution procedures to alter these processes, which may result in temporarily poor performance (e.g., Tiger Woods's less-than-optimal performance while he changed of his golf swing). Ultimately, however, these changes should produce performance benefits as skill execution will more closely mirror desired outcomes (see Beilock, Carr, et al., 2002, for further discussion of this issue).

The types of attention studies outlined here lend indirect insight into the cognitive mechanisms driving skill failure in high stakes situations, but it is also possible to

more directly assess the impact of pressure to perform at a high level on skill execution. In a separate experiment in his 2004 study, Gray directly investigated the effects of performance pressure on baseball batting in college baseball players. Following a series of pretests in which individuals performed the virtual batting task under the two dual-task conditions described earlier (i.e., judging tone frequency or direction of bat movement), batters were split into two groups. Batters in the pressure group were instructed that they had been paired with one other batter in the study, and that if both they and their teammate could increase their total number of hits in the next block of trials by a designated amount, they would receive a monetary reward. Batters in this group were further instructed that their teammate had already successfully reached the criterion for reward. Thus, both social pressure and monetary incentive were used to induce feelings of performance pressure in the baseball players (a manipulation first used by Beilock & Carr, 2001). Batters in a second, control group were not presented with the above pressure scenario, they were simply told to try to perform the task to the best of their ability. Both groups then performed the batting task under the same two dual-task conditions used in the pretests.

Batters in the pressure group exhibited clear choking effects. Mean temporal batting errors were significantly higher following the pressure manipulation in comparison to before the pressure manipulation. Not only did these batters fail to reach the incentive criterion, but their performance under pressure was actually worse than their baseline performance—direct evidence for choking. In terms of batters in the control group, there was no significant difference between mean temporal errors in the two blocks of trials.

How exactly did performance pressure cause batting performance to degrade in these highly skilled baseball players? One mechanism that appeared to be related to choking was a change in these players' attentional focus. Figure 19.2 shows the mean number of judgment errors in the two secondary tasks before (pretest) and after (posttest) the pressure manipulations. In the pressure group, there was a significant decrease in the percentage of judgment errors in the skill-focused secondary task (judging the direction of the bat movement) from pre- to posttest. This indicates that the pressure caused these batters to turn their attention inward and explicitly monitor their swing execution, resulting in better skill-focused judgments. To our knowledge, this finding provides the first direct evidence that pressure increases attention to execution, in line with explicit monitoring theories of chok-

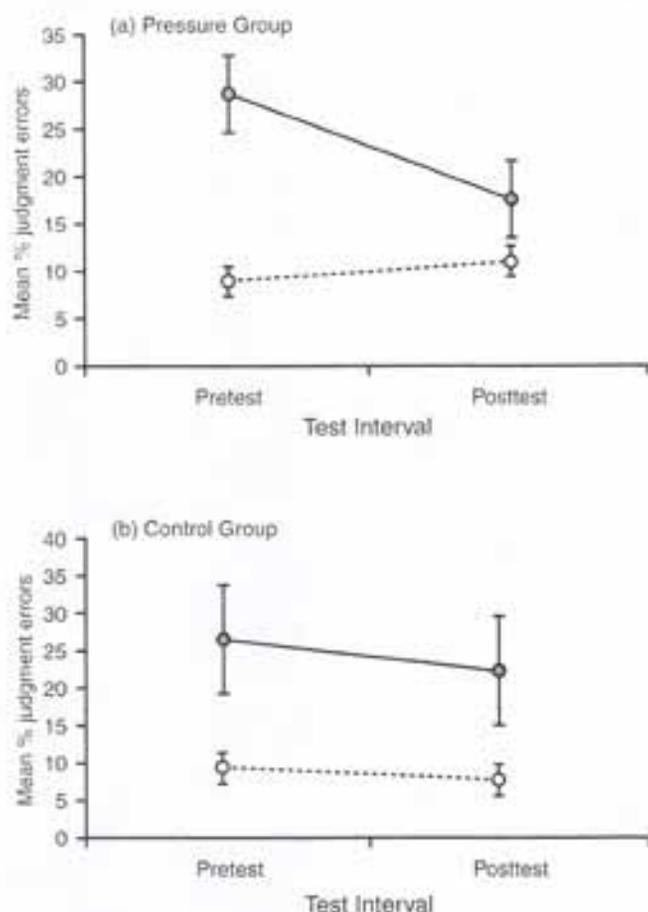


Figure 19.2 Mean percentage of judgment errors for dual-task judgments in the pre- and posttest conditions. (a) Pressure group. (b) Control group. Solid symbols and solid lines plot data for the skill-focused dual task (judging direction of bat movement), and open symbols and dashed lines plot data for the extraneous dual task (judging tone frequency). Error bars are standard deviations. *Source:* "Attending to the Execution of a Complex Sensorimotor Skill: Expertise Differences, Choking and Stumps," by R. Gray, 2004, *Journal of Experimental Psychology: Applied*, 10, pp. 42-54. Copyright American Psychological Association. Reprinted with permission.

ing (Baumeister, 1984; Beilock & Carr, 2001). A second, possibly related mechanism associated with the choking effect in this study was a change in the swing biomechanics. Batters in the pressure group exhibited an increased amount of variability in the timing of the different stages of their swing, consistent with Masters's (1992) notion of pressure-induced dechunking of well-learned processes.

