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Putting pressure on theories of choking: towards an expanded perspective on breakdown in skilled performance

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Abstract There is a widespread view that well-learned skills are automated, and that attention to the performance of these skills is damaging because it disrupts the automatic processes involved in their execution. This idea serves as the basis for an account of choking in high pressure situations. On this view, choking is the result of self-focused attention induced by anxiety. Recent research in sports psychology has produced a significant body of experimental evidence widely interpreted as supporting this account of choking in certain kinds of complex sensorimotor skills. We argue against this interpretation, pointing to problems with both the empirical evidence and the underlying theory. The experimental research fails to provide direct support for the central claims of the self-focus approach, contains inconsistencies, and suffers from problems of ecological validity. In addition, qualitative studies of choking have yielded contrary results. We further argue that in their current forms the self-focus and rival distraction approaches both lack the theoretical resources to provide a good theory of choking, and we argue for an expanded approach. Some of the elements that should be in an expanded approach include accounts of the features of pressure situations that influence the psychological response, the processes of situation appraisal, and the ways that attentional control can be overwhelmed, leading to distraction in some cases, and in others, perhaps, to damaging attention to skill execution. We also suggest that choking may sometimes involve performance-impairing mechanisms other than distraction or self-focus.

Keywords Skill · Choking under pressure · Self-focus · Distraction · Situation appraisal · Sport psychology

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1 Introduction

Elite performers in sport and other skill domains know that things can go wrong in an extraordinary variety of ways. The conditions for successful performance under pressure are fragile. Yet experts continue to train, commit, make sacrifices, plan, adapt, and believe. And sometimes, at least, they excel. When they do not, when hopes are dashed or potential unfulfilled, underperformance is often subtle, its sources mysterious.

Often, expert performers bounce back from temporary adversity, backing themselves, coming back stronger. The mere incidence of an unexpected technical failing or one strategic error does not itself inevitably bring either sudden crashing performance breakdown, or a slow slide into mediocrity. Whatever complex factors initiate impairment in skill execution, what sometimes seems to make or break performance is the psychological impact of that first surprising setback, the expert's affective and cognitive appraisal of trouble under pressure. Notoriously in elite sport, different individuals can respond to similar situations in very different ways. A rare new challenging opportunity which affords visceral excitement for one can elicit in another a dark sense of threat or self-doubt. In different ways and at different timescales, the effects of a struggle or reversal can sometimes magnify and iterate: skills that were once effortlessly integrated can fragment in novel, cascading motor-cognitive misalignments.

In extreme cases, acute or catastrophic deterioration in performance can result. These rarer cases attract a great deal of attention among pundits and theorists. There is an awful, sad drama in the disintegration of movement routines and skills which are usually smooth and flowing, whether it happens all of a sudden at some final hurdle, or more gradually as glory drains away. One cricket bowler who had suffered dramatic and unexpected performance impairment said 'in all my sport I've never experienced anything so terrifying, thinking "I can't do this"' (Bawden and Maynard, 2001, p. 941). This is embodied cognition in the raw, with emotion and personality, kinesthesis and physiology, discipline and drives all affected together and on show. Interest in the diverse phenomena often given the labels 'choking' and 'the yips' springs not only from prurient fascination with public breakdown, but also from a wish to understand and intervene. This drives a quest among sports scientists and (increasingly) cognitive theorists more generally to identify the key mechanisms behind choking under pressure.

We harbour some doubts about the unity or coherence of the phenomena labelled 'choking' across different sports and contexts by practitioners, coaches, and the media. The idea that 'choking' marks a clear, well-defined explanatory target might not be right: discourse about choking, perhaps like talk about 'flow', may be partly constructed in the course of other social and communicative activities, rather than describing a distinctive set of psychological or biomechanical processes. We argue here that, at the least, choking is likely to be substantially more complex than current theories recognize. Indeed, one crucial problem with the current debate is that it suffers from a poorly developed characterization of the explanandum.

A further challenge and opportunity is that a plausible account of choking under pressure needs to be integrated with our understanding of the nature of expertise and skilled movement. It may also help us address more general questions about cognition and agency. The influential theories of skill learning offered by Fitts and Posner (1967) and by Dreyfus and Dreyfus (1986) differ in many respects, but they share the overall idea that skill acquisition involves a transition from cognitively demanding control to intuitive response entirely unmediated by higher cognition. Theorists in these distinct psychological and philosophical traditions often point out, rightly, that increased self-focus can sometimes disrupt skilled movement execution. Paying attention to, increasing awareness of, or seeking extra cognitive control over the component parts of a grooved movement sequence can sometimes fragment smooth action. Self-focus theories, though differing in detail, generalize from this observation to suggest that well-learned motor expertise is always and essentially automated. The idea that skill is automatic then lends itself naturally to a picture of choking, or severe performance failure under pressure, as caused by attention to the performance of the skill, the inappropriate intervention of awareness or top-down control. Thus, Baumeister (1984) claims that performance pressure is experienced when a high level of importance is placed on performing well, and choking arises because this draws the individual's attention to the processes involved in the skill, which impairs automatic control. Masters (1992) and Beilock and Carr (2001) develop similar accounts, which we assess below. and though Papineau (this issue) denies that increased self-focus explains choking, he accepts a self-focus account of the yips.

In the extreme, these self-focus accounts thus leave no room for any beneficial form of self-awareness or cognitive control in online, real-time expert performance. Even Papineau, who accepts that keeping higher-level intentions in mind is essential, argues that thinking during competition about the *components* of basic actions – for example, about adjusting your wrists in cricket batting – 'will reduce skilled performers to the level of beginners' (this issue, p.2 draft). In this respect, these accounts fit with pervasive practitioners' lore about the dangers of 'overthinking'. They deny the possibility that any kind of swift, flexible, on-the-fly dynamic cognitive activity can effectively shape expert performance in the heat of competition. Indeed, theorists and sportspeople often treat 'thinking' as synonymous with debilitating, slow, effortful processes such as worrying: Papineau, for example, explains his view of the negative effects of *thinking* about the components of basic actions by reference to performers who are 'worrying about' those components (p.2 draft).

In contrast, we believe that online expert performance in sensorimotor domains like sport is neither fully automatic nor insulated from cognitive processing, which we do not equate either with anxiety or with deliberate, conscious reflection. Instead, we have argued, skilled performance typically depends on cognition, rests on resistance to automation, the capacity to uncouple chunked routines when required, and involves active, dynamic, condensed, context-sensitive forms of cognitive control and 'thinking': expert attention can roam or float at very fast timescales across distinct levels of the integrated sensorimotor system, making subtle adjustments on the fly to everything from strategy to fine-grained motor processes (Sutton, 2007; Geeves et al., 2008, 2014; Sutton et al., 2011; McIlwain and Sutton, 2014; Christensen et al., submitted.

Skill experience is rich and various, and we suggest below that there are many forms of self-focus and self-awareness. Some of these can be damaging while other forms may be essential to good performance for some people in some contexts. Concepts of self-focus, self-monitoring, and self-consciousness are not always clarified or distinguished carefully in the literature on choking. For the most part our aim here is accurately to characterize the specific intended uses of these concepts by the particular theorists we discuss. Though we do not offer a novel taxonomy of our own, we do stress certain key distinctions. There are forms of 'self-focus' which are distinct from body-focused attention, from technique-focused attention, and from skill or task focus. Likewise, we will suggest, not all forms of embodied self-awareness need involve full-scale self-consciousness.

Expert performers regularly face new challenges and unexpected forms of pressure without choking. They constantly go beyond their particular past experiences. They have flexible repertoires of embodied skill which help them adapt to new opponents or team-mates, unpredictable environments, hostile crowds, injury, extreme emotion, or strange weather. Elite athletes value highly the ability to generalize skills to increasingly challenging conditions, and often structure training regimes around preparing to cope effectively outside their 'comfort zone'. Such variability is entirely to be expected: challenging and more or less unfamiliar conditions are just part of the deal at these levels of performance. This is one reason that leaving performance – even online, on-the-fly performance – up to automated motor processes alone is unlikely to be sufficient to ground sustained expertise in dynamic domains. Rather, the alignment, mesh, or *integration* of cognitive and motor processes at a range of timescales will sometimes need to be flexibly adjusted to changing circumstances.

Like most contributors to this issue, we begin our discussion of choking under pressure with a dichotomy entrenched in the literature between the 'self-focus' approaches just mentioned, and competing 'distraction' theories'. The 'self-focus' approach dominates contemporary research on choking in sporting skill, and has produced a significant body of empirical research in recent years. The primary aim of this paper, implemented in sections 2–4, is a critical assessment of the self-focus approach.

But we also then argue, in section 5, for a more encompassing approach to choking that goes beyond current theories, addressing a broader range of phenomena: this constructive account is, however, independent of the critical evaluation. The causes of choking are likely to be complex. Current theories focus on only a part of the phenomenon they are trying to explain, and aren't sufficiently well elaborated to provide strong support for their key claims. In particular, we suggest, they do not clearly address the problem of explaining why only some performers choke under pressure, and only on some occasions. So they fail to build frameworks rich enough to explain the variation in the occurrence of choking in real performance situations. Our constructive contribution identifies three elements required for a more encompassing theory. We develop initial accounts of the features of pressure situations that influence the psychological response; the processes of situation appraisal that may explain why some are more prone to choking than others; and the ways that attentional control can be overwhelmed, leading to distraction in some cases, and in others, perhaps, to damaging attention to skill execution. We also suggest that choking may involve performance-impairing mechanisms other than distraction or self-focus.

Developing a more comprehensive theory of choking with high levels of predictive and explanatory adequacy will be challenging. But it is important to characterize what a good theory would be like, both because it helps us to see more clearly the limitations of current approaches, and to identify directions for improvement. One key lesson is that the construction of such a theory will require close engagement between empirical and theoretical research. Experimental research provides the controlled testing of hypotheses that is the bedrock for science, but often employs artificial conditions and must rely on complex inferences to link experimental results to the real world phenomenon that is the ultimate target for explanation. These inferences are sometimes not well-articulated, and not always well-founded. Synoptic theory can help to provide conceptual bridges between the laboratory and the natural setting, and developing synoptic theory is a strength of philosophy.

But to play this bridging role philosophical skill theory needs close engagement with experimental research. While philosophical work on skill often draws on empirical literature (Birch, 2011; Brownstein, 2014; Eriksen, 2010; Moe, 2005), sustained and mutually informative exchange will need deeper critical engagement. This involves at least the following six requirements: i) responding to the field as a whole in its diversity, rather than to isolated papers; ii) responding to the conceptual foundations of the research, such as the older automaticity-based theories of skill which inform the self-focus theory of choking; iii) engaging with the details of the methods employed, and to the ways both methods and results are intended to map onto the phenomena outside the laboratory setting; iv) responding to the detailed pattern of the findings across studies, rather than to the headline results alone; v) developing theory that builds on all aspects of this empirical research – both quantitative and qualitative – as well as on cognitive theory and philosophical, phenomenological, or ethnographic analysis; vi) providing constructive, usable suggestions on how to do empirical research differently. In this paper we hope to meet the first four of these requirements as best we can, and (in section 5) to indicate directions for meeting the final two requirements.

By putting pressure on what are currently sometimes rather thin accounts of the cognition and biomechanics of choking, we can acknowledge the potential relevance of more idiosyncratic features of personal history and motivation, and the capacity to engage reflectively with emotional experience. The highly-skilled expert performer is not only a uniquely-honed machine, but has also acquired a distinctive, expanded form of agency. The cooperative, interactive, looping mesh of strategic cognitive processes with lower-order motor control mechanisms is fragile and can go wrong at many levels and timescales. We seek to identify some relevant parameters, so that questions about their interrelations can be addressed more explicitly in future research. We hope this moves us a little further towards a rich, integrated picture of both the effective operation and the breakdown of skilled agency.

2 Self-focus approaches to choking in sensorimotor skills

2.1 Self-focus theories

2.1.1 The conceptual framework

Baumeister and Showers (1986) presented a conceptual framework for research on choking which was based on the main kinds of approach prevalent at the time. This framework distinguishes between *arousal* and *attentional* theories of choking, and then between *self-focus* and *distraction* attentional theories. Baumeister and Showers dismiss arousal theories as lacking explanatory and predictive capacity (pp. 363–5 & pp. 375–7), and propose that the central theoretical concern of research on choking should be with articulating and comparing self-focus and distraction theories (p. 376). They claim that each of these types of theory might explain some forms of choking, and also note that self-focus and distraction might both contribute to choking (p. 376). Subsequent research has elaborated on this framework, and a substantial body of empirical work has attempted to test comparatively self-focus and distraction accounts of choking in sporting and related sensorimotor skills (for recent reviews see Beilock and Gray, 2007, and Hill et al., 2010b).

