Phenom Cogn Sci
DOI 10.1007/s11097-014-9401-z

Strengths and weaknesses of reflection as a guide to action: pressure assails performance in multiple ways

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Abstract The current status of Beilock and Carr's (2001) "execution focus" theory of choking under pressure in performance of a sensorimotor skill is reviewed and assessed, mainly from the perspective of cognitive psychology, and put into the context of a wider range of issues, attempting to take philosophical analysis into account. These issues include other kinds of skills, pre-performance practice, post-performance evaluation and repair, and integrating new and creative achievements into repertoires of heavily practiced routines. The focus is on variation in the demand for reflection versus automaticity across the full gamut of learning and experience, not just game-time performance. Though automaticity remains important and there are many circumstances in which being "in the zone" is good whereas "execution focus" can do harm, it appears that reflective action deserves just as much a place at the performance table as does unreflective action.

Keywords Skilled peformance · Choking under pressure · Automaticity · Reflection · Unreflective action

To think or not to think, when, and about what? This collection of articles on the relation between action and choking under pressure raises many questions about how performance is affected by reflection — conscious intentional thinking about a goal-directed action or sequence of actions to be performed. Reflection can be devoted to the parameters and operational steps of performing the task: strategic goals and subgoals, perceptual inputs, information needs and knowledge base, motor outputs, control structure and execution. We might call this attention to task. Reflection can also be devoted to the conditions and circumstances under which performance is taking place:

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Published online: 31 December 2014

social context, consequences of succeeding or failing, how one will regard oneself or be regarded by others because of the performance. We might call this attention to self. Reflection can take place in real time during the performance, prior to the performance in practice, planning, and anticipation, or after the performance in remembering, analyzing, and repairing or improving. And “reflection” is not all there is. There could be different kinds of thinking, or different goals and targets of thinking that are maximally beneficial at different levels of practice, experience, and expertise. Some kinds of task-relevant mentation might be “automatic” rather than “controlled” – more like being “on autopilot” or “in the zone” than thinking one's way through via reflection.

Cognitive psychology and philosophy of mind have made much of the value of “automatic” performance. In the philosophical literature, as Cappuccio summarizes in his introduction to this Special Section, Dreyfus has argued that, as Cappuccio puts it, “an agent masters a skillful action only when his or her movements are automatized” and “optimal performances spontaneously spring from thoughtless and almost unaware automaticity.” Dreyfus (2002) calls this state of mind and mode of performance “absorbed coping”, appearing to mean much the same thing as cognitive psychologists like Fitts and Posner (1967), Keele and Summers (1976), or Beilock and Carr (2001) mean by “automatic”, “proceduralized”, or “routinized” performance. However, Dreyfus applies this notion to much more complicated performances in a much wider range of situations and conditions than did Fitts and Posner (1967), Keele and Summers (1976), or Beilock and Carr (2001). Dreyfus' expansion of scope makes for some important issues concerning what can and cannot be anticipated in practice, which will arise later. For the moment, suffice it to say that the notion of “absorbed coping” aptly captures a state of mind and mode of performance entered into by highly skilled athletes in many game situations – especially situations that have been encountered frequently in the past and whose demands can be met through highly practiced action routines. The bigger research picture, however, suggests there are limits to the ability of skilled athletes to sustain automatic performance under all conditions in which it might be beneficial – simply put, many of these conditions have not been practiced. And for less knowledgeable, less skilled, less practiced, less experienced performers, automaticity may be difficult or impossible to attain. Thinking through the performance may be their only option, because no component, parameter, or property of the task has yet been automated.

What do I mean by that last sentence? Some people think of automaticity as an all-or-none thing – you've got it or you don't. But in my view automaticity is a continuous variable. There is a degree of automaticity that attaches to any given task, and as practice under the right conditions accumulates, then that task's degree of automaticity increases. Furthermore, automaticity can attach to particular component operations involved in the task – parts of the task can be automated while other parts are not. And the integration of those parts into a coherent whole is yet another thing. Integrating parts together needs practice and that practice can result in degrees of automation, just as with the parts themselves. And eventually the performer will need to deal with circumstances that are sufficiently new that they could not have been encountered during practice. Do circumstances matter, or is an automated performance transportable from situation to situation without loss?