As one may have noticed, the work presented above in support of explicit monitoring theories largely deals with athletes performing at a high skill level. What about novices? Theories of skill acquisition and automaticity

suggest that the attentional mechanisms governing novice and expert performance are quite different. Although novice performance is thought to be supported by declarative or explicit knowledge that is held in working memory and attended to in step-by-step fashion, expert performance (at least for highly practiced skill components) is thought to occur more automatically, largely controlled by procedures that run outside of working memory during execution (Anderson, 1993; Fitts & Posner, 1967). Thus, from the standpoint of explicit monitoring theories, unskilled performers should not choke if pressure prompts attention to execution. This is due to the fact that these performers are already attending to their skill in real time. In an attempt to explore this notion, Beilock and Carr (2001) had participants practice a golf-putting task. The participants were exposed to a high-pressure situation both early and late in practice. Early in practice, pressure to do well actually facilitated execution. Only at the later stages of learning did performance decrements under pressure emerge.

Thus, it appears that the proceduralized performances of experts are negatively affected by performance pressure, whereas novice skill execution, which is already attended to in real time, is not harmed by pressure-induced attention to execution. This finding is consistent with Marchant and Wang's (2001) assertion that most of the evidence for choking under pressure has been derived from well-learned sensorimotor tasks that automate via proceduralization with extended practice. Mirroring this idea, Paulus, Shannon, Wilson, and Boone (1972) found a positive correlation between high school students' gymnastic ability and audience-induced performance decrements. That is, the better gymnasts were more likely to perform poorly in front of an audience. Furthermore, Mullen and Hardy's (2000) work exploring the effects of anxiety and performance pressure on golf putting shows a similar pattern of results. Less skilled golfers' putting performance (as measured by absolute putting error scores) was not significantly harmed by a high-anxiety pressure situation in comparison to a low-pressure control condition, but highly skilled golfers showed performance decrements under pressure.

It should be noted that the viewpoint put forth in the skill acquisition and automaticity literature that high-level performance is based, at least in part, on automated performance processes that are best run without conscious awareness is not held by all those who study skilled performance. Specifically, Ericsson and Lehmann (1996, p. 291) have suggested that "most forms of expert performance remain mediated by attention-demanding cognitive

processes." In this view, pressure-induced attention to execution should not disrupt high-level skills because such skills are already attended to in real time.

What can one make of this notion given the preponderance of evidence presented in support of the idea that explicit attention to high-level skills disrupts execution? In line with skill acquisition and automaticity theories, we argue that some components of high-level performance become proceduralized with practice in such a way that explicitly trying to access these processes disrupts execution. One consequence of such proceduralization is that skilled performers' attentional resources are freed up to monitor higher level, metacognitive, and self-regulatory goals that are important aspects of exceptional performance (Kanfer & Ackerman, 1989). Unfortunately, under pressure, individuals may discard metacognitive strategies in favor of trying to control execution processes that are best left unattended. This shift in attention may not only disrupt proceduralized performance processes, but may limit strategic thinking as well. Of course, more research in this area will benefit not only the choking literature, but also the skill acquisition and expertise literature.

Pressure's Double Whammy

Explicit monitoring and distraction theories essentially make opposite predictions regarding how pressure exerts its impact. Whereas distraction theories suggest that pressure shifts needed attention away from execution, explicit monitoring theories suggest that pressure shifts too much attention to skill execution processes. Can both theories be correct?

Beilock, Kulp, et al. (2004) have suggested that performance pressure creates two effects that alter how attention is allocated to execution: (1) Pressure induces worries about the situation and its consequences, thereby reducing working memory capacity available for performance, as distraction theories would propose; and (2) at the same time, pressure prompts individuals to attempt to control execution to ensure optimal performance, in line with explicit monitoring theories. This suggests that how a skill fails is dependent on performance representation and implementation. That is, skills that rely heavily on working memory will fail when pressure consumes the resources necessary for performance, and proceduralized skills that run largely outside of working memory will fail when pressure-induced attention brings such processes back into conscious awareness. And, skills that concurrently load on working memory and rely upon proceduralized skills might be susceptible to both effects at once.

It is important to note that it does not seem to be merely a cognitive versus motor distinction that predicts how a skill will fail under pressure. That is, just because one is performing an academically based cognitive task does not mean this task will show signs of failure via pressure-induced distraction. Likewise, sports skills do not necessarily fail via pressure-induced explicit monitoring. Rather, it appears to be the manner in which skills utilize online attentional resources that dictates how they will fail (though often, this is related to skill domain). Thus, sports skills that make heavy demands on working memory, such as strategizing, problem solving, and decision making (i.e., skills that involve considering multiple options simultaneously and updating information in real time), will likely fail as a result of pressure-induced working memory consumption, similar to a working-memory-dependent academic task. In contrast, motor skills that run largely outside of working memory (e.g., a highly practiced golf putt or baseball swing) will fail when pressure-induced attention disrupts automated control processes.