In basic structure, self-focus theories claim that performance pressure creates self-consciousness, and that this causes the individual to attend to and attempt to control the motor processes involved in performing the task, disrupting automated motor processes and thereby causing poorer performance. We call this *the basic self-focus model* (Fig. 1a). Conversely, distraction theories are said to claim that performance pressure generates worries about the situation which compete in working memory with the control operations that govern task performance, impairing those processes and, consequently, performance. We call this *the basic distraction model* (Fig. 1b).

2.1.2 Baumeister's self-focus theory

Baumeister's (1984) theory of choking has the core structure depicted in Fig. 1a, with several additional features (Fig. 2). Baumeister characterizes *performance pressure* as any factor or combination of factors that increase the importance of performing well on a particular occasion (p. 610). He characterizes *choking* as inferior performance that occurs in response to pressure (p. 610). Baumeister's model of choking (pp. 610–11) proposes that choking occurs because pressure increases self-consciousness. He describes both physiological and cognitive mechanisms as contributing to this process, with heightened arousal possibly responsible for increased self-consciousness,

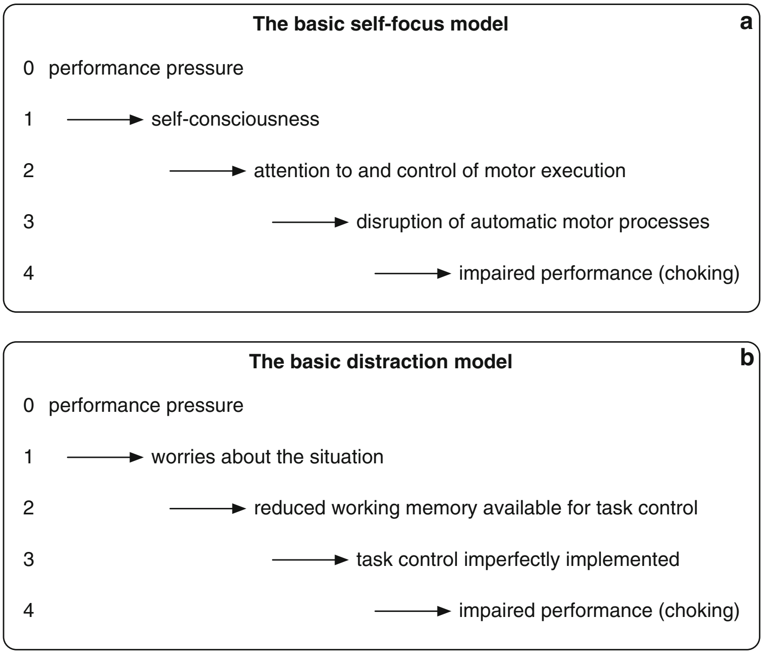

Fig. 1 **a** The basic self-focus model. **b** The basic distraction model

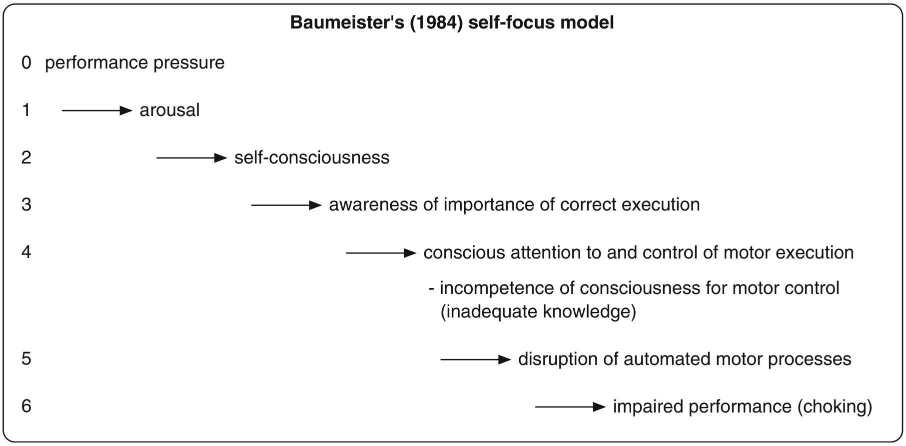

Fig. 2 Baumeister's (1984) self-focus model

accompanied by a cognitive realization that it is important that the behavior is executed correctly. This prompts an attempt to consciously monitor and control the motor processes involved in the behavior, such as the coordination and precision of the muscle movements. However, 'consciousness' lacks the knowledge required for this type of control, with the ironic effect that performance quality is reduced. Baumeister and Showers (1986) further specify that conscious attention disrupts or inhibits automated motor processes.

In addition, Baumeister and Showers (1986) identify a number of forms of performance pressure and features of the situation and individual that may play a role in 'mediating' choking. These include reward contingency, punishment contingency, ego-relevance, task complexity, efficacy expectancies, anxiety, self-consciousness, skill level, and self-esteem. Baumeister and Showers do not systematize these conceptualizations of potential features of choking in the form of a structured explanation or model so they can't be considered part of a theory. They are, rather, a collection of ideas that might be relevant to understanding choking.

2.1.3 Masters' reinvestment theory

Like Baumeister (1984), Masters (1992) characterizes choking as performance failure under pressure, and claims that choking occurs as a result of attention to motor execution (p. 345). He identifies the mechanism responsible for performance impairment as the disruption of the automated processes that normally produce the action (p. 344). Masters differs from Baumeister in claiming that explicit knowledge about the skill plays a critical role in promoting efforts to consciously control the skill (Fig. 3a). Specifically, Masters claims that when under pressure the performer begins to think about how they are executing the skill, and tries to control it using explicit knowledge of its mechanics (p. 345). He calls this a 'reinvestment' of knowledge in skill control because it involves applying the knowledge that was employed for skill control at earlier stages of skill learning. This leads Masters to propose that skills acquired in distracting conditions which prevent the acquisition of explicit knowledge about the skill will be less susceptible to choking (p. 345).

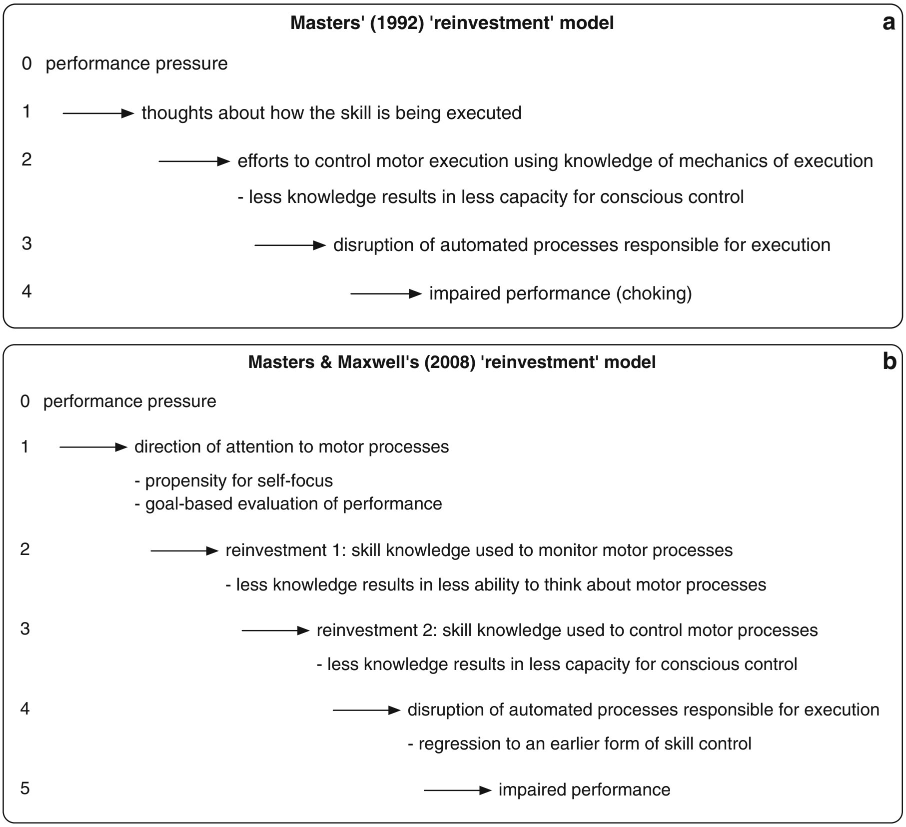

Fig. 3 **a** Masters' (1992) 'reinvestment' model. **b** Masters and Maxwell's (2008) 'reinvestment' model

The presentation of 'reinvestment theory' by Masters and Maxwell (2008) adds some additional features to the account and expands its scope. Rather than being a theory of choking in particular, Masters and Maxwell intend reinvestment theory as an explanation for performance impairment in sensorimotor skills in a wide range of contexts. Pressure is listed as only one of many contingencies that can produce self-focus induced impairment, and many of the examples they discuss, such as self-focus after injury, are not responses to performance pressure in the sense intended by Baumeister.

It is not entirely clear how the various ideas described by Masters and Maxwell should be integrated as a model. They describe three different things that can influence attention to motor processes – goal-based performance evaluation, propensity for self-focus, and explicit skill knowledge – and it isn't clear how these relate to each other. Masters and Maxwell claim that in the context of performance pressure the individual evaluates their performance relative to their goals, and if it is not satisfactory they increase self-regulation (2008, p. 160). This will presumably take the form of the conscious control of motor processes. Propensity for self-focus also increases the likelihood that the individual will focus on and attempt to control motor processes. In addition, explicit skill knowledge affects attention to and control of motor processes. Figure 3b is one interpretation of how these could operate together. Here, skill knowledge is depicted as playing a role after the initial direction of attention to motor processes, but it is also possible that it would influence the direction of attention. Figure 3b characterizes explicit skill knowledge as contributing to the ongoing capacity to monitor and control motor execution. The effect of the reinvestment of skill knowledge in control is disruption of automatic motor processes and a regression to an earlier stage of skill development (p. 164). Like Baumeister and Showers, Masters and Maxwell list a range of factors that can influence attention to skill execution, but which do not form a systematic part of their theory.

2.1.4 Beilock and Carr's explicit monitoring theory

Beilock and Carr's (2001) account largely follows that of Baumeister. They describe self-focus theories as claiming that performance pressure raises self-consciousness and anxiety, which increases attention to the step-by-step control of skill processes. This disrupts proceduralized motor programs (p. 701). They use a characterization of the disruption of motor processes that they attribute to Masters (1992), but they don't adopt Masters' claim that knowledge about the skill plays a strong role in the capacity for monitoring and control of motor processes. Here they follow Baumeister in claiming that extended experience performing in conditions of self-focus should protect against choking rather than increase susceptibility.

Beilock and Carr suggest that 'explicit monitoring' is a better label than 'self-focus' for this kind of theory (2001, p. 701), but we think there are some problems with this attempted clarification. The theories of Baumeister and Masters incorporate two kinds of self-focus: a personal self-consciousness that includes worry about the situation and concern for performance (Fig. 2 steps 2–3, Fig. 3b step 1), and attention to skill execution (Fig. 2 step 4, Fig. 3b steps 2–3). The latter is the proximal mechanism that is supposed to cause choking, so there is some basis for giving it theoretical priority. Nevertheless, the former kind of self-consciousness plays an important role in this kind of theory because it helps explain why attention to skill execution occurs in response to pressure. Note that if we eliminate personal self-consciousness from the models depicted in Figs 1–3, they would incorporate no mechanism that links performance pressure to attention to skill execution. Baumeister and Showers (1986) in particular showed great concern with the role of personal self-consciousness in choking, discussing a variety of features of performance pressure that might give rise to personal self-consciousness, including the ego-relevance of the performance (pp. 369–70) and the presence of an audience (pp. 370–72).

These theories are thus not *only* concerned with attention to skill execution, and Beilock and Carr themselves accept Baumeister's claim that attention to execution is induced by "self-consciousness and anxiety about performing correctly" (2001, p. 701). Formulated as a model their account is in essence the same as that depicted in Fig. 1a, with some minor differences in wording. They emphasize monitoring of motor performance, and Jackson et al. (2006, p. 64) and Hill et al. (2010b, p. 27) see this as an important conceptual difference from Masters' account, with the latter emphasizing conscious control. However, Beilock and Carr don't draw a clear distinction between conscious monitoring and conscious control, and it is not clear from their account that monitoring and control are markedly distinct sources of impairment.