Thus are we pointed toward a more step-by-step picture of any given task performance, in which parts might need practice, parts can be automated, the whole needs practice, and the whole itself might eventually become automated – transformed into a single unified, integrated, and coherent "part", so to speak – and confronting us with what to do when circumstances are really quite novel and perhaps the integrated part proves insufficiently adaptable.

1 Performing under pressure, the action-situation combination, and conditions of practice

This brings us to the major topic at hand: Performing under pressure. Almost by definition, pressure situations are unusual occurrences fraught with extra value, placing demands above and beyond what has commonly been experienced, especially motivational and emotional demands. Suppose you are in a pressure situation. You experience a strong desire to do as well as you possibly can, to do better than you usually do, even to achieve a level of performance that you might rarely (or never) have reached before. How will this feeling of pressure affect how well you do? Empirical data of the kinds commonly relied upon in cognitive psychology and cognitive neuroscience suggest a rather complicated answer in which the possible outcomes are probabilistic rather than certain. What happens in mind, brain, and body depends on the relative strengths and relationships among several quite different processes and tendencies triggered by pressure, as well as on the kind of task being performed, how much practice the performer has at the task, and finally on how much of that practice resembles the current situation with its particular conditions, demands, and consequences (including whether or not there is pressure). This last factor – the contextual embedding of an action, which I'll refer to as the "action-situation combination" – is extremely important.

Golfers (and golf commentators) often debate whether, when a shot really matters, one should bear down and concentrate on the action, or alternatively, relax, clear the mind, and go with the flow. As we will see, the experimental literature from cognitive psychology suggests that there is no one right answer. The best response depends upon how experienced the golfer is, and more especially, on how many times he or she has faced a shot similar to the one now being faced with something like its particular demands, context, and consequences. If the shot is of the well-practiced garden variety, then going with the flow (and even hurrying up to short-circuit any tendencies to reflect too much) will be the path most likely to succeed, whereas a very unusual shot, or a shot taken under more unusual conditions, might require more thoughtful consideration. The more experienced the golfer, the more shots might belong to the well-practiced garden-variety category, but no skill can be rehearsed under all possible conditions to a degree that it becomes automatic on all occasions.

Acquiring a high level of skill requires practice, but different kinds of practice will enhance skill in different ways. Basketball players sometimes argue with coaches about what to do during practice, as in this pithy exchange from the movie *Hoosiers*: A player asks, "When do we scrimmage?" The coach replies, "We don't." The player says, "Aw, that ain't no fun." And the coach replies: "My practices are not designed for your enjoyment." The coach then starts a drill in which players dribble a basketball slalom-fashion through a row of chairs. The cognitive literature, and as I interpret it recent philosophical analysis as well (e.g., Rucinska, 2014; Rucinska, undated), suggest to me that the coach has a deep point but that he might be going too far. Scrimmages, or game-like simulations as part of practice, can serve several functions that are indispensable, as long as scrimmages are set up with those functions in mind: integration of component skills into the flow of full performances and creative application of one's skills to those dynamic and unusual situations that arise in full performances but are difficult to realize in structured drills. However, structured drills aimed at particular components of the larger game can also serve indispensable functions, if the drills are set up with an eye toward long-term retention of what each drill teaches and integration of the drilled component into the ongoing sequences of goal-directed actions as they arise in full game or game-like performances. Hence the timing and ordering of drills can be as important as what each individual drill actually consists of, as shown quite clearly in the large literatures on the benefits of spaced rather than massed practice sessions and varied rather than constant practice-session parameters (for reviews see, e.g., Donovan & Radosevich, 1999; Lee & Genovese, 1988; Taylor & Rohrer, 2010; Williams & Hodges, 2005).