Although these ideas are consistent with the pressure data to date, future work is needed to flesh out these important issues. For example, why don't novice sensorimotor skills fail via pressure-induced distraction, as shown for the working-memory-demanding cognitive tasks presented? Although unpracticed motor skills are based, in part, on explicitly accessible declarative knowledge (Beilock, Wierenga, et al., 2002) and may be harmed by dual-task situations (Beilock, Carr, et al., 2002; Beilock, Wierenga, et al., 2002), this knowledge does not appear to be organized in such a fashion that pressure-induced strains on working memory necessarily disrupt execution. Indeed, much like easy cognitive tasks that do not fall prey to pressure-induced failure (see Beilock, Kulp, et al., 2004), it may be that novice sensorimotor skills are not demanding enough on working memory (or demanding in the right way) to show signs of failure via distraction.

Behavioral Theories

Attentional theories of performance pressure account for how pressure changes the attentional processes and memory structures supporting skill execution. However, to gain a complete understanding of the choking phenomenon, one must not only understand the cognitive processes that govern failure, one must also explore how the biomechanical processes that actually implement skills are compromised by performance pressure. We have already described some evidence for biomechanical changes associated with pressure (see Gray's, 2004, work, described earlier). In this

section, we outline the main theory that has tried to capture pressure-induced changes in the motor implementation of skill execution.

Freezing Degrees of Freedom

One of the most prominent theories of the biomechanical processes associated with performance stress is the idea of "freezing degrees of freedom" (*df*), first proposed by Bernstein (1967) and studied in more detail by Vereijken, van Emmerik, Whiting, and Newell (1992). When we first learn to perform a complex motor task, such as throwing a ball, there are innumerable possible ways the action could be coordinated because each joint involved (e.g., wrist, elbow, shoulder) has multiple degrees of freedom (*df*). As a solution to this *df* problem, Bernstein suggested that novice performers may "freeze" the *df* by keeping some joints rigidly locked in place and/or by tightly coupling the movements of different joints. With practice, performers will begin to "unfreeze" the rigid couplings between parts of the body to allow for more flexible movement control. Bernstein further proposed that under conditions of high stress, expert performers may revert to the novice freezing strategy to reduce task complexity.

Recently, evidence has been provided to support Bernstein's (1967) account of the biomechanical changes associated with performance stress. Collins, Jones, Fairweather, Doolan, and Priestley (2001) investigated the movement patterns of weight lifters under training and competitive conditions. Under conditions in which a lift made in practice was not successfully completed during competition (i.e., the lifter choked), there was a higher cross-correlation between the neck and hip joints in some lifters, consistent with freezing *df*. A similar finding was reported by Higuchi, Imanaka, and Hatayama (2002) for a computer-simulated batting task. Pressure was induced in this study by negative feedback (via mild shocks) for performance errors. In the pressure condition, there was a higher correlation between the onset times of the kinematic events involved in the hitting movement (e.g., movement initiation, end of backswing), consistent with a reduction in the number of *df* for movement control. Finally, Pijpers, Oudejans, Holsheimer, and Bakker (2003) recently investigated the effects of anxiety on the movement behavior of novice rock climbers. Anxiety was manipulated by having participants climb at two different heights on an indoor climbing wall. Consistent with a freezing *df* theory, when climbing high on the wall, participants exhibited movements that were more rigid and less fluent compared to climbers at the low level on the wall. This promising line of research is a good example of how the dynamic systems

approach to perceptual-motor control used in ecological psychology (Kelso & Schöner, 1988) can be applied to the choking-under-pressure phenomenon.

How does the phenomenon of freezing *df* relate to the dechunking results found by Gray (2004)? On the surface, these two biomechanical processes seem to predict opposite effects. When an action is broken down into smaller, independent subunits during dechunking, one would expect to see an increase in movement variability because errors and delays can occur for each subunit. Alternatively, when a performer freezes the *df* by increasing the coupling between joints, one would expect to see a decrease in movement variability. We would argue that both dechunking and freezing *df* represent a temporary regress to a lower-skill level (associated with an earlier stage of skill acquisition) brought on by an increase in explicit monitoring of the motor action. Whether increased or decreased movement variability is observed will depend on what aspect of the movement is being measured. Take, for example, the climbing study by Pijpers et al. (2003). In a follow-up to this study, Pijpers, Oudejans, and Bakker (2005) reported that along with rigid, low-variability, whole-body movements reported in their 2003 study, there were some aspects of the climbing behavior that became more variable under the high-anxiety condition. When climbing high on the wall, participants exhibited greater variability in the number of exploratory hand movements used to test for holds, the movement time for the climb, and the length of rest between traverses. Similarly, we would expect that if the cross-correlations between the movements of different joints had been measured in the baseball batting study by Gray (2004), a decrease in movement variability (as indexed by an increase in the cross-correlation) would have been observed. Therefore, it appears that performance stress induces a variety of changes in movement behavior. It will be important for future research to identify which of these changes are the most detrimental to overall performance and how their incidence can be reduced.

INDIVIDUAL DIFFERENCES AND SUSCEPTIBILITY TO PRESSURE-INDUCED FAILURE

In the previous section, we examined the causal mechanisms of choking under pressure. A dominant theme that emerged was that a skill's susceptibility to pressure-induced failure is dependent on the types of resources that skill relies on most heavily (e.g., working memory capacity; proceduralized control structures). In this section,

rather than examining differences as a function of the type of skill being performed, we look to a number of individual differences in the performer as predictors of susceptibility to performance decrements under pressure.