Another important feature of Beilock and Carr's account is that they describe the mechanisms posited by self-focus and distraction theories as "complete opposites". They suggest that the two theories may have different domains of application, with distraction theory applying to skills that rely on working memory, and self-focus theories applying to automated skills whose control structures operate outside working memory (p. 701). Beilock and Gray provide a more detailed characterization of this distinction:

> 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. (Beilock and Gray, 2007, p. 434, emphases added)

This contrast echoes Baumeister and Showers' claim, described above, that each of the types of theory may explain some forms of choking, but is more specific and sharply drawn. Baumeister and Showers emphasize at a number of points that the two types of approach can overlap, and they note that on some views self-focus *is* a form of distraction. Beilock on the other hand predominantly emphasizes the idea that the forms of explanation are distinct and apply to different domains. Although Beilock and Gray do note that there could be hybrid forms of skill that involve both automated motor control and cognitive processes that perform strategic control functions, and suggest that in such cases choking could involve both self-focus and distraction (2007, p. 434), they do not take these important suggestions further.

2.1.5 Summary

In sum, the core idea sketched in Fig. 1a is popular, and several theories have been based on it. These various accounts differ in their details and emphasis, with Baumeister being concerned with the psychological processes of personal self-consciousness that induce motor self-focus, Masters emphasizing the deleterious effects of the acquisition of explicit skill knowledge, and Beilock and Carr drawing a strong contrast between self-focus and distraction theories that sees them as having markedly different domains.

2.2 Experimental research

A substantial body of research has tested and developed the self-focus view of choking. We concentrate here on the research performed by Sian Beilock, Rob Gray and collaborators because it constitutes the most developed body of experimental research in support of the self-focus account of choking. Other important bodies of experimental work are relevant, including Wulf's research on the effects of attention on the performance of motor skills (Wulf, 2007): but this is less directly concerned with choking.

The research by Beilock and Gray appears to support the account given by Beilock and Carr (2001), including the existence of a strong distinction between automated and non-automated skills, and, accordingly, between the domains of applicability of self-focus and distraction theories. More specifically, the research appears to show an overall pattern of dissociation in performance patterns that is summarized in Table 1. Individuals performing tasks that clearly rely on working memory, such as mathematical problem solving, or sensorimotor tasks for which they are novices, show the patterns of performance expected for tasks that are dependent on working memory, while individuals performing sensorimotor tasks at which they are expert show the performance patterns expected for automated sensorimotor skills.

2.2.1 Experimental conditions

The experimental demonstration of this pattern is based on the comparison of the performance of a skill in different conditions, and comparison between experts and novices. Fairly standard conditions have been employed, and in order to evaluate the results of the experiments we need to consider in detail the nature of the conditions, which are as follows.

Primary tasks The primary tasks used are often versions of a real world skill adapted for the requirements of the experiment. Thus, in Beilock and Carr's (2001) experiment 1 participants performed golf putts in the laboratory on a carpet, aiming to make the ball stop at a target 1.5 m away (p. 704). Gray (2004) used a simulated baseball batting task in which participants swung a baseball bat at a virtual ball that was displayed on a screen as coming towards them (p. 44).

Table 1 Predicted performance attributes of automated and non-automated skills

Performance attributes	Automated sensorimotor skills	WM-dependent skills
dual-task performance	tolerant	impaired
pressure that creates distraction	tolerant	impaired
instructed self-focus	impaired	tolerant
pressure that induces self-focus	impaired	tolerant
episodic memory	reduced	enhanced
novice-expert differences	strong differences: novices show WM-dependence; expertise strengthens the characteristics associated with automation	not examined

DeCaro et al. (2011) employed artificial tasks thought to depend on either working memory or procedural memory. Two were categorization tasks:

'rule-based' categorization depends on explicit cognitive processing in working memory, while 'information-integration' categorization is thought to be based on procedural memory (Ashby and O'Brien, 2005). They also employed the serial reaction time task (SRTT), which is a simple sensorimotor task that involves implicit learning.

Single task conditions In a single task condition only the primary task is performed.

Extraneous dual-task conditions In addition to the primary task, participants perform a secondary task that is designed to draw attention away from the primary task. This can be taken to provide a test for the distraction approach to choking inasmuch as the secondary task can be viewed as mimicking the effects of distraction on performance posited by the basic distraction model (Fig. 1b). In Beilock and Carr (2001) experiment 3 the secondary task involved monitoring a recorded list of words for a target word (p. 716). In Gray (2004) experiment 1 the secondary task involved monitoring tones that were presented at random times during the batting task. The tones were of a high or low frequency and the participant had to report whether the tone was high or low (p. 45).

Skill-focus conditions Participants are either instructed to focus on the execution of the skill or perform a secondary task that requires attention to the execution of the skill. Beilock et al. (2002) experiment 2 involved a primary task in which participants dribbled a soccer ball through a slalom course. Tones were presented randomly and at the time a tone occurred participants had to report whether they had just touched the ball with the inside or outside of their foot (pp. 10–11). Gray (2004) presented tones during the batting task, as with the extraneous condition, but required the participants to report whether the bat was moving upwards or downwards at the time the tone occurred by saying "up" or "down".

Pressure conditions Participants perform the primary task in the context of a scenario designed to create performance pressure. Using golf putting as the primary task, Beilock and Carr (2001) employed a pressure condition in which the participant was told they would receive $5 if they improved their performance by 20 % in the next set of putts. The individual was also told that the reward was based on team effort, they had been paired with a second participant, and that both needed to achieve the performance target to receive the prize. The participant was then told that the second person had already completed the task and had achieved the 20 % performance improvement. Gray (2004) employed a very similar pressure condition with baseball batting as the primary task; the improvement criterion was 15 % and the prize was $20.

DeCaro et al. (2011) distinguished between *outcome* and *monitoring* pressure conditions. The outcome pressure condition was the same as the pressure condition used by Beilock and Carr (2001), but with a prize of $10. In the monitoring pressure condition the participants were told that their performance would be videotaped, and that students and professors would view the footage to see how people perform the skill. In addition, the video might be used as part of a film that would be distributed to universities nationally (p. 396).

2.2.2 Results

The results from this research appear to conform to the overall pattern shown in Table 1. We can group the findings according to the main question that they address.

Are complex motor skills like golf putting automated? Beilock and Carr (2001) performed a novice-expert comparison of memory for performance using a golf-putting task. Immediately after completing a round of putts participants were given a questionnaire designed to elicit episodic memories for the last putt performed. Beilock and Carr (2001) found that experts had reduced memory for performance compared with novices, as expected for an automated sensorimotor skill.

Are these skills impaired by self-focus and tolerant of distraction? For the soccer dribbling task Beilock et al. (2002) showed in experts a pattern of tolerance for the extraneous dual-task condition and impairment in the skill-focus condition, just as would be expected for an automated motor skill. They also showed a clear novice-expert distinction, with novices harmed by distraction but unaffected by the skill-focus condition. Gray (2004) found a similar pattern using the baseball batting task: experts tolerated distraction but were impaired by the skill-focus condition, while novices were impaired by distraction and unaffected by the skill-focus condition.

Are these skills impaired by performance pressure? As part of a more complex experiment, Beilock and Carr (2001) found that novice participants who had been trained on the golf putting task showed impaired performance when subjected to the pressure condition. Gray (2004) found that the batting performance of the baseball experts deteriorated during the pressure condition.

Is the impairment in response to pressure caused by self-focus? Gray (2004) found that when performing the baseball batting task under pressure participants were better at the skill-focus judgment task than in low pressure conditions. In contrast, their accuracy on the extraneous judgment task was unaffected. He interpreted this as showing that skill-focused attention is greater under pressure.

Do different kinds of pressure have selective effects? According to Beilock and Carr's account choking in non-automated skills is caused by distraction, and in automated skills is caused by self-focus. For this to be right it must be the case that performance pressure can cause both distraction and self-focus. This raises the possibility that particular forms of performance pressure might tend to specifically induce distraction or self-focus, and that these forms of pressure would selectively impair non-automated and automated skills, respectively. The results of DeCaro et al. (2011) supported this. They found that outcome pressure harmed the task thought to depend on working memory (rule-based classification), but not the tasks thought to be based on procedural memory (information-integration classification and the SRTT). Monitoring pressure had the opposite effect, harming information-integration classification and the SRTT but not rule-based classification.

Thus, a significant body of research has yielded results that appear to be consistent, and that fit the pattern summarized in Table 1. This pattern can be predicted on the basis of the self-focus theory of choking, and so the evidence seems to support this approach.

3 Problems with the self-focus research

There are, however, a number of problems with these studies. First, the research doesn't compare self-focus theory with the most developed contemporary versions of distraction theory. Second, these studies don't directly test the central claims of self-focus theory. Third, the research is conflicted: on close examination, similar experimental conditions have yielded contradictory results and been given contradictory interpretations. Fourth, the poor ecological validity of the experiments means that it is unsafe to use them as a basis for conclusions about real world choking.

3.1 Failure to compare self-focus theory with the most developed forms of distraction theory

The studies described above are conceptually framed as comparisons of self-focus and distraction theories of choking, and they appear to support the self-focus approach by showing that expert performance of automated skills is impaired by the skill-focus and pressure conditions, but not the extraneous dual-task conditions. As we noted above, the extraneous dual-task conditions can be interpreted as a test for the basic distraction model. However, these studies do not address more developed distraction theories, which differ in significant ways from the basic distraction model.

Eysenck and Calvo's (1992) *processing efficiency theory* (PET) extends the basic distraction model by introducing a concept of *compensatory effort* (Fig. 4a). According to this account performance anxiety generates worries which take up working memory resources. But in addition to this, worry can prompt compensatory effort that increases the resources devoted to the task and may initiate remedial strategies (pp. 415–6). If this effort is not sufficient, then performance will be impaired. *Attentional control theory* (ACT) (Fig. 4b) is a further development of processing efficiency theory (Eysenck et al., 2007). According to this account anxiety is experienced when there is a threat to a current goal, and this has a number of effects on attention. It directs attention to the source of the threat, and it alters the balance of influence between two attentional systems: a top-down goal-directed system and a bottom-up stimulus-driven system (p. 338). The influence of the bottom-up system is increased, and the effect of this is to reduce the ability to inhibit task-irrelevant information. As with processing efficiency theory, compensatory effort can mitigate performance impairment, but will fail when resources are insufficient for the demands of the task.

The differences between these theories and the basic distraction model have at least two important implications for the research described above. Firstly, PET would not necessarily predict that distraction will affect performance in these conditions because

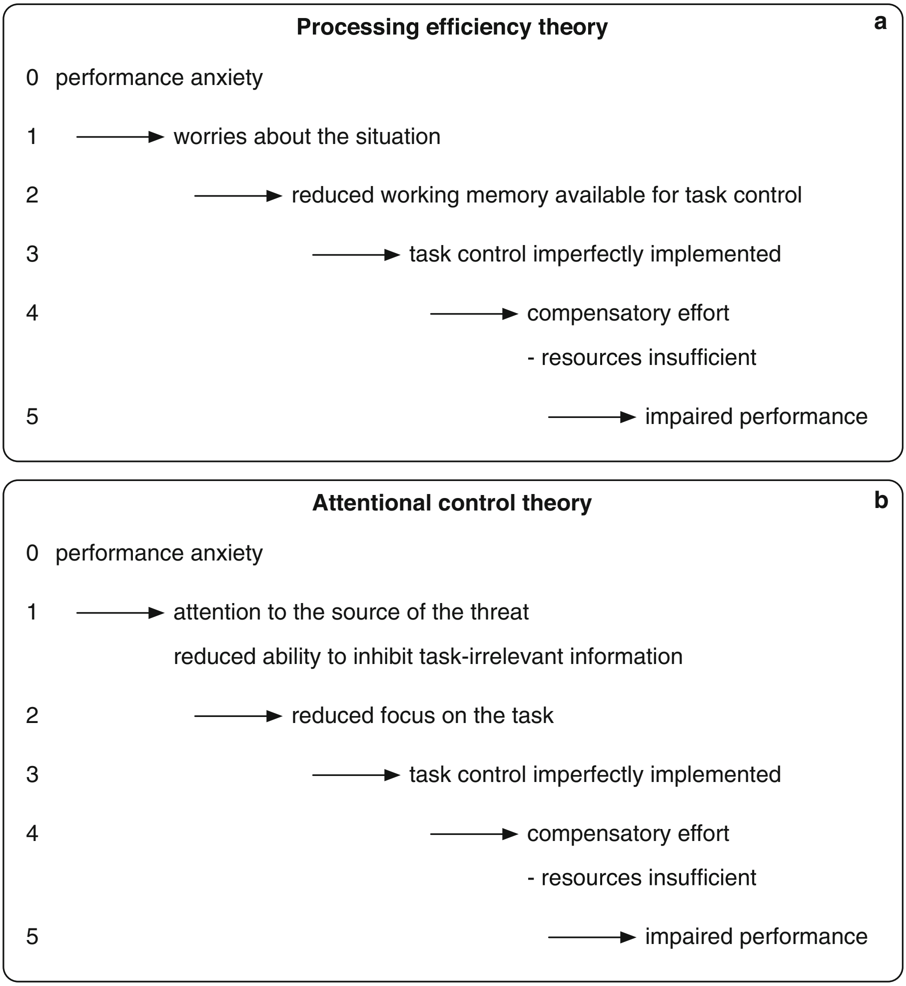

Fig. 4 **a** Processing Efficiency Theory (PET). **b** Attentional Control Theory (ACT)

of the role of compensatory effort, but it might predict that distraction will affect performance in more realistic, demanding performance conditions. We discuss this further below. Secondly, the extraneous dual-task conditions do not provide a good model for the kind of distraction that ACT proposes occurs in choking. The extraneous dual-task conditions have no emotional significance; they simply load working memory with cognitive processes irrelevant to the primary task. In contrast, according to ACT perceived threat has a biasing effect on attentional control. While the capacity limits of working memory play a role in ACT, the impairing effects of distraction are not solely caused by the overloading of working memory.