What is the lesson? Scrimmages and game simulations in the absence of drills are definitely a losing cause, because the components on which drills focus are often sufficiently complex and difficult as to require separate instruction and practice, as is the transition from one drillable component to another in putting together a full performance. Indeed, there is a large literature on the attention and capacity demands of so-called "task-switching", which shows that transitioning from one even very simple task or individual component of a larger sequence of tasks to another exacts a cost in time and the chance for error, and that this cost can be reduced by practice (Minear & Shaw, 2008; Strobach, Liepelt, Schubert, & Kiesel, 2012). However, drills without scrimmages and game simulations are also a losing cause, because an isolated drill produces an isolated component. A full performance requires transitioning among components, and perhaps integrating and automating the sequence. Thus an isolated component – no matter how good it has become – is not enough.

In the spirit of what Ericcson (2006; Ericcson, Krampe, & Tesch-Romer, 1993) has called "deliberate practice" (see also Cote, Baker, & Abernethy, 2007), the benefits of simulation can be magnified when simulation is followed by post-simulation analysis and the chance to try it again. The same sorts of benefits can be obtained from reflective analysis after a game performance rather than a practice, though athletes squirm during film sessions when forced to view, remember, and analyze the mistakes they made (despite reveling when they view, remember, and analyze their highlights). Such outcome-meaningful remembrance and analysis, even though sometimes emotionally painful, constitutes one kind of "reflection" (after the fact) that is likely to contribute to improvement (in the future). Post-performance reflection of this type opens the door to intentional, heavily controlled practice activities at the extreme end of "deliberate practice", aimed specifically at intervening in an established skill that possesses specific faults or shortcomings that need to be repaired.

2 Practice to automate versus practice to repair

Taking apart an existing skill, one that might be integrated, proceduralized, and automated, in order to fix a flaw suggests considerably more flexibility and perhaps a different approach to learning than is described in extant theories of automaticity, and such controlled intervention to alter an already-established skill sounds very little like the sort of stereotyped repetition usually implemented in laboratory studies of practice-based automaticity (e.g., Anderson, 1982, 1987, 1993; Logan, 1988, 2002; Newell & Rosenbloom, 1981; Raichle et al. 1994; Shiffrin & Schneider, 1977; for reviews see Carr & Hinckley, 2011; Holt & Rainey, 2002). These studies, which often employ tasks with singular decisions and simple motor actions, generally evidence monotonic improvements in the accuracy and speed of an ever-strengthening strategy for reliably achieving the same end point via the same path each time performance is executed. Even in examinations of more complex multi-step sequences of actions, as in Bryan and Harter (1899) or Brown and Carr (1989), the end result of learning is still thought of as a routinized skill with relatively high efficiency but relatively low flexibility, its performance parameters tuned and limited rather narrowly to the particular range of inputs, outputs, and conditions that have been practiced. Transfer beyond this range is quite possible but often limited in scope (see, e.g., Koh & Meyer, 1991). Intervening to fix a problem that arises in such a routinized skill goes beyond the bounds of theories of repetition-based automaticity, as does the ability of expert performers to deal with unusual situations by doing something new and different on the fly when new demands arise during a performance – the issue considered next.

3 How do performers deal with unusual situtations?

Enter here the very useful notion of "enactive creativity" proposed by Rucinska (2014; see also Hutto, 2014, and Hutto & Myin, 2013, on "radical enactivism"; and the related idea of "deliberate play" discussed by Cote et al., 2007 and Memmert et al., 2010). According to Rucinska, researchers should be trying to determine not just how a skill can be improved within its existing parameters and boundaries, but how it can be pushed to new and higher levels, how to build the creativity that an expert performer needs in order to deal not just with the myriad situations that arise rather regularly, but with the unusual or particularly challenging situations that come along less frequently and are pivotal to great success (see also Ericcson et al. 1993; Hristovski, Davids, Passos, & Araujo, 2012). Rucinska argues that this kind of creativity can be understood as a capacity for active exploration of the limits of one's know-how, and that practice can facilitate such creativity if it is organized to enable (even to force) the performer to diversify his or her experiences and to attempt to master the opportunities provided by changing performance environments – the kind of opportunities called "affordances" by Gibson (1977, 1979). Rather than assuming creativity-in-action to be by definition untrainable, Rucinska argues that creative application of skill in unusual situations is itself a skill that can benefit from practice.