Dispositional Self-Consciousness

Self-consciousness refers to one's level of awareness about internal states and processes (Baumeister, 1984; Fenigstein, Scheier, & Buss, 1975). Using a version of explicit monitoring theory as a guideline, Baumeister hypothesized that individuals low in dispositional self-consciousness would be more prone to performance decrements under pressure than those high in self-consciousness. High self-conscious individuals are accustomed to attending to their performance. Thus, to the extent that pressure prompts attention to execution (as explicit monitoring theories would predict), those who are accustomed to performance monitoring (i.e., high self-conscious individuals) should be less impacted by increased self-awareness than those who are not (i.e., low self-conscious individuals). In a series of experiments, participants performed an unfamiliar ball roll-up motor task in which the goal was to maneuver a ball into various target holes. Baumeister found that those scoring higher in dispositional self-consciousness were less prone to choke under pressure than those who scored lower.

Although Baumeister's (1984) findings are consistent with explicit monitoring theories of choking, more recent work has called the specifics of these results into question. In particular, Wang et al. (2004) examined individual differences in self-consciousness as a predictor of choking under pressure in a well-learned basketball free-throw shooting task. It was found that highly self-conscious athletes (specifically, privately self-conscious; see Fenigstein et al., 1975) were *more* susceptible to choking under pressure, not *less*, as Baumeister had found.

Wang et al. (2004) suggest that these disparate findings may be due to differences in the skill level of the performers in the two studies. Baumeister's (1984) participants were relatively unskilled at performing the ball-rolling task. In contrast, Wang et al.'s participants were skilled basketball players performing a well-learned free-throw shooting task. It may be that at low levels of learning, individuals high in self-consciousness are less prone to choke, not because they are adapted to performing in a self-focused state, but because they are more likely to allocate attentional processes to execution. As mentioned earlier, such attentional processes seem to be beneficial in the initial stages of learning yet disrupt well-

learned, automated performance processes (Beilock, Carr, et al., 2002). Thus, in Wang et al.'s work, attention to execution (increased by high levels of dispositional self-consciousness) may have harmed a *well-learned* skill. And in Baumeister's work, these same attentional processes may have aided (or at least did not hurt) performance of a relatively *unpracticed* task.

Reinvestment

Similar to the notion that individuals high in self-consciousness may be most prone to pressure-induced failure, Masters, Polman, and Hammond (1993) proposed an individual difference personality variable termed "reinvestment" that may predict an individual's propensity for performance failure under stress. To assess this personality variable, Masters et al. (1993) developed the Reinvestment Scale, which is loosely based on the Cognitive Failures Questionnaire (Broadbent, Cooper, FitzGerald, & Parkes, 1982), the Emotional Control Questionnaire (Roger & Nesselrover, 1987), and the Private and Public factors of the Self-Consciousness Scale (Fenigstein et al., 1975). The Reinvestment Scale attempts to capture the likelihood that one will try to "reinvest" explicit knowledge or attempt to perform one's skill using conscious control in certain situations. Masters et al. (1993) suggested that under high-pressure conditions, those scoring higher on the Reinvestment Scale should be more likely to show signs of stress-induced performance failure. And, indeed, this is what he found. Under low-pressure conditions, the performance of low and high reinvesters did not differ on a well-learned golf-putting task. However, in a heightened pressure situation, high reinvesters were more likely to show performance decrements than their low reinvester counterparts (for confirmatory evidence, see Jackson, Ashford, & Norsworthy, 2006). Moreover, in a subsequent study using university squash and tennis players, Masters et al. found that one's Reinvestment Scale score correlated with the extent to which one's teammates reported that one was likely to choke under pressure.

Although more work is needed to determine the exact relationship between reinvestment, self-consciousness, and choking under pressure, the work discussed here suggests that it may be possible to identify a priori those athletes who will be most susceptible to unwanted performance breakdowns in high-stakes situations. Furthermore, when high-level skills are being performed, it looks like those who have the tendency to monitor their performance (e.g., as measured by high scores on the self-

consciousness and reinvestment scales) will be most likely to choke under pressure.

Trait Anxiety

In the academic test anxiety literature, a number of studies have demonstrated that individuals with high levels of trait anxiety are especially vulnerable to the detrimental impact of stressful situations (Eysenck, 1992). Do the same sort of effects apply in sporting tasks under pressure? Recent work by Wang et al. (2004) suggests that they do. Individuals who reported higher levels of trait anxiety (assessed using the Sport Anxiety Scale; R. E. Smith, Smoll, & Shutz, 1990) performed more poorly on a well-learned basketball task under pressure than those who did not. Furthermore, this effect was magnified for highly trait-anxious athletes who were also high in self-consciousness (see previous section).

Murray and Janelle (2003) also found that individuals higher in trait anxiety are more susceptible to stress-induced performance decrements than their low-anxious counterparts. In one study, participants performed a simulated driving task and a secondary visual search task (requiring that participants respond as quickly as possible to visual cues presented in either central or peripheral vision) under baseline and competition conditions. Although driving performance did not significantly change as a function of condition, response times showed a different pattern of results. In competition, response times were reduced for the low-anxious group but increased for the high-anxious group in comparison to the baseline condition. Murray and Janelle suggest that those with higher dispositional levels of anxiety may not be as efficient in processing information under stress. It should be noted, however, that this inefficient search strategy under stress is not necessarily limited to those high in trait anxiety. Janelle (2002) suggests that anxiety in general may alter visual search and gaze behavior, resulting in inefficient and ineffective search strategies.