More specifically, in the case of a non-emotionally significant secondary task, compensatory effort can be used to re-organize cognitive processes to improve efficiency and reduce interference between the tasks. Significant performance impairment should occur only when working memory capacity is exceeded and performance of task control processes breaks down. In contrast, according to ACT a salient threat, such as the prospect of an embarrassing failure, will tend to draw attention to the threat. Compensatory effort can be used in an effort to counter this distraction, but interference to normal task control can occur even when working memory is not overloaded. Thus, the kind of distraction created by a secondary task with no emotional significance is quite different to the kind of distraction created by threat, at least as this is characterized by ACT.

Since these studies do not properly contrast the self-focus approach with the most advanced distraction theories, the extent to which they can be taken as providing support for the self-focus approach in comparison with the distraction approach is correspondingly limited.

One reason why distraction theories may not have been considered in detail in this research is because the dominant view is that motor skills are largely automated, and it is consequently not expected that they will be sensitive to distraction. PET and ACT are intended to explain the effects of anxiety on cognitive tasks that rely on working memory (Eysenck and Calvo, 1992, p. 414, Eysenck et al., 2007, p. 336), so based on the background view of motor skills it would seem unlikely that these distraction theories apply in the motor domain. This is an unsatisfactory situation, however, because it creates a circularity that reduces the value of the evidence. Distraction is considered an unlikely cause of choking in motor skills, only perfunctory tests of distraction-based explanation are performed, and it is concluded that distraction does not cause choking in motor skills.

3.2 Absence of direct tests for the central claims of self-focus theory

The research described above supports a number of elements of Beilock and Carr's self-focus account, and the apparent consistency of the overall pattern seems to provide strong abductive support for this account. That is, Beilock and Carr's self-focus theory would seem to provide a better explanation for this pattern of evidence than any apparent rival. It is nevertheless important to recognize that the research doesn't directly test the key claims of this account. As outlined above, we interpret Beilock and Carr's version of self-focus theory to include the basic self-focus model (Fig. 1a), a strong distinction between automated and non-automated skills, and the view that complex motor skills like golf putting and baseball batting are automated.

We can characterise the basic self-focus model as making the following four defining claims:

- C1 Attention to motor execution disrupts automatic motor processes, impairing performance.
- C2 Self-consciousness directs attention to motor execution or skill focus.
- C3 Performance pressure causes self-consciousness.
- C4 The mechanism described by C1-C3 is responsible for the performance impairment that occurs in choking.

Claims C1-C3 together describe a complete mechanism for performance impairment. C4 asserts that this mechanism is responsible for the performance impairment that occurs in choking. Because these four claims express the core ideas of the basic self-focus model, accepting or rejecting the model hinges on accepting or rejecting them. Accordingly, the most informative and compelling empirical tests for the theory will be direct tests of these claims. Tests of component claims made by the basic self-focus model, or background claims made by the larger theory, are inherently less informative and so provide weaker support.

3.2.1 The demonstration argument

One way to conceptualize relations between theory and evidence here is in terms of an idealized argument for the basic self-focus model, which we call the *demonstration argument.* This argument proceeds in three steps, each based on direct empirical tests for key claims. The tests involved in each step would involve comparisons between predictions of the basic self-focus model and fully elaborated versions of the most plausible alternative accounts. The first step shows that attention to motor execution can impair performance, thus establishing C1. The next step is to establish that the mechanism described by C1 is in fact responsible for performance impairments that occur in response to performance pressure - C2 and C3. The final step then shows that this mechanism causes choking. That is, it establishes C4.

The experiments employing the skill-focus conditions succeed fairly convincingly in establishing the first step of this argument: they show that attention to motor execution can impair performance (C1). But establishing C1 alone is not sufficient: we need C2 and C3 in addition. For this it must be shown that impairments in response to pressure not only can be, but actually are caused by this mechanism. The closest to a direct test of C2 and C3 is Gray's (2004) experiment examining performance on skill-focused and extraneous judgments in the context of performance pressure. If the impairments of the primary task in response to pressure are caused by attention to execution then performance on the skill-focus judgment should improve in comparison with low pressure conditions, while performance on the extraneous judgment task should be unaffected. This is what Gray found.

This experiment nevertheless doesn't provide a strong, direct test for C2 and C3 because it doesn't show causation, only correlation. Moreover, there are reasons why increased attention to execution might occur under pressure even when it isn't the primary cause of impairment. It might, for example, occur as a secondary effect of the performance impairment. In other words, the performance of the participants deteriorated under pressure, and this caused an increase in attention to execution.

It is also notable that the research doesn't include any direct tests for C4. Performance impairment in response to pressure *is* choking according to Baumeister's definition, but this research has not empirically validated that definition.[1] There is consequently no clear empirical basis for claiming that the performance impairments produced in the laboratory constitute choking. Stronger explicit tests for C4 would involve using an empirically validated definition of choking as a basis for assessing effects found in the laboratory, and also direct investigation of real world choking, of a kind we discuss below that probes the causal mechanisms involved.

The research thus fails to satisfy the criteria required by the demonstration argument. But it might be argued in response that the research substantially strengthens the plausibility of Beilock and Carr's theory of choking, even if it doesn't directly test

[1] Below we discuss the idea that choking should be characterized as a severe performance impairment.

the main claims of the basic self-focus model. That is, it provides the basis for a strong abductive argument for the self-focus theory of choking.

3.2.2 The indirect argument

A loose formulation of this argument, which we call the *indirect argument*, is as follows. The self-focus theory of choking sees the performance impairment that occurs in choking as arising from a disruption to automaticity, and is consequently closely linked to a widespread view that advanced stages of skill acquisition are marked by a high level of automaticity (Fitts and Posner, 1967; Dreyfus and Dreyfus, 1986). It may be the case that not all skills proceed to a high level of automaticity, but motor skills like golf putting and baseball batting are paradigm examples of skills that have been thought to automate. This view of skill learning and control lends a great deal of initial plausibility to the self-focus theory of choking, since automated skills should be disrupted by conscious attention and control, but tolerant of distraction. If these skills are tolerant of distraction then distraction is on the face of it an unlikely source of impairment during choking. This leaves conscious attention to execution as the strongest candidate for the impairing mechanism.

The main force of the research is that it supports this picture and provides evidence for some specific claims of self-focus theory. The idea that motor skills such as golf putting and baseball batting are automated is supported by the experiments showing reduced memory for performance and tolerance for distraction (Beilock and Carr, 2001; Beilock et al., 2002; Gray, 2004). The experiments showing impairment in skill-focus conditions support the idea that attention to execution is disruptive (Beilock et al., 2002; Gray, 2004). The experiments showing performance impairment in the pressure condition provide an initial basis for linking this mechanism to pressure (Beilock and Carr, 2001; Gray, 2004). Since the skills have been shown to be tolerant of distraction it is likely that the performance impairments that occurred in the pressure conditions were caused by self-focus since this is the only other candidate mechanism. Gray's (2004) experiment showing elevated attention to execution in pressure conditions further strengthens this inference, even if it doesn't directly show that this attention is causing the impairment. And while the research may not have directly shown that this form of impairment is responsible for real world choking, this is a reasonable conclusion to draw based on the overall set of results and the background theory. In other words, given this evidence together with the background theory, it might appear that the self-focus theory of choking is more likely to explain choking in motor skills like golf putting than is any apparent alternative account.

Furthermore, it could be argued, given the complexity of the phenomena and the difficulty of conducting controlled experiments on such phenomena, we should accept indirect abductive arguments like this. Insisting that we should only accept claims that have been directly tested would be requiring an epistemic standard that is unreasonable.

We agree that abductive arguments are a reasonable basis for accepting theories. Indeed, the interpretation of even the most 'direct' empirical tests relies on a conceptual background, so the evaluation of evidence is always abductive. The point of seeking empirical tests for theory that are as direct as possible is not to escape from a reliance on abduction: it is to strengthen the abductive case for the theory by providing the most direct checks possible on the assumptions and inferences that contribute to the abductive argument. A complex argument like this indirect argument is inevitably vulnerable to potentially faulty assumptions and inferences. If there are few or no direct empirical tests of the main claims of the theory, we need to be appropriately cautious in our regard for the theory. Including tests of the main claims that are as direct as possible doesn't eliminate the potential for error, but it does increase confidence.

3.2.3 Potential weaknesses of the indirect argument

But there are a number of possible weaknesses in this indirect argument. At the conceptual base of the account, there is room to doubt that working memory really plays little role in the performance of motor skills like golf putting. The view that these skills are largely automatic is widespread, but as Papineau (this issue) observes, it is also evident to practitioners that "having one's mind right" plays an important role in good performance. Doubt about whether motor skills are strongly automatic raises the possibility that distraction might contribute to choking in motor skills, and since this research has not carefully examined and tested distraction-based explanations it doesn't provide a strong basis for ruling them out.

There is also room to doubt that distraction and self-focus are the only two mechanisms of impairment that should be seriously investigated as potential causes of choking. Reasonable *prima facie* plausibility can be given to other potential mechanisms. For instance, some emotional responses to the performance situation - such as fear of imminent failure, shame about failing in public, or unrealistic hopes about countering recent poor form in a highly competitive situation – might weaken the motivation required to sustain the effort needed for high performance (Lazarus, 2000). Some forms of negative emotional arousal, such as strong fear, might also interfere with normal task control more directly by activating an avoidance system (Carver, 2006) that conflicts with the sensory, cognitive and motor system processes involved in normal performance. There is evidence to indicate that sensorimotor control can be impaired by certain forms of negative emotional state: for example, anxiety can impair posture control (Wada et al., 2001; Ohno et al., 2004).[2] The background theory on which the indirect argument relies on simply doesn't consider such possibilities so it doesn't provide any argument against them, and the experimental research provides no basis for ruling them out.

The strength of the indirect argument is also subject to concerns about the consistency of the evidence and the ecological validity of the experiments.

3.3 Inconsistent results and interpretations

As described above, DeCaro et al. (2011) found that distinct forms of pressure had selective effects. What they called outcome pressure impaired a skill dependent on working memory, but did not impair skills thought to operate independently of working memory. What they called monitoring pressure impaired skills that were thought to be automated, but not a skill dependent on working memory. If we focus on the way these

[2] We are not suggesting that all forms of negative emotion impair performance; to the contrary, emotions such as anxiety and anger can sometimes facilitate high performance (Lazarus, 2000; Hanin, 2007; Lane et al., 2012).

experiments are conceptualized, they appear to extend the prior research. But when viewed more closely the experiments raise some serious difficulties. This is because the ‘outcome’ pressure condition used by DeCaro et al. (2011) is essentially the same as the pressure condition employed by Beilock and Carr (2001) and Gray (2004) to induce impairments in sensorimotor skills that are supposedly automated (golf putting and baseball batting). In other words, this pressure scenario *did* cause impairment to putatively automated skills in the experiments of Beilock and Carr (2001) and Gray (2004), where it is interpreted as causing attention to skill execution, but *did not* cause impairment to putatively automated skills in the experiments of DeCaro et al. (2011), where it is interpreted as causing distraction rather than attention to skill execution.