To my mind as a cognitive psychologist Rucinska is offering a bold and perhaps counterintuitive assertion, that in skilled performance creativity can be routinized if it is practiced enough under the right conditions. One might imagine that such cannot be true – by definition, a skill that is "routinized" has become a stiff and unyielding habit, a reflex such that when a performer is presented with a particular stimulus situation, the response is a particular action pattern whose parameters have been burned into the brain and the muscles and hence arises in a same-old form. But I encourage anyone who imagines in this way to consider what "routinization" and "automaticity" actually mean: These ideas refer to a well-established mental program for achieving goal-directed action with a minimum of conscious, limited-capacity, executive control.

Understanding how this applies to Rucinska's proposal requires focusing on the goals of actions – the goal-action relationship – and what that implies when dealing with an unusual situation Such a focus highlights a puzzle made clear in a comment Rucinska gave to a draft of this paper: “Hmm… the playing training I propose gets you out of the standard context, so it should be useless… Yet, in new contexts one can learn to respond to new sets of affordances.” Rucinska is particularly impressed by evidence that playing games that are unfamiliar and on their surface very far removed from one's primary skill can still enhance performance in that primary skill. Apparently the necessary ingredient is an underlying abstract similarity in the kinds of performances and the kinds of thinking, that are required in the primary skill. This evidence suggests that dealing with unusual circumstances and event sequences in an appropriate and effective way – which requires creation – is a trainable skill in and of itself.

How can this be? From the perspective of automaticity theory, what must get automated is the pursuit of the goal of the actions being practiced. And of course that goal is to achieve the desired end state (say, scoring a basket in basketball while being closely guarded or getting off a pinpoint crossing pass in soccer despite a defender's interference) under whatever circumstances might present themselves. It is this last criterion – “under whatever circumstances might present themselves” – that separates “enactive creativity” from the existing studies of “practice-induced routinization”. The existing studies have mainly focused on the effects of practice within largely unvarying circumstances, or circumstances that vary only along certain researcher-chosen dimensions while keeping all else as constant as possible. What I would like to say (and I think that Rucinska is saying this as well, which is why I'm piggybacking my argument on her work) is that achieving goals through unusual means might very well be a goal-directed task activity that can be practiced and routinized, at least to some degree. The routinized result would be that the performer does "absorbed coping" in Dreyfus' sense, and demonstrates “enactive creativity” ala’ Rucinska. But only if the conditions of practice are constantly varying, and trying different actions in response to those conditions is encouraged as part of the goal during practice.

Thus enactive creativity refers not to the automated aspects of highly-practiced expert sensorimotor skill exercised in ordinary situations, but to the complementary ability of the expert performer to go beyond what would commonly be seen as the routine and the automatic to engage with unusual challenges provided by performance situations that have rarely if ever been directly encountered in the performer's previous experience. My proposal is that to the extent the performer has practiced such adaptation under a variety of different new and challenging circumstances, and on top of that has had the chance to reflect on what was successful and what was unsuccessful about each attempt, the performer will be equipped to try to adapt to a new situation that has not been previously encountered. It is already well-established that variety during practice increases breadth of transfer (see Bjork, Dunlosky, & Kornell, 2013; Dunlosky, Rawson, Marsh, Nathan, & Willingham, 2012; Taylor & Rohrer, 2010; and again see Koh & Meyer, 1991). However, the principle of routinization has more often been demonstrated in laboratory studies of simple skills or simple components of more complex performances performed under fairly constant circumstances than in complex real-world skills and contexts. Rucinska goes beyond the laboratory evidence to propose that enactive creativity in very complex real-time performances is a skill that can be practiced, and if the practice is sufficiently broad and intensive, then the skill of adapting to the new and unusual will be all the better. I am proposing to add to Rucinska's insights what we know about the benefits of reflection and deliberate practice.