One reason individuals high in trait anxiety may perform differently under pressure in comparison to their low-anxious counterparts is that low- and high-anxious individuals appear to interpret pressure in fundamentally different ways. Giacobbi and Weinberg (2000) examined the coping responses of low and high trait-anxious athletes. They found that in response to stressful situations, high trait-anxious athletes used different and often nonproductive coping behaviors (e.g., self-blame) in comparison to low trait-anxious athletes. Thus, individuals high in trait anxiety may actually view pressure differently than low

trait-anxious individuals, which may explain, at least in part, why their performance seems to suffer more under stress. Future work in this area will certainly shed additional light on this issue.

ALLEVIATING PRESSURE-INDUCED FAILURE

One of the main goals of choking under pressure research is to understand unwanted performance decrements to the extent necessary to develop strategies to alleviate failure. In this section, we describe some of the work that has been conducted on this issue. As a preview, it does not appear that there is one *correct* pressure-inoculation strategy. Rather, there appear to be a number of training mechanisms and techniques through which pressure-induced failures may be lessened. For instance, as will be seen in the following paragraphs, some training conditions have attempted to adapt individuals to the types of attentional monitoring that pressure is thought to induce, and others have prevented participants from gaining the type of knowledge that pressure situations may exploit.

Skill Monitoring

Beilock and Carr (2001) examined performance under pressure in a golf-putting task to determine whether practice at dealing with the causal mechanisms proposed by explicit monitoring theories of choking would reduce pressure-induced failure. Here we describe an abbreviated version of this training paradigm.

Participants were trained to a high-skill level on a golf putting task under one of two learning conditions and then exposed to a pressure situation. The first training condition involved ordinary single-task practice, which provided a baseline measure of choking. In the second, "self-conscious" or "skill-focus" training condition, participants learned the putting task while being videotaped for subsequent public analysis by experts, a manipulation first used by Lewis and Linder (1997). This manipulation was designed to expose performers to having attention called to themselves and their performance in a way intended to induce explicit monitoring of skill execution—the aspect of pressure that explicit monitoring theories propose causes failure. Following training, all groups were exposed to the same pressure situation created by a performance-contingent monetary award.

Choking occurred for those individuals who were trained on the putting task in the single-task condition used as a baseline. However, choking did not occur for those trained in the self-conscious condition. Beilock and Carr (2001) concluded that training under conditions that

prompted attention to the component processes of execution enabled performers to adapt to the type of attentional focus that often occurs under pressure. In this way, self-consciousness training served to inoculate individuals against the negative consequences of overattending to well-learned performance processes, the mechanism that explicit monitoring theories suggest is responsible for performance decrements in high-pressure situations.

It should be noted that measures were not taken to ensure that individuals were attending to their skill under the self-consciousness condition in Beilock and Carr's (2001) work. However, to the extent that pressure harms performance by prompting explicit attention to execution in this type of task, and individuals in the self-consciousness condition did not fall prey to pressure's impact, it follows that participants were performing the task in a manner that adapted them to attending to execution. It is also possible that self-consciousness training may serve another purpose in addition to or instead of adapting individuals to explicitly monitoring execution. Namely, it may adapt individuals to the pressure situation in general. To the extent that athletes become accustomed to performing under pressure, a high-stakes situation may not represent much that is new to them. In turn, when this type of situation arises, they may not feel as much pressure as nonadapted individuals, and suboptimal skill execution may be avoided.

Distraction under Pressure

Using the same technique of videotaping for subsequent analysis by experts described in Beilock and Carr's (2001) work, Lewis and Linder (1997) also demonstrated that learning a golf-putting skill in a self-awareness-heightened environment inoculates individuals against pressure-induced failure at high levels of practice. Like Beilock and Carr, Lewis and Linder found that pressure caused choking in those individuals who had not been adapted to self-awareness. Furthermore, they found that the introduction of a secondary task (counting backward from 100) while performing under pressure helped to alleviate the performance decrements shown by the nonadapted golfers. Lewis and Linder concluded that the secondary backward-counting task occupied working memory, preventing attention from being focused on the proceduralized processes that controlled performance. As a consequence, choking under pressure was ameliorated, another finding that is consistent with explicit monitoring theories.

It may also be possible to limit attention to execution under pressure without adding a distracting secondary

task. Beilock, Bertenthal, et al. (2004) recently found that simply limiting the opportunity for skill-focused explicit monitoring through instructions to perform a putting task rapidly improved the performance of experienced golfers, relative to a condition in which the same golfers were told to take as much time as they needed to be accurate. The impact of this manipulation was phenomenologically noticeable: Several golfers reported that the speed instructions aided their performance by keeping them from thinking too much about execution. Thus, under pressure, making individuals perform their well-learned skill at a faster rate may actually prevent them from thinking too much about execution. Future research is needed to explicitly test this idea.

Implicit Learning

Rather than training individuals to adapt to the type of pressure-induced attention that explicit monitoring theories propose pressure induces, Masters (1992) argues that it may be better to train individuals without this type of knowledge to begin with (see Magill, 1998, for a general review of implicit motor learning). Masters suggests that, under pressure, performers may reinvest the explicit or declarative knowledge acquired during the early stages of skill acquisition, leading to a disruption of procedural performance processes. Under this logic, if performers do not have such knowledge to reinvest (i.e., they do not have a large body of declarative knowledge), they may not fall prey to pressure's negative effects.