This inconsistency is perplexing. Based on the earlier findings and their interpretation we should predict that the results of DeCaro et al.’s experiments would be different to what they actually were. That is, the ‘outcome’ pressure condition should have caused attention to execution and impaired the skills thought to be automated. Conversely, if we accept the DeCaro et al. findings and their interpretation of them it is hard to understand why the Beilock and Carr (2001) and Gray (2004) studies obtained the results they did. The pressure condition should have caused distraction, but not attention to execution, and should have had no effect on the putatively automated golf putting and baseball batting tasks. Consequently, we are unable to draw conclusions from any of the experiments involving the pressure condition; unless reasons can be found to reject some of these results we don’t know which experiments to trust.

If we have to set aside the results that involve the pressure condition the strength of support that the research contributes to the indirect argument is significantly weakened. We argued above that the research doesn’t directly show that the performance impairments that occurred in the pressure condition were caused by attention to execution. Nevertheless, the evidence was suggestive. But without this evidence, the research provides no empirical basis for drawing a link between performance impairments that result from attention to execution and impairments in response to pressure. This link can still be made based on the theoretical expectations for automated skills and the evidence that appears to show that golf putting and baseball batting are automated. But the research no longer provides empirical support for these expectations.

3.4 Problems of ecological validity

The experimental research described above is intended to support conclusions about skill control and choking in real world conditions. But to draw such conclusions with confidence we need an account of how the experimental conditions are related to real world conditions, specifying the grounds for taking particular experimental conditions as representative, and identifying dissimilarities that might affect our ability to generalize from the experimental results to skill in its real world context. Ideally, the interpretation of a particular set of findings would take the form of an explicit bridging theory that specifies clearly how the findings relate to real world phenomena.

Several researchers have raised concerns about the ecological validity of the tasks and attentional manipulations employed in laboratory-based experiments on choking (Wilson et al., 2007; Gucciardi and Dimmock, 2008; Hill et al., 2010a). These criticisms have centered on the unusual nature of the skill-focus conditions and the general dissimilarity of the laboratory tasks in comparison with performance in real world situations (see also Illundáin-Agurruza, 2013). Expanding on these points, we think that there are at least six areas where the ecological validity of the research is questionable: (1) the unusual nature of the context, (2) the low difficulty and monotony of the tasks used to assess experts, (3) the unusual nature of the skill-focus conditions in comparison with patterns of attention we might expect in natural conditions, (4) the relatively low intensity of the pressure conditions, (5) the relatively mild nature of the performance impairments found, and (6) the consistency of the performance impairments.

3.4.1 The unfamiliar nature of the context and task

In much of the experimental work we have described, both the laboratory context and the tasks the participants are required to perform are unfamiliar and significantly dissimilar to the tasks that the athletes would perform as part of normal competition. For instance, the putting task employed by Beilock and Carr (2001) was in the laboratory on carpet, and involved making the ball stop at a target on the carpet (p. 704). The pressure condition described in section 2.2 has general features that are common – incentive to perform well and dependence of others on good performance – but in specific features the scenario is unlike any that the participants are likely to have encountered as part of their normal golf experience. Moreover, the nature of the 'team' and its criteria for success are distinctly odd. There is no obvious, intuitive rationale for composing and evaluating a team this way.

This matters because these experiments are intended to reveal the nature of skill control and responses to pressure that occur in real world contexts. But elite athletes and other highly skilled individuals develop very specific performance techniques and strategies, such as pre-shot routines, which help them perform at a high level and cope with pressure (Cotterill, 2010). The unfamiliar and peculiar nature of the tasks makes it much less likely that they would draw on these techniques and strategies. If so, the experiments would then fail to reveal either the normal forms of control employed by the athletes, or the way that they would respond to pressure in real world performance conditions.

3.4.2 The low difficulty and monotony of the tasks used to assess experts

The difficulty of the tasks employed to assess expert performance has been very low in comparison with the performance conditions and pressure that experts normally experience when they are performing at a high level. For example, in Beilock and Carr's (2001) study golf experts were required to perform 70 putts on an indoor carpeted putting green from a fixed location 1.5 m from the target. In Gray's (2004) experiments baseball experts were required to complete between three and five hundred trials attempting to hit a virtual ball, where there were only two kinds of pitches (fast and slow). In each case these are simple and monotonous conditions in comparison with the conditions experts face in high level competition.

To generalize from the experimental conditions to the real world skills we have to assume that the nature of skill control is unaffected by the difficulty and variability of performance conditions. This is very unlikely to be true.[3] Thus, Beilock and Gray found that the experts performing golf putts experienced reduced episodic memory in comparison with novices ('expertise-induced amnesia'), while Gray found that the experts performing the baseball batting task were unaffected by a distracting secondary task. These are attributes expected of automated sensorimotor skills, as depicted in Table 1. But there is room to doubt that these same effects would be found in performance conditions that are realistic and challenging for experts. That is, it may not be the case that an elite golfer will show reduced episodic memory for putts taken in the context of a competition on a challenging golf course against high quality opponents.[4] Equally, the performance of a baseball player facing an excellent pitcher in a complex game situation may well be impaired if the player were required to perform an irrelevant task while batting (Christensen et al. submitted, in preparation).

This has implications for the comparison between self-focus and distraction theories. The finding that self-focus conditions impair performance in these kinds of skills but distraction doesn't seem to support the self-focus view, at least if we restrict our understanding of distraction to the basic distraction model. But the experiments examine the skills in conditions which are, from an expert's point of view, very easy. If working memory makes a contribution to performance there are reasons to think that this contribution would be greatest in difficult conditions. That is, we might expect experts to show much greater sensitivity to distraction in difficult conditions as compared with very easy conditions. These experiments thus leave open the possibility that distraction makes an important contribution to choking, given that real world choking tends to occur in conditions that are highly demanding.

3.4.3 The unusual nature of the skill-focus conditions

With regard to the unusual nature of the instructions used to get participants to focus on skill execution, the patterns of attention that are involved are abnormal in comparison with the patterns of attention we might expect in normal performance, and may also differ from those that occur in choking. Thus, Beilock et al. (2002) asked soccer players to attend to the side of the foot that contacted the ball, while Gray (2004) instructed participants to attend to whether the bat was moving up or down at the point when a tone sounded. In one respect the unusual nature of these attentional instructions is not unreasonable: the hypothesis being investigated is that during choking the individual adopts an abnormal self-focused pattern of attention, and this impairs performance. However, the patterns of attention that are induced by these instructions might be different to the kinds of self-focus involved in choking, if indeed self-focus does play a role in choking. For example, under pressure the performer's attention might be drawn to details of their technique that they are concerned about, such as aspects of stance or the proper timing of a difficult movement transition. Such technique-oriented attention may be subtly but importantly different from attention focused on the body or equipment. Thus, a guitarist who selectively focuses on *fingering* during a difficult passage

[3] In section 5 below and +Christensen et al. (submitted, in preparation), we give theoretical grounds for thinking that task difficulty will affect dual-task sensitivity.

[4] Some anecdotal evidence suggests that there may be large individual differences in the nature of individual experts' memory for specific competitive performances, even within particular sports like golf and cricket (Sutton, 2007).

has a subtly but crucially different form of attention to one who focuses on her *fingers* while playing. To generalize from the experimental conditions to real world choking we need to assume either that all forms of self-focused attention are equivalent, and equivalently bad, or that these particular kinds of self-focus occur in choking. But both assumptions might be wrong.

An issue of concern to philosophers is whether these experiments support the view that skilled action is non-reflective (Cappuccio, this issue). That is, can we reasonably infer from these experiments that reflective awareness plays no role in skilled action? The abnormal nature of the self-focus instructions makes this inference dubious. The fact that unusual forms of self-focus harm the performance of these skills in these (fairly simple) conditions doesn't show that self-awareness plays no role in sensorimotor skill. These experiments leave open the possibility that experts develop forms of self-awareness that assist action control. For example, a mountain biker may develop an enhanced awareness of balance, and anticipatively adjust balance using body movements according to the changing demands of the trail, line and speed.[5]

In general, we should expect that experts develop highly tuned patterns of attention (Sutton et al., 2011; Christensen et al. submitted, in preparation). Because these patterns of attention will be finely structured we can't use crude, abnormal attentional instructions as an effective, sensitive assay for determining what the natural targets of expert attention are.[6] Crude attentional instructions to focus on a particular target during performance can disrupt the performance *even if* the target forms part of the natural attentional pattern of the expert. For example, drivers use patterns of attention that are spread across multiple targets so as to allow them to maintain integrated awareness of the situation, monitoring their position in the lane, relations to nearby cars, and their instruments, checking speed in particular. It is quite likely that a driver who was instructed to look for red cars and identify their make would exhibit impaired driving performance, even though being aware of nearby cars is an important part of normal driving.[7]

The fact that the skill-focus conditions employed in the experiments tend to differentially impair performance in comparison with extraneous distraction does indicate that these kinds of self-focus can be especially harmful compared with other unnatural attentional distortions. That is, the research shows convincingly that unnaturally induced self-focus is not *just* a kind of distraction. But the method employed is not sufficiently sensitive to be a reliable guide to the natural patterns of attention and awareness in experts. Indeed, we should distinguish the expert's embodied *self-awareness* from self-consciousness and self-focus. For example, a mountain bike rider can be aware of shifting her stance on the bike forwards at the start of a technical climb (one that includes difficult obstacles) while having her main focus of attention on the line that she will take. In ordinary usage being self-conscious is usually interpreted as impairing and something to be avoided, but being self-aware in contrast is thought of as

[5] Our mountain bike examples are based on discussions with Kath Bicknell, who conducts research on embodied cognition in mountain bike racing (Bicknell, 2010) and is an experienced rider, on Lopes and McCormack, 2010, and on the experiences of Christensen as novice mountain biker.

[6] In section 5 below we discuss ways of improving the ecological validity of experimental research.

[7] Barbara Montero helped us to refine this example (personal communication). Engstrom et al. (2005) show that increases in visual and cognitive load can adversely affect driving performance.

enabling and desirable. We suggest that this folk-conceptual distinction probably corresponds to distinct forms of attention that both include information about the self.

Further, there may be not just two but a variety of relevant forms of self-perception. Thus, there may be forms of skill awareness that are distinct from skill self-consciousness, forms of motor awareness that are distinct from motor self-consciousness, and so on (Sheets-Johnstone, 2009; Colombetti, 2011). Being aware of stance and balance while riding a mountain bike is distinct from focused attention on the body. Indeed, riders aim to ride with ‘light hands’, and can be aware of light hands without directing focused attention to their hands. The skill-focus conditions succeed in producing impairing forms of attention to the motor and bodily self, but this doesn’t rule out the possibility that there are forms of body, motor and skill awareness that are beneficial for skilled performance.

3.4.4 The low intensity of the pressure conditions

As we’ve discussed, the interpretation of the experiments involving the pressure condition is clouded by the inconsistency in the results. But even if this inconsistency is resolved, for example by providing grounds for viewing the findings of DeCaro et al. (2011) as anomalous, there are further problems with the ecological validity of the scenario employed in the pressure condition.

One problem is that the intensity of the pressure is much lower than the intensity of the performance pressure likely to be experienced in real world choking. As described above, Baumeister defined performance pressure as any set of factors that increase the importance of performing well on a particular occasion. In the pressure condition the main consequences of failing to meet the performance criterion are missing out on a small money reward and disappointing an entirely nominal teammate. This is mild pressure in comparison with high stakes performance situations in elite sports, such as a major national or international competition.

Certainly the pressure is not always equally high at every elite sporting event. But there are cases in which a whole year of effort by an individual performer, or a team, or an entire national organization, is at stake, with all the emotional significance of the social bonds, the personal aspirations, and the hopes of fans that are typically involved. Sometimes an entire career can be at stake, along with years or a decade of preparation for a particular opportunity. Such cases may be rare enough, but they are of special significance to elite performers, who will often identify such high-pressure events as the motivating force for their entire career. Further, these high-intensity events are among those at which choking is possible. Consider the brilliant Italian footballer Roberto Baggio: needing to score to keep Italy in the penalty shootout against Brazil in the 1994 World Cup Final, Baggio fired his shot wildly over the crossbar. The British swimmer Melanie Marshall was world number one in the 200 m freestyle going in to the 2004 Olympics: after finishing last in her semi-final and thus failing to qualify for the final, she said “It is not just 4 years, it's 15 – to say I'm gutted would be an understatement. I don't know what went wrong, there was nothing left. To finish 16th is embarrassing for me and for everybody else, it's just awful” (Peterborough Telegraph, 2004).