4 Gentile's two-process framework for understanding skill acquisition

Rucinska's ideas are in the spirit of a simple but helpful framework for skill acquisition proposed by Gentile (1972, 1987, 1998). All skills share an initial Stage 1 in which, through observation, trial and error, and perhaps instruction, the novice acquires a general understanding of what the new skill involves, sufficient to begin trying to carry out instances of performance. Gentile calls this "getting the idea". In Stage 2, which Gentile calls "fixation versus diversification", development bifurcates depending on the nature of the skill. "Closed" skills require fixation or automation, which proceeds first by restricting strategies, selecting the most efficient, and then by practicing the selected strategy to reduce its variability and increase its efficiency (as in Brown & Carr, 1989; Crossman 1959; Fitts & Posner 1967). As already seen, this kind of automaticity is widely studied, and in fact it has proven extremely useful in the real world. Think of Henry Ford's assembly line. Alfred North Whitehead (1911) seems to have had this kind of automaticity in mind when he pronounced that "It is a profoundly erroneous truism, repeated by all copybooks, and by eminent people when they are making speeches, that we should cultivate the habit of thinking of what we are doing. The precise opposite is the case. Civilization advances by extending the number of important operations that we can perform without thinking about them. Operations of thought are like cavalry charges in a battle - they are strictly limited in number, they require fresh horses, and must only be made at decisive moments."

By contrast, open skills require diversification rather than fixation. Practice must emphasize appropriate adaptation to changing conditions rather than regimentation of the same action under the same conditions. In an open skill it may be that no two instances of performance are ever the same, and if conditions and demands change sufficiently from instance to instance, then the parameters of the skill may increase in variability as experience accumulates, rather than decreasing as with a closed skill. Nevertheless, while observed variability may increase, so will the range of conditions and challenges in which the performer can achieve an effective match between strategy and goal.

Thus in Gentile's world there are two kinds of skills, though a single individual might learn and use both kinds. Rucinska's notion of enactive creativity allows us to go beyond Gentile, raising the possibility that a single skill might be a hybrid, sometimes behaving as if it were closed and sometimes demanding openness. This is an important insight, and it suggests an important direction for further research: Figuring out how closed and open modes of operation are integrated into smooth and effective real-time performances, an issue about which we currently know little.

5 The current view from cognitive psychology and cognitive neuroscience on the nature of performance under pressure

Now that we have a framework in which to think about flexibility as well as automaticity, how they might work together, and the issue of dealing with demanding circumstances over and above the ordinary routines of practice and the common events of a game, we can take on the nature of pressure and its effects, including the phenomenon of "choking under pressure", in more detail. Empirical results from behavioral studies, mental chronometry, self report, and neuroimaging suggest that pressure is multi-faceted. Its net impact – whether performance will suffer (the phenomenon of "choking") or might instead be improved (being a "pressure player" who "rises to the challenge") will vary greatly depending first on the cognitive and functional architectures of the skill (different stories for different skills and in particular for motor-intensive skills such as sport versus working-memory-intensive skills such as mathematical computation or chess), second on the amount of skill-relevant knowledge, practice, and experience possessed by the performer (different stories for different levels of expertise), and third on the performer's facility with attentional control and emotional regulation (different stories for different amounts of experience under the particular conditions of pressurized performance, different degrees of "performance anxiety", and different motivational orientations). Because these factors interact, the topographical map of performing under pressure is high-relief and its landscape is difficult to navigate.

6 What *is* pressure and how is it created experimentally?

Observation of the characteristics of high-stakes situations, as well as qualitative interview data from high-level performers (e.g., Mesagno & Hill, 2013; Hill & Shaw, 2013) suggests that a pressure situation consists of a mixture or combination of four different conditions which we might call "pressure operators". The first is economic reward: Something of high value can be gained or lost. This might be money, admission to a school, a good grade, a license certification, or victory in a competition. The second is social responsibility: Other people are depending on you to succeed. This could be your work group, your school project group, your teammates. The third is public scrutiny: People are watching, eyes are on you. These eyes could be an audience, your friends, your parents, your teammates. The fourth is evaluation: People are judging. There is some overlap here with public scrutiny but it goes beyond mere watchers to people who might have power over your future: your teacher, supervisor, boss, coach.