Support for this idea comes from work in which Masters (1992) trained individuals on a golf-putting task under either explicit or implicit learning conditions and then exposed them to a high-pressure environment. In the explicit training condition, individuals were asked to follow a detailed set of instructions regarding how to putt. In the implicit training condition, participants received no putting instructions and were asked to carry out a secondary, random-letter-generation task while putting. Comparisons from the last training session to the high-pressure situation demonstrated that although the implicit group improved under pressure, the explicit group did not. Masters has taken this pattern of results as support for the notion that training individuals without explicit knowledge of their performance helps prevent breakdowns under pressure (see also Hardy et al., 1996).

It should be noted, however, that in Masters's (1992) study, the performance of the dual-task implicit group was at a substantially lower accuracy level than the explicit learning group prior to the high-pressure situation (as mea-

sured by the mean number of putts holed during the last training session). If pressure prompts attention to execution, and this attention to performance has differential effects as a function of skill level (i.e., novice performers benefit from attention to performance, but highly skilled individuals are harmed), another possible interpretation of the results of Masters's study is that pressure-induced attention to performance aided the implicit learning group because they were less skilled, whereas the explicit group, operating at a higher skill level, was harmed by such attention. Recent work shows, however, that it is possible to circumvent this issue regarding differences in performance after training in explicit and implicit motor learning conditions via prolonged periods of practice (Maxwell, Masters, & Eves, 2000). And, moreover, there is a growing body of work suggesting that implicit training may prove to be a useful tool in preventing choking under pressure (Poolton, Maxwell, & Masters, 2004, 2005). Thus, more work is needed to further our understanding of the inoculation benefits that implicit learning may afford in terms of success under stress (MacMahon & Masters, 2002; see also Masters, 2000, for a discussion of implicit learning and its consequences).

OTHER FORMS OF CHOKING

In an earlier section of this chapter we spent time outlining what we felt choking under pressure was and what it was not. Not only is it important to agree on a concrete operational definition of choking, but it is also imperative that we understand similarities and differences between what we have termed choking under pressure and other performance-failure phenomena. We outline two such types of failures that have received considerable interest in sport. Our goal is to try to understand how these failures relate to the choking research presented earlier.

The Yips

The yips have been described as a disruption in the execution of a fine motor skill as a result of involuntary jerks, tremors, and spasms of the extremities. The yips are often accompanied by increased levels of anxiety and a heightened fear of failure. Although the yips are most often talked about in relation to golf putting, they have also been documented in other complex motor skills, such as in cricket (Bawden & Maynard, 2001).

The yips have commonly been described in one of two ways: as a form of dystonia or as a type of choking under pressure (A. M. Smith et al., 2003). Dystonia is a neurolog-

ical disorder typified by involuntary movements that result in a twisting and spasming of body parts. Task-specific dystonias are isolated to specific tasks or particular situations in which an individual is required to perform a well-learned and repetitive movement, such as playing a musical instrument, performing an intricate medical surgery procedure, or golf putting. The cause of dystonia has been linked to abnormalities in the functioning of the basal ganglia and motor pathways, as well as to head injuries and stroke.

A. M. Smith and colleagues (2003) developed a model in which performance anxiety exacerbates either of two types of yips. In the case of Type I yips, increased performance anxiety is thought to prompt a form of focal dystonia. In the case of Type II yips, the same form of anxiety is proposed to increase self-awareness and attention to performance, ultimately resulting in choking. Although both Type I and Type II yips are characterized by different intermediary processes, both forms are thought to manifest themselves in terms of a jerk, twitch, tremor, or freezing of the putting stroke, which disrupts putting execution. Thus, documentation of the yips seems to involve both attentional and biomechanical correlates of failure, similar to the work currently being done on the choking phenomenon.

Stereotype Threat

Choking under pressure has been characterized as suboptimal performance in response to heightened levels of pressure. Introducing a negative stereotype about a social group in a particular domain can reduce one's quality of performance as well. For example, when negative stereotypes are activated, African Americans perform worse on math tasks described as assessing intelligence (Steele & Aronson, 1995), and Whites perform worse on golf-putting tasks described as assessing natural athletic ability (Stone, Lynch, Sjomeling, & Darley, 1999).

The performance failure that results from making salient a negative group stereotype has been termed *stereotype threat* (Steele, 1997). Although stereotype threat has been repeatedly demonstrated, little is known about why it occurs or how it relates to other types of skill failure. One possibility is that stereotype threat is one form of choking under pressure (Beilock & McConnell, 2004). That is, activating a negative stereotype about how one should perform leads to suboptimal performance, much in the way that making salient the consequences of losing an important game may result in choking under pressure. To test this idea, Beilock and colleagues (Beilock, Jellison, Rydell, McConnell, & Carr, in press) examined whether stereotype

threat and performance pressure led to the same patterns of skill failure and, moreover, whether the cognitive mechanisms responsible for pressure-induced failure and those responsible for stereotype threat were similar.