In these cases the athletes were close to attaining the highest achievements possible in their sport, and there were strong reasons to believe that they could succeed.

Reaching this point had involved many years of preparation, and the opportunities were in each case rare occurrences. Though even the best athletes can expect to be in this kind of situation at most only a few times, these are the events that they often care about most, against which their careers may be defined, and in which the danger and the cost of performance impairment, whether mild or severe, is viscerally real. Excelling in elite sport essentially involves coping with such pressures.

To generalize from the experimental research described above to real world choking we need to assume that the large differences in the intensity and nature of the pressure do not affect the basic mechanisms in operation. This may not be the case. For instance, it is likely that different psychological effects arise from a sense of obligation to specific emotionally important others as compared with a somewhat arbitrarily imposed transient obligation to an unknown individual. It is also possible that severe stress caused by a performance situation with major life-affecting consequences has qualitatively distinct effects on cognitive and motor systems in comparison with mild stress.

In addition to low intensity, the incentive structure of the laboratory pressure conditions is predominantly negative, which makes generalization problematic because real world performance situations can have a wide range of incentive structures. We discuss this issue in section 5.3.

3.4.5 The mild nature of the performance impairments found

The issue of the low intensity of the pressure is related to the relatively small performance impairments found, which are modest in comparison with the severe performance breakdowns that can occur in cases of real world choking (Hill et al., 2009). For example, Beilock and Carr (2001, p. 717) found that a single task group performing a putting task suffered an increase of 2.21 cm in the mean distance to the target in an 18 putt high pressure test in comparison with an immediately preceding 18 putt low pressure test, where the putting distance was between 1.2 and 1.5 m from the target. This is not a striking performance decline, and, indeed, the performance of the group in the high pressure test was little different to their performance in the 18 putt bout preceding the low pressure test.

Hill et al. (2009) argue that the standard definition of choking taken from Baumeister (1984; Baumeister and Shower 1986) fails to capture the phenomenon as it occurs in real sporting contexts. Based on the views of experts in applied sports psychology who conducted research on anxiety and performance and who worked with athletes they suggest that choking should be understood as a significant or catastrophic drop in performance, rather than a mere decline (pp. 206–7). We think this is reasonable, but regardless of the specific definition of choking employed it is certainly possible that different mechanisms are involved in severe performance failures as compared with mild performance decreases. It is consequently not safe to assume that the performance impairments found in these studies are the same as those that occur in real world choking.

3.4.6 The within-study consistency of the performance impairments

The effects of the pressure scenario were not consistent across studies, but they were consistent within studies. Beilock and Carr (2001) and Gray (2004) found that the pressure scenario produced a statistically reliable decrease in performance in the groups performing skills thought to be automated. DeCaro et al. (2011) found that the pressure scenario, in this case labeled 'outcome pressure', produced no impairment in supposedly automated skills, but reliably impaired a skill dependent on working memory.

If we set aside the DeCaro et al. finding and consider the first two studies, the finding that the pressure scenario produced consistent decreases in performance is, ironically, a reason for doubting that the mechanism involved is the same as that involved in real world choking. Not all highly skilled individuals choke, and those who do choke do not usually choke every time they experience some performance pressure. Beilock and Gray note the problem, saying that "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" (2007, p. 428). However, they do not register the conceptual significance of the problem: if real world choking has a very different pattern of incidence to the phenomenon found in the laboratory, then different mechanisms are at work. It may be the case that the laboratory research identifies some of the mechanisms involved in real world choking, but at the very least additional mechanisms are required to explain why there is much greater inter- and intra-individual variability in the occurrence of real world choking.

4 Contrary evidence

Up to this point our discussion has focused on limitations of the experimental research that has been viewed as supporting the self-focus approach. We argued that these limitations undermine use of this research to draw conclusions about real world choking. But we have not yet provided positive reasons to think that real world choking does in fact violate the predictions of self-focus theory. In section 5 we will shift register by offering our own alternative theoretical framework, which seeks to integrate a wider range of interacting factors that can contribute to choking, and presents suggestions for empirical work to test and develop this broader account. But this constructive part of our project is independent of our critical evaluation of self-focus theories: the concerns we worked through in section 3 above need to be answered, even if our alternative framework is not the right one.

But first, in this section we briefly note a distinct and independent body of work on real world choking. There is some tension between the predictions of self-focus theory and several qualitative studies of choking (Gucciardi et al., 2010; Hill et al., 2010a; Oudejans et al., 2011). These studies were designed to provide a richer descriptive understanding of real world choking than has been assumed in the experimental research (Gucciardi and Dimmock, 2008; Hill et al., 2009). Qualitative methods have important limitations, such as relying on memory and personal understanding of the choking process, but they do provide a depiction of the phenomenon under investigation (McIlwain and Sutton, forthcoming). It is consequently a significant problem for the self-focus approach that the results of these studies emphasise distraction rather than self-focus as a key mechanism involved in choking.

Specifically, Gucciardi et al. (2010), Hill et al. (2010a), and Oudejans et al. (2011) each found that those who had experienced choking tended to report distraction as the main cause, with few describing attention to execution as playing a role. In addition, Gucciardi et al. (2010) and Hill et al. (2010a) reported other contributing factors that are not directly addressed by the self-focus theories, including unrealistically high expectations in chokers and a tendency to use performance outcomes for self-validation. Hill et al. (2010a) found that, in contrast, individuals who did well under pressure had more realistic expectations for performance, adopted a task-focused approach, and maintained a neutral stance towards particular outcomes during performance. To repeat, the results of these qualitative studies need careful evaluation in their own right, which we will offer in future work. Here, though, we discuss some of their particular implications for self-focus theories further in the next section.

5 An expanded approach to choking

One potential response to the apparent tension between the results of self-focus and qualitative approaches would be to develop refined experimental designs in support of the self-focus account, seeking more consistent results and stronger ecological validity. Another possible response is to take the qualitative findings as providing support for the application of distraction theories to choking in these kinds of skills (Wilson, 2008). A third response involves developing an expanded approach to choking. Such an approach would address a wider range of issues, aiming at more comprehensive and systematic theory.

The first two responses each have merit, but we think the third response is the right one. The development of well-designed experiments with good ecological validity requires theory that is more elaborated than either self-focus or distraction approaches currently provide. The problems of ecological validity faced by the self-focus research can in part be attributed to an unsystematic approach to theory construction. Moreover, a good theory of choking needs to incorporate a broader range of issues in order to achieve high levels of predictive and explanatory adequacy. Indeed, as we noted, Baumeister and Showers (1986) and Masters and Maxwell (2008) discuss many factors that influence choking but that aren't part of their respective theories. A full theory of choking needs to explicitly address these issues. In this section we identify some key requirements for such an expanded approach.

5.1 An elaborated descriptive picture of choking

The problems of ecological validity and the mismatch with the qualitative evidence are symptoms of a basic theoretical weakness in the self-focus approach, namely a poorly developed characterization of the phenomenon that is the target of explanation, or *explanandum*. The ability to develop good theory - the *explanans* - is fundamentally constrained by the quality of the characterization of the explanatory target. The self-focus approach has suffered from using a characterization of choking that has had little detail, and which was not given careful empirical validation. The qualitative evidence is particularly important in this respect because it is a starting point for developing a clearer, empirically validated picture of the nature of choking. A variety of methods will be required to overcome the limits of the self-report methods that the qualitative studies rely on (McIlwain and Sutton, forthcoming; Sutton and McIlwain, forthcoming), but an elaborated descriptive picture of choking will have many benefits. It can inform more specific and detailed models, richer theory, and experimental design with greater ecological validity.

5.2 A more nuanced and elaborated theory of normal skill control

As we've discussed, the idea that many skills become automated in the course of skill acquisition – with motor skills as paradigm cases – is the primary source of support for the self-focus view of choking. But the evidence discussed above gives rise to a striking tension. On the one hand there is the evidence showing that golf putting and baseball batting show sensitivity to skill focus conditions and tolerance for distraction. These are characteristics expected for automated skills. But there is also the evidence from the qualitative studies that distraction plays a large role in choking in golf and other sporting skills.

The development of a good theory of choking will require a theory of normal skill control that is able to resolve this tension. Our theory of skill learning and control illustrates one way to resolve the tension (Christensen et al. submitted, in preparation). This theory is called *Mesh* because it proposes that cognitive control plays an important ongoing role in advanced skill, with cognitive and automatic processes being closely integrated. This integration involves a broadly hierarchical division of responsibilities, with cognitive control often focused on strategic aspects of performance and automatic processes typically more concerned with implementation. In addition, the role of cognitive control becomes increasingly important as performance difficulty increases.

According to *Mesh,* the fundamental reason advanced skills do not automate fully is that the performance demands of such skills are too complex and variable. Certainly, precise adjustment to a complex situation does depend on a great deal of automation in perception, judgement, and action control. But experts achieve the highest levels of performance by integrating or meshing cognitive and automatic processes closely. A musician can focus on expression rather than technique, while a sportsperson can focus on the strategic and tactical demands of the situation, relying on lower-order technique to handle the detailed implementation of action. But expert attention also roams, and when strategically required can slide down, so to speak, to focus on relatively specific features of implementation: the fingering in a difficult passage, or the adjustment of the wrists against a spin bowler in particularly challenging conditions for cricket batting. This roaming flexible allocation of mindful attention is itself a skill that may be honed through experience, and with practice may take up fewer attentional resources in its own right (Geeves et al., 2008).

The distinctive features of *Mesh* can be highlighted by contrasting it with other theories of skill learning and control. Classic theories such as Fitts and Posner (1967) and Dreyfus and Dreyfus (1986) describe a progression during skill acquisition from cognitive to automatic control: this assumes that automatic control processes become competent to generate skilful responses to the full range of situations that the expert normally encounters. Contrary to this, *Mesh* claims that cognitive guidance generally plays a crucial role in the construction of situation-specific responses. The core reason is that advanced skills are characteristically performed in situations that exhibit high levels of variability, and cognitive control is required for interpretation and situation-specific shaping of responses.

Mesh proposes that cognitive control typically plays an active, continuous role in shaping action. We can better specify this role by contrasting it with a less interventionist view of cognition in skill. Starkes et al. (2004) distinguish between *perceptual-cognitive* processes and *perceptual-motor* processes: one possibility is that these are largely distinct, with perceptual-motor processes being largely automated and perceptual-cognitive processes remaining under cognitive control. Thus, in soccer a decision about whether to pass or attempt to go around a defender might be performed cognitively, while the action itself (e.g., pass) is performed automatically. Starkes et al. appear to hold this view (see especially pp. 266–68), and Beilock and Gray (2007) draw a similar distinction (p. 434), summarized in the quote presented above (section 2.1.4). In contrast, *Mesh* claims that action execution is usually cognitively guided.

We can clarify this difference by distinguishing between *stage setting* and *guidance* models of the role of cognitive control in the production of skilled action. On the stage setting model cognitive control is responsible for establishing the larger context in which action occurs, for example by performing strategic judgments and decisions that determine whether an action is to be performed, while execution occurs automatically. For example, the participants in Beilock and Carr's (2001) putting experiments no doubt employed cognitive control in understanding the task instructions and in preparing to perform the putts. However, according to Beilock and Carr, for the experts the execution of the putts was automatic. On the guidance model adopted by *Mesh* cognitive control not only specifies the type of action together with key parametric adjustments that shape the action to the situation, but also sustains and adjusts the action through the course of execution (in this respect the account has similarities to that of Pacherie, 2008). In the case of a relatively fast, short action such as a golf putt there will be little adjustment through the course of the action, but cognitive control nevertheless makes an important contribution to execution by maintaining an 'action set', or control configuration, that guides the motor processes involved in execution.[8]

In the case of actions with extended duration performed in complex, dynamic situations, cognitive control may both establish an action set and adjust it during the course of executing the action. For example, as a mountain biker approaches a corner she initially sets up for a particular line, such as a 'late apex' line with a wide entry and tight exit, anticipatively adjusting speed and then lean to suit the line and surface. As she executes the turn she maintains and adjusts her action set, for instance by increasing lean and loading the tires (by driving her weight through the pedals) if high speed threatens to cause her to run wide at the exit.

The stage setting and guidance models thus give divergent predictions concerning the effects of distraction on action execution. According to the stage setting model action execution should be tolerant of distraction. This yields the expectations depicted in the left column of Table 1. In contrast, distraction should tend to impair action execution, according to the guidance model, because it will weaken the action set and may prevent necessary adjustments. The extent to which action execution is sensitive to distraction will depend on the difficulty of the conditions. In easy conditions the action

[8] The concept of an action set that we are employing here is based on that of a 'task set' (Sakai, 2008). A task set is a control configuration required for performing a particular task, while an action set, as we are employing the term, is a control configuration specific to a particular action.

set is simple and little or no adjustment is required, which should result in relative tolerance for distraction. But in difficult conditions the action set that is required for effective performance is demanding, and adjustments may be required. As a result, action execution will show much higher sensitivity to distraction. In easy conditions, then, the expectations of the stage setting and guidance models are similar, and the guidance model can accommodate the experimental evidence showing that golf putting and baseball batting tolerated distraction (Beilock and Carr, 2001; Gray, 2004). But the guidance model predicts that in more complex, realistic conditions action execution will exhibit sensitivity to distraction: this is consistent with the results of the qualitative studies described in section 4.

Our account is not the only way to reconcile these different forms of evidence. But a good theory of choking needs to be based on a theory of normal skill control that provides some reconciliation of this kind. The Fitts and Posner (1967) view of skill acquisition, on which the self-focus theory is based, can't accommodate this mixed pattern of evidence. But if we abandon the Fitts and Posner view of skill the self-focus approach to choking is unlikely to survive in its current form. As discussed above, the self-focus approach relies on the idea that the only plausible candidate mechanism for impairment in automated skills is attention to execution. In contrast, an enriched picture of normal skill control will recognise that there are other mechanisms that can play a role in choking. Attention to skill execution might contribute to choking, perhaps in some cases more than others, and for some people more than others. But it is not likely that attention to execution is the sole cause of choking, even in skills like golf putting that do involve significant automaticity.

5.3 Appraisal of the performance situation

A major theoretical weakness of the self-focus approach is that it hasn't properly addressed the problem of why choking occurs in some cases and not others. The most fundamental question for a theory of choking is not 'Why does choking occur?', but rather, 'Why does choking *sometimes* occur?' The failure to tackle this issue systematically is especially problematic because Baumeister and Showers were sharply critical of existing arousal theories of choking on the grounds that they failed to adequately explain why choking occurs in only some cases (1986, p. 363–4). Yet, taken at face value, all of the self-focus models of choking described above (Figs 1a, 2, 3a, b) imply that choking should always occur in response to pressure. Distraction theories (Figs 1b, 4a, b) also have limited resources for explaining why choking occurs in some cases and not others.

A crucial problem for both approaches is that they begin with the assumption that performance pressure produces a negative psychological response, either self-consciousness (Fig. 1a) or worry (Fig. 1b). Framing the issue properly requires an explicit account of the features of the objective pressure situation that influence choking and the appraisal process that interprets the situation and can produce varied responses to it (see Fig. 5). As a first approximation we can characterize the pressure situation as having two key elements: *incentive structure*, by which we mean the positive and negative consequences of performance outcomes for the individual, and *narrow task difficulty*, by which we mean the challenge posed by the task for the individual, given his or her abilities under ideal incentive conditions.

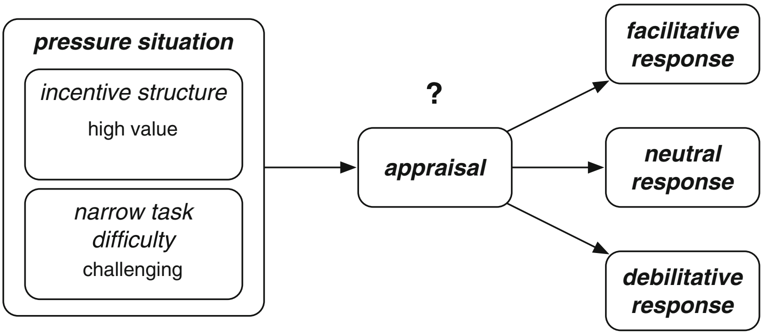

Fig. 5 Appraisal

We need to distinguish narrow task difficulty from a broader notion because, understood in a wider sense, the difficulty of a task includes the effects of its incentive structure on performance. Thus, the difficulty of a 2 m putt from a particular location on a particular green with a $100 bet on the outcome includes the subjective effects of the bet. In contrast, narrow task difficulty is the degree of challenge posed by a task when the incentive structure is such that it allows the individual to fully express their ability to perform the task. Thus, the narrow difficulty of a 2 m putt from a particular location on a particular green is the difficulty it has for an individual when the incentive structure allows the individual to perform at their best. This approximately corresponds to the ordinary notion of difficulty as applied to sensorimotor tasks: distinguishing narrow from broad difficulty makes it possible to capture the idea that performance pressure can make it difficult to perform an 'easy' task. In our discussion, though, we focus primarily on cases where the consequences have high impact and the task is very challenging in the narrow sense. This will be the most typical situation in elite sports competition.

The individual's response to the situation depends on an *appraisal* that takes these and other features of the situation into account (Lazarus, 2000; Jones, 2003). The qualitative evidence discussed above indicates that different individuals are interpreting performance situations in very different ways, which lead to very different kinds of responses (Hill et al., 2010a). In Fig. 5 we depict three kinds: a *debilitative response*, in which there is substantial performance impairment, a *neutral response*, in which the appraisal has no negative or positive impact on performance, and a *facilitative response*, in which the appraisal results in improved performance.

Participants in the Gucciardi et al. (2010) and Hill et al. (2010a) studies claimed that performance anxiety could be a spur to higher performance, suggesting that pressure does sometimes produce a facilitative response (see also Hanin, 2007, p. 51). This is compatible with *Mesh*, as we've described it above, because increased cognitive effort could produce strengthened implementation of higher order technique such as the pre-shot routine, and improved situation awareness and action targeting. The self-focus approach, on the other hand, offers no theoretical basis for understanding what a facilitative response could be. It sees optimal performance as largely automatic (Beilock and Carr, 2001), so cognitive effort should always interfere. This is encapsulated in Baumeister (1984); Baumeister and Showers, 1986) characterization of choking as ‘paradoxical’: performers do worse *because* they try to improve their performance.

One of the differences between the individuals who tended to choke and those who did well under pressure in the Hill et al. (2010a) study was a difference in viewing the situation as threatening or an opportunity. Thus, one participant said “I enjoy first tee nerves, as I think of it as a positive thing. It makes me concentrate more. You want to do it even more, because you want to impress. I practice for those moments” (p. 228). This raises the possibility that an appraisal of threat tends to lead to a debilitative response to pressure whereas an appraisal of opportunity tends to result in a facilitative response (see also Lazarus, 2000).

In light of these considerations it is worth reconsidering the nature of the pressure conditions employed in the self-focus research. We argued above that the intensity of the pressure is low in comparison with the performance pressure that elite performers experience in real world conditions. But it should also be noted that the incentive structure of the conditions is strongly slanted towards threat rather than opportunity. The threat in the pressure condition lies in the risk of failing to match the performance standard of the teammate, of being negatively compared to the teammate, of causing the teammate to miss out on the money prize when they’ve fulfilled their part of the requirement, of disappointing them, and in the fact that the risk of failure is high because the performance criterion is hard to achieve (a 20 % improvement). Conversely, the best that the participant can achieve is to match the performance of the teammate, not ‘let the team down’, and win a very small prize. This very distinctive, slanted incentive structure is another reason for doubting that the results of the self-focus experiments should be viewed as a general guide to response to pressure. Real world performance pressure can have a wide range of incentive structures, including incentive structures that offer much greater opportunity.

One way to address this problem experimentally would be to vary the components of pressure independently and examine the effects on performance. For instance, the size of the reward could be varied while holding other components constant, or the criterion for success could be varied, etc. It is possible that some combinations might have very different performance effects. For example, a pressure condition with no social component, a more substantial reward (e.g., $50), and a more attainable success criterion (e.g., 10 % improvement), might result in improved performance rather than a performance decline. Similarly, a realistic opportunity to beat the performance of a teammate or other participant, rather than simply match it, might produce improved performance.

To understand variation in the incidence of choking we need to distinguish between two issues. The first concerns the way that variation in the situation can make choking more or less likely. Thus, some situations can have a structure that makes choking especially likely. The second issue concerns the way that variation in the interpretation of the situation affects the likelihood of choking. Thus, in a given situation, some individuals interpret the situation in a way that makes choking more likely, while others interpret the situation in a way that reduces the likelihood of choking. To help distinguish these two issues we can contrast the *pre-interpreted structure* of a situation and the *interpreted structure* of a situation. The pre-interpreted structure of a situation for a given individual includes the objectively determined incentive structure and difficulty of the task for that individual. That is, it includes the individual’s abilities and the general nature of the incentive values of the various outcomes that are possible for that individual. The interpreted structure of the situation is the way that the individual perceives the task and its incentive structure. This can differ substantially from the pre-interpreted structure. Thus, a particular individual may see themselves as lacking the ability to succeed in a given situation, when in fact their abilities are more than adequate. Likewise, a given individual can fail to appreciate the value that a particular outcome has for them, for instance by not properly understanding the impact that winning or losing a particular game will have on their career.

A full theory of choking needs to address the roles of both pre-interpreted situation structure and interpretation in influencing choking. The manipulations of pressure described above alter the pre-interpreted situation structure. If such manipulations have consistent effects, which we think is very likely, it will be because different individuals tend to have similar responses to similar situations. But at a finer grain it is necessary to understand how divergent responses can occur. It may be that the consistency of response to a situation is itself influenced by the pre-interpreted situation structure: some situations may be such that almost everyone responds in the same way, while others may produce comparatively divergent responses. Thus, our criticisms of the pressure condition used in the self-focus experiments in part concern the fact that the nature of the scenario imposes strong constraints on likely interpretations. That is, the pre-interpreted structure of the situation is such that few if any participants are likely to interpret it positively, as an opportunity.

So far we haven't addressed the nature of the cognitive mechanisms involved in appraisal. In our view these will be complex, including conscious and unconscious processes, and processes that are partly conscious. Thus, emotion research has drawn a distinction between *primary appraisal*, which is an initial evaluation of the significance of the situation that is often non-conscious, and *secondary appraisal*, which involves more complex interpretation and is often conscious (Lazarus, 1991; Lambie and Marcel, 2002). Personality traits such as dispositional self-consciousness and trait anxiety will influence appraisal, but the qualitative evidence suggests that conceptual schemas for interpretation play a crucial role in conscious appraisal. Thus, individuals with a propensity to choke appeared to interpret performance situations in a way that accentuated the personal significance of particular performance outcomes, while those who did well tended to de-emphasize the personal significance of outcomes. One effect of accentuating the personal significance of outcomes will be to increase the perceived potential threat presented by the performance situation.

However, it is important to keep in mind that non-conscious appraisal mechanisms are also likely to play an important role. The contribution of these mechanisms to decision-making is evident in the Iowa Gambling Task (Bechara et al., 1997). In the standard version of this experimental paradigm participants select cards from four decks, where a given card can provide rewards or penalties that can be high or low, specified in amounts of money. The decks are structured such that two provide high rewards and high penalties and will yield a net loss, while the other two provide small rewards and small penalties, and will yield a net gain. The relevant point is that normal participants learn to select from the advantageous decks before they are consciously aware of the reasons why they should make this choice, and they develop hunches prior to full conscious understanding (Bechara et al., 1997). Non-conscious evaluative mechanisms may make a contribution to choking by tracking recent performance history and generating expectancies about the likelihood of success in the current situation. Hill et al. (2010a) found that chokers tended to have less rigorous preparation for competition than those who did not choke, and described themselves as feeling overloaded. It is possible that they had lower expectancies of success compared with athletes who prepared rigorously, though they might not have been consciously aware of low confidence prior to encountering the situation.

An important, challenging performance event inevitably presents significant risk. But some performers exhibit hardiness (Kobasa, 1979) - a tendency to see a difficult situations as a challenge, and to maintain a firm commitment to succeeding and a firm belief that one can control the relevant parameters. For hardy individuals with strong expectancies of success, the situation predominantly presents opportunity. Moreover, in the face of particular misses and errors, confidence in ability should lead to a response that maintains and strengthens normal task control. In contrast, an individual with low expectancies of success is likely to experience an important performance situation primarily as a threat. In the face of misses and errors, low confidence may lead to a reduced commitment to normal task control.

Two basic points condense our discussion of situation appraisal. Firstly, a good theory of choking needs to explain how the nature of the situation affects the likelihood of choking. Secondly, a theory of choking needs to address the issue of divergent responses to situations whose pre-interpreted structure is similar. An account of appraisal will be central. Personality traits, conceptually-based interpretive strategies, and non-conscious evaluative mechanisms are all likely to play a role in appraisal, influencing the nature of the response to performance pressure.