We first examined whether, similar to performance pressure, expert golfers are susceptible to the negative effects of stereotype threat (Beilock, Jellison, et al., in press). Male athletes who were skilled golfers performed a series of golf putts on an indoor putting green before (pretest) and after (posttest) receiving either a negative stereotype about their golf-putting performance (ST condition) or no information (control condition). All participants read that the study involved researching golf ability. In addition, participants in the ST condition read that previous research had demonstrated that women actually tend to be better putters than men. Thus, we were attempting to create a negative stereotype about how male golfers in our study should perform (i.e., worse than women). Results showed no difference in putting performance as a function of group in the pretest. However, in the posttest, the ST group performed significantly worse than the control group (see Figure 19.3). Thus, this first experiment succeeded in demonstrating that highly skilled golfers show patterns of failure under stereotype threat similar to that previously seen in high-pressure situations (see Gray, 2004; Jackson et al., 2006).

In a follow-up experiment, we examined whether the mechanisms governing stereotype threat were similar to those seen in pressure-induced failure situations. As mentioned above, previous work has demonstrated that well-learned sensorimotor skills fail under pressure via the prompting of explicit attention to execution processes that are best left outside of conscious control (Beilock & Carr, 2001; Gray, 2004; Jackson et al., 2006; Lewis & Linder, 1997; Masters, 1992). If stereotype threat operates in a similar manner to pressure in highly skilled golf putting, then not only should skilled golfers fail in stereotype threat situations, but drawing attention away from performance under stereotype threat should reduce this type of maladaptive attentional control. That is, to the extent that, similar to performance pressure, stereotype threat harms high-level putting by inducing attention to execution processes that are best left outside of explicit awareness, then the addition of a secondary task that reduces attention to the step-by-step unfolding of performance should lessen stereotype threat effects.

Male athletes who were skilled golfers performed a series of golf putts under both single-task and dual-task conditions, both before and after receiving a negative

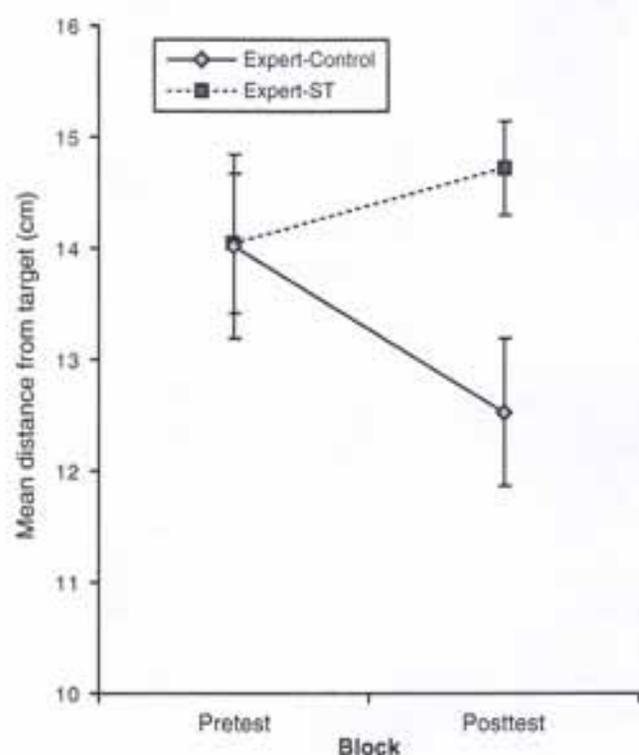


Figure 19.3 Mean distance from the target (cm) that the ball stopped after each putt in the pretest and posttest for expert golfers under stereotype threat (ST) and control conditions. Error bars represent standard errors. Source: "On the Causal Mechanisms of Stereotype Threat: Can Skills That Don't Rely Heavily on Working Memory Still Be Threatened?" by S. L. Beilock, W. A. Jellison, R. J. Rydell, A. R. McConnell, and T. H. Carr, in press, *Personality and Social Psychology Bulletin*. Reprinted with permission.

stereotype about how they should perform (Beilock, Jellison, et al., in press). As can be seen in Figure 19.4, prior to the introduction of the negative performance stereotype, there was no significant difference between single-task and dual-task performance. In contrast, following the introduction of ST, golfers performed significantly worse in the single-task than in the dual-task condition. These results suggest that, similar to pressure-induced failure in high-level proceduralized skills such as putting, stereotype threat occurs because the introduction of a negative stereotype prompts attention to execution in a manner that disrupts the automated processes of such skills. Adding a secondary task prevents this type of maladaptive attention to execution. In a subsequent study (Beilock, Jellison, et al., in press) we determined that this secondary task did not just divert skilled golfers' attention away from the stereotype presented to participants, as even a secondary