5.4 Distraction

The self-focus and distraction approaches both see choking as involving a departure from normal patterns of attentional control. Beilock and Carr’s (2001) characterization of the mechanisms posited by self-focus and distraction theories as “complete opposites” can be challenged. The difference between self-focus and distraction theories is not that the latter involve distraction and the former do not, it is that they see two different kinds of distraction as causing choking. Accordingly, a good theory of choking – even one developed within the self-focus approach – must include an account of the mechanisms of distraction that overwhelm normal attentional control. The importance of distraction is further reinforced by the qualitative studies, which all prominently emphasize distraction (understood as contrasting with self-focus) as a reason for the performance impairment that occurs in choking. The distraction theories we described in section 3.1, PET and ACT, provide some conceptual resources for understanding how attentional control fails, but are arguably incomplete.

As discussed above, these distraction theories assume that the situation is perceived as sufficiently threatening to provoke a substantial threat response: so an account of appraisal is required to understand the circumstances in which this will be the case. The question then is why the psychological response to the threat overwhelms the resources of attentional control. PET and ACT suggest that task difficulty and compensatory effort play important roles.

We suggested two related reasons why the extraneous dual-task conditions described in 2.2 didn’t produce significant performance impairment in the primary tasks. The first is because the task difficulty was low in comparison with the abilities of the expert participants. The experts were consequently likely to have possessed sufficient working memory capacity for both the primary and secondary tasks. Secondly, they may have been able to use compensatory effort to mitigate the effects of the distraction.

The limitations of the capacity to compensate for distraction provide an initial answer to the question of why attentional control can fail under pressure. Narrow task difficulty, in the sense defined above, will typically be high in elite sports competition, which means that even limited misdirection of attention and intrusion of extraneous thoughts is likely to affect task control, and there is little spare capacity for compensatory effort. In addition, ACT proposes that attentional control is fundamentally altered by strong threat, which will tend to make it difficult to exert voluntary control over attention when there is a perception of strong threat.

Nevertheless, PET and ACT do not fully explain why attentional control fails in some cases. One issue that needs to be addressed is the nature of compensatory effort. Here we can distinguish between at least two kinds of compensatory control. One type involves the direct maintenance of effective task control, and includes reorganizing task control processes more efficiently and increased monitoring of task processes, such as the pre-shot routine in golf, to ensure proper implementation. A second type includes strategies for emotional self-regulation, such as acknowledging to oneself that misses can occur because of features of the situation that can't be controlled. 'Self-talk', or talk that a performer directs to themselves to influence their performance, is a form of compensatory control that may perform both roles (Hatzigeorgiadis et al., 2009; Miles and Neil, 2013). As we saw, Masters and Maxwell (2008) regard self-talk as one of the potential triggers for attention to motor control and impaired performance, but the studies by Hatzigeorgiadis et al. and Miles and Neil indicate that it can play a positive role in self-regulation. This could occur by providing nudges (Sutton, 2007) or more complex interpretations that alter the emotional and cognitive response. To understand why attentional control sometimes breaks down we need to understand the comparative efficacy of different kinds of compensatory strategies: but neither PET nor ACT illuminate this.

A second issue that needs further explanation is the attention-drawing attributes of the things that are distracting. All elite athletes will have acquired attentional control abilities that allow them to maintain task focus in difficult conditions. So why is the distraction sometimes so powerful that it overrides these abilities? The biasing of attention to threat-related stimuli proposed by ACT provides a partial explanation, but there may be more involved in the power of the distraction than this. Another possible causal element is the fact that the personal self and highly significant outcomes can be very strong *attentional magnets*. By this we mean that the motivational significance associated with these things has a biasing effect on attention, drawing attention to them when they are salient.[9] Thus, a strongly hoped-for or feared outcome may draw attention powerfully when it becomes salient in the situation, even though the individual knows that it is better to focus on task processes. Equally, it may be hard to avoid self-evaluation in response to significant performance outcomes, and, once they begin, it may be very hard to stop self-evaluative thoughts from proceeding, even

[9] We base this concept of an attentional magnet on the related notion of a 'motivational magnet' (Berridge and Robinson, 2003).

when the individual knows that these thoughts are interfering with performance. Indeed, there may be an amplifying, cascading feedback effect in which self-critical thoughts increase the perceived significance of the threat, increase the biasing of attention to threat, and generate further worry and self-criticism.

These considerations reinforce the importance of the appraisal processes we discussed in the previous section. Appraisal doesn't simply occur at the beginning of a performance situation, it continues throughout performance (Lazarus, 2000), and the nature of the interpretive strategies can have an effect on whether an initial performance impairment in response to pressure progresses into a serious performance breakdown or is effectively mitigated by compensatory processes.

5.5 Attention to motor execution

Attention to motor execution might contribute to choking in some cases, but to identify these cases self-focus theories require more specific accounts of the mechanisms involved. As discussed in section 2.1.2, Baumeister claims that under pressure performers consciously decide to monitor motor execution in order to ensure correct performance, and this disrupts automatic motor processes (1984, p.610; Fig. 2). But as we've argued, some forms of attention to execution may make a positive contribution to high level performance. Another possibility that should be considered is that there are forms of attention to execution that play an ameliorative role when things are not going well. We've suggested that attention to execution might occur as a secondary effect of impairment rather than as the primary cause, and it is possible that this is sometimes beneficial. Five of the chokers in Hill et al.'s study claimed that self-focus could prevent a more severe performance breakdown, even if it didn't allow optimal performance (2010a, pp.228-9).

The skill-focus experiments show that some kinds of attention to execution are deleterious, but they do not show that all forms of motor awareness and attention to execution cause impairment. It is important, then, to clarify which kinds of self-focus cause impairment, or provide a stronger case that all forms of attention to execution are damaging. Putting this in terms of Baumeister's model as depicted in Fig. 2, steps 4 and 5 require further elaboration: the nature of the attention to motor execution and the nature of the impairment both need further specification.

The model also requires a more detailed account of the mechanisms that produce damaging forms of attention to execution. In Baumeister's account attention to execution occurs simply because in response to pressure the individual consciously decides to monitor and control performance. It is not clear why an elite athlete or other highly skilled individual would consciously decide to adopt a damaging form of attention that departs from normal attentional control, however. A more rational response to a high pressure situation would be to try to adopt the pattern of attention that the individual has when performing well. We're not suggesting that elite athletes and other highly skilled individuals always act rationally, but we do think it likely that experts often have a considerable degree of awareness of the differing patterns of attention they have in different conditions, such as in practice as compared with competition, and when performing well as compared with performing poorly.

Relatedly, Masters and Maxwell (2008) need to explain why there should be a straightforward positive relation between the possession of 'skill knowledge' (by which they mean declarative knowledge of motor technique) and tendency to apply that knowledge to performance. While an individual *might* use knowledge of technique to try to control motor processes in ways that are maladaptive, it is not clear why highly skilled individuals would typically do so under pressure. Highly skilled individuals will often have a great deal of explicit knowledge concerning technique, but as we suggested above, they will in addition have acquired higher order knowledge about the processes and conditions involved in performing well as compared with those where they perform poorly. This higher order knowledge can be used to control where and how knowledge of motor technique is applied.[10] For instance, a golfer might have exquisitely detailed knowledge of motor technique, and use this knowledge during practice to focus on and improve specific components of her action. Yet during competition the golfer might focus entirely on higher order technique (such as correctly implementing the pre-shot routine) and the goal (position of the hole, the path of the ball, etc.), because she knows that it is with this pattern of attention that she performs at a high level.

One approach that might be taken to this issue is to employ some of the conceptual resources discussed above for understanding distraction, including stereotypical attention biases and attentional magnets. One possibility is a model in which high threat triggers a stereotypical self-regulatory response to threat, and motor processes form a salient part of the threat because of the perceived risk of poor execution (Fig. 6). This might induce sustained monitoring and control, but it is also possible that cognitive control will override this attentional focus. If the individual is particularly worried about aspects of motor technique then motor execution may act as an attentional magnet, making it difficult to avoid attending to it.

A model like this could potentially help to explain why a maladaptive focus on motor execution could occur and persist even when the individual 'knows better'. It could also help to explain why attention to motor control might occur in only some cases of choking, and might only be part of the choking process. This is because the stereotypical self-regulatory response can have other attentional targets in addition to or instead of motor execution.

5.6 Other performance-impairing mechanisms

Baumeister's conceptual framework for choking research narrows the focus of investigation to the comparison of self-focus and distraction theories. Given how little is known about skill control, especially in real world performance conditions, this narrow focus is arguably premature. In section 3.2.3 we suggested that prima facie plausibility can be given to other mechanisms, including interference to sensory and motor processing by some kinds of negative emotions, and reduced task effort as a result of the perception of low prospects for success, or to escape from a painful situation. As we noted, because the research in support of the self-focus approach hasn't considered these possibilities it is unable to rule them out.

In support of the idea that anxiety might sometimes interfere with sensory and motor processing we noted evidence that it can affect postural control (Wada et al., 2001).

[10] See Chaffin and Logan (2006) and Geeves et al. (2008, 2014) for a discussion of flexible attentional focus in music performance.

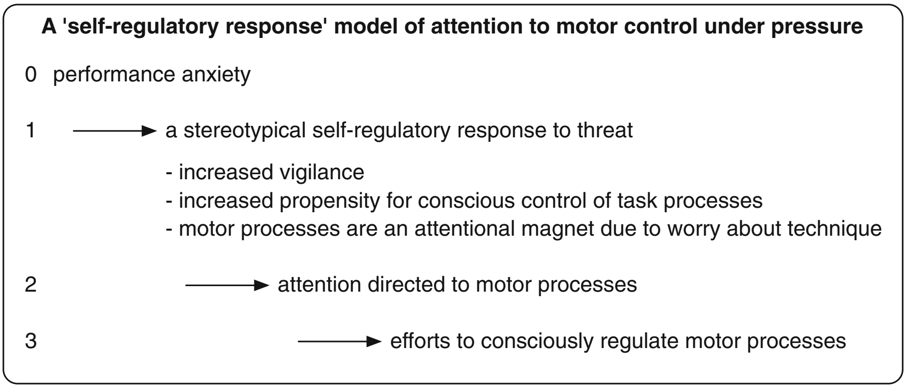

Fig. 6 An attentional biasing model

This appears to occur through alteration of visual processing (Ohno et al., 2004), and in connection with this it is intriguing that there are a number of reports of impaired imagery during choking and the yips (Sachdev, 1992, p. 328; Bawden and Maynard, 2001, p. 942; Hill et al., 2010a, p. 232). Since imagery draws on brain areas involved in perception and motor implementation (Kosslyn et al., 2001), these impairments might be a symptom of altered processing in these regions as a result of stress, and perhaps also of altered interactions between these areas and executive control. Such problems could potentially affect the planning and implementation of actions. While it is speculative to suggest that mechanisms like this might contribute to choking, it may be worth exploring such possibilities.

6 Conclusions

There is little doubt that attention to skill execution can sometimes impair the fluency of performance. But it is a large step to the conclusion that this is the primary cause of choking in some or many cases. We've argued that current research doesn't provide a compelling case for this, and we've also argued that a more synoptic, systematic approach is needed. Baumeister and Showers (1986) recognised that choking involves a rich set of 'mediating' factors, and discussed attributes of pressure and the psychological processes that interpret and respond to pressure. But the conceptual framework they proposed restricted investigation to a limited set of fairly simple theoretical options centred on identifying a proximal mechanism of performance impairment. This was a mistake, and the problems we've discussed – an oversimplified theoretical contrast, poorly developed inferential structure with inconsistent interpretations, poor ecological validity, and contrary evidence from qualitative studies – stem from this excessively narrow focus. Regardless of the specific theoretical approach preferred, these kinds of problems can only be avoided by developing an expanded conceptual framework and theory that is more comprehensive.

An expanded approach will be better placed to reveal the complexities of the mechanisms involved in responses to performance pressure. An important possibility to consider is that these responses are so diverse that 'choking' is not really a single phenomenon. Another crucial issue in need of further investigation is the fine-grained structured of self-awareness in performance. We've suggested that there may be important distinctions between awareness of self-related information and focused attention to particular forms of self-related information. There may also be important distinctions between body-focused attention and technique-focused attention. In our view it will be important to disentangle these possibilities conceptually and empirically in order to better characterize patterns of attention that are harmful or beneficial for performance. However these issues turn out, we think future research should involve a balance between synthetic exploratory investigation that expands our understanding of the possibilities, and analytic development of theories that provide fully specified models and a rigorous explanatory framework that shows in detail how the models apply in experimental and natural contexts.

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