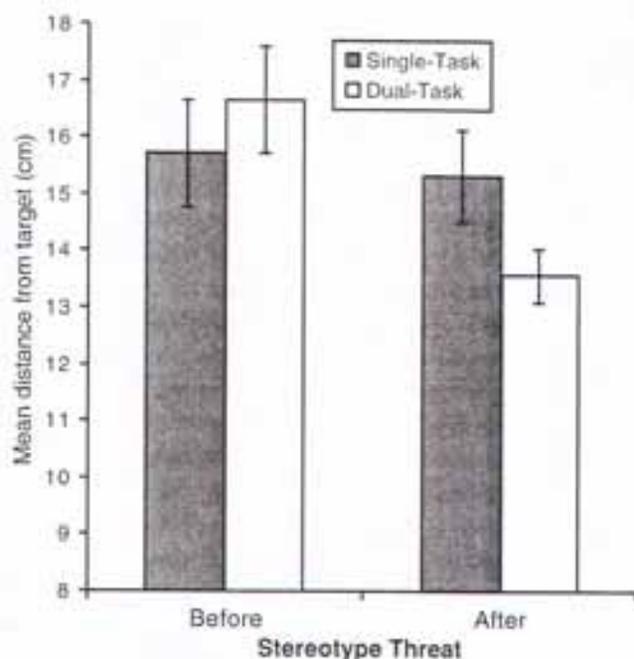


Figure 19.4 Mean distance from the target (cm) that the ball stopped after each putt in the single-task and dual-task conditions both before and after the introduction of stereotype threat. Error bars represent standard errors. *Source:* "On the Causal Mechanisms of Stereotype Threat: Can Skills That Don't Rely Heavily on Working Memory Still Be Threatened?" by S. L. Beilock, W. A. Jellison, R. J. Rydell, A. R. McConnell, and T. H. Carr, in press, *Personality and Social Psychology Bulletin*. Reprinted with permission.

task itself that required processing and responding to stereotype-relevant information produced the same pattern of results as that just described.

Thus, both the yips and stereotype threat seem to have a lot in common with the choking-under-pressure phenomenon. More work is needed to understand precisely how these instances of failure are similar and how they are different. Only then will we have a fuller understanding of why suboptimal performance occurs and how it can be alleviated.

CONCLUSION

Choking under pressure can be a very serious problem for skilled athletes. A single instance of this nefarious phenomenon may mark the abrupt end of a previously successful career. For example, kicker Scott Norwood of the Buffalo Bills retired the year after missing the potential game-winning field goal in Super Bowl XXV. Although one can only speculate about the relative causes of Norwood's

career end, his missed field goal will forever mark his NFL career. Evidence for this comes from the fact that other instances of choking have resulted in players being ostracized and ridiculed by fans for years after their playing career is over. Take, for example, Boston Red Sox first baseman Bill Buckner, who muffed the ground ball in the 1986 World Series; this is an event he has never lived down. Thus, choking is an important phenomenon that attracts attention not only from sport researchers, but from coaches, players, and fans alike. In this chapter, we examined several aspects of the choking phenomenon, with the ultimate goal of providing a comprehensive review of work in this area.

In an attempt to understand why athletes choke under pressure, researchers have examined the underlying causes of pressure-induced failure. Work in this area suggests that choking is a highly complex phenomenon with underlying mechanisms that depend on the cognitive demands of the skill being investigated as well as individual characteristics of the performer. Moreover, not only are researchers examining the attentional correlates associated with less-than-optimal performance, but recent work has begun to capture how performance pressure serves to alter the biomechanical components that implement a skill. Of course, more work is needed to provide a comprehensive view of pressure-induced failure that simultaneously takes into account the attentional mechanisms and biomechanical correlates of skill breakdown.

Attention has also been devoted to the individual differences that separate those most likely to fail under pressure from those whose performances are immune to the same levels of stress. Several researchers have examined personality traits that may be predictors of performance failure under pressure, including dispositional self-consciousness, reinvestment, and trait anxiety.

Using findings regarding how skills fail under pressure as a jumping board, techniques for inoculating performers against choking have also been established. Work by Beilock and Carr (2001), Lewis and Linder (1997), and others (e.g., Tenenbaum et al., 2005) has demonstrated that giving athletes practice at dealing with the types of attentional demands that performance pressure induces can reduce skill failure when the stakes are high. Others (e.g., Masters, 1992) have demonstrated that preventing athletes from acquiring the type of explicit knowledge that pressure may exploit to begin with may also help to quell the negative effects of stress at high levels of performance.

Clearly, much work still needs to be done before we gain a full understanding of this complex phenomenon.

Nonetheless, from the work highlighted in this chapter, it is clear that we are making headway in understanding the choking phenomenon. One area that deserves more attention relates to instances of choking under pressure in the real world. As we discussed, it is not clear from past research how frequently choking under pressure actually occurs in high-level athletes and what situations tend to increase the probability of such occurrences. One problem with this line of research has been that comparisons between high-pressure and low-pressure performance in the real world are often made across athletes. As we have defined it here, choking under pressure is an individual phenomenon: It is performance under pressure by an athlete that is poorer than that particular athlete's typical level of performance. Therefore, future research examining real-world performance across low- and high-pressure situations with the same athlete is needed.

Another interesting issue that has been addressed in only a small number of studies is the connection between the attentional and biomechanical processes associated with choking. For example, are dechunking and freezing degrees of freedom both associated with an increase in skill-focused attention? For what types of skills do each of these biomechanical correlates of pressure occur? Addressing questions such as these will require more research along the lines of Gray's (2004) work that measures a performer's attentional processes and movement patterns simultaneously. Finally, another promising future direction involves the examination of the various task and individual difference variables (e.g., attentional requirements of the task being performed, skill level, trait anxiety levels) that seem to produce some interesting boundary conditions for the choking phenomenon.

In conclusion, although we have learned a lot about why skills may be prone to failure in important situations, there is still much work to be done. It is our hope that this chapter facilitates new research into the choking phenomenon—research that will benefit coaches, practitioners, and performers alike.

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