Though it is possible that these operators might work relatively independently and even create different kinds of impacts – and we will address that possibility later – experimental research on pressure often applies some or all of them together. A typical pressure scenario might include two, three, or all four:

A monetary reward can be won if performance meets some criterion.
There is a teammate or group of teammates whose own reward depends on the performer's success.
There is an audience. The experimenter stays in the venue observing, or a group of people is set up to view the performance.
There is evaluation. Perhaps a video camera is turned on, with a cover story that the recording is for subsequent expert analysis and judgment about the performance's quality.

These conditions, especially in combination, might instill a desire to perform well if taken seriously by the performer. Debriefing interviews in our own studies and those of other investigators show that they do, both in the laboratory and in the real world of competition (see, e.g., Beilock & Carr, 2001; Beilock et al. 2004a; Beilock & Carr, 2005; Hill, Hanton, Matthews, & Fleming, 2010a, b; Hanton et al. 2011; Hill & Shaw, 2013; Mesagno, Harvey, & Janelle, 2011). However, it is important to point out that in most laboratory experiments, the magnitude of perceived pressure is almost certainly toward the lower end of the full range of pressure situations participants have experience with, and even when groups of participants in our experiments have reported raised levels of pressure and desire to perform well compared to practice conditions, they have not reported large increases in nervousness or anxiety. Thus while qualitative interview data with high-level athletes is likely to reflect high levels of felt pressure, the experimental data is more likely to document the impact of lower levels. With that significant caveat in place regarding the differing scopes of experimental and interview studies, we can ask what happens as a result of feeling pressure and the desire to perform well that it elicits.

7 Impacts of pressure on human motivation, emotion, and cognition

Combining the experimental evidence with the evidence from qualitative interviews, the effects of pressure appear to arise from four processes that can be triggered within the cognitive, motivational, and emotional systems of the performer. These are:

(1) Increased Motivation and Arousal, which together raise task focus, discourage mind-wandering, and influence attentional capacities and task strategies, mainly for the better;
(2) Increased Competition for Working Memory, created by an invasion of consciously-entertained thoughts about the situation and its consequences into conscious consideration, which might make no difference but more likely will cause harm;
(3) Increased Attention to Task Detail, aimed (sometimes with good effect and sometimes inappropriately) at ensuring proper step-by-step planning and execution of real-time performance with the admirable (but again sometimes inappropriate) goal of crafting each step deliberately, in the belief that such close attention and care will reduce mistakes and maximize success;
(4) Increased Anxiety, which commonly follows on the heals of increasing arousal but hopefully at a distance, though in some individuals it might be an immediate reaction (e.g., as in the case of a math-anxious individual faced with a math problem). At very low levels, anxiety can be difficult to distinguish from arousal and may not detract from arousal's benefits, but at higher levels anxiety can transform motivational effects from a beneficial focus on what can be gained through success to a dysfunctional focus on avoiding the losses that might be suffered from failure (Chib et al. 2012). At even higher levels anxiety can turn into panic, promoting task disengagement – simply giving up in response to too much pressure. Disengagement is the ultimate in choking. One certainly cannot succeed if one gives up even trying.

It might be imagined that the last three – Increased Competition for Working Memory, Increased Attention to Task Detail, and Increased Anxiety – could be viewed as competing theories of how best to characterize a unitary negative perturbation created by pressure (see Beilock & Carr, 2001; Mobbs, Hassabis, Seymour, Marchant, Weiskopf, Dolan, & Frith, 2009). We have come to think that these three are different and separable perturbations, and that they arise relatively independently and can operate simultaneously in a pressure situation (Beilock and Carr, 2001; Beilock et al. 2004b). Their impacts vary in salience, relative contribution, and potential for helping or hurting, depending on the kinds of tasks, amounts of experience, levels of expertise, and choices of strategies to govern task performance.

If the line of argument taken so far is even close to correct, then there is no simple account of the role of reflection in guiding action. At the very least, one must ask what counts as reflection and one must talk about reflection when, on what, and by whom in order to build and apply an adequate theory. And more important, one must consider the differences in cognitive substrates that exist across different domains of cognitive skill. What happens in a sensorimotor-intensive skill like golf putting or soccer dribbling or baseball hitting can be quite different from what happens in a working-memory-intensive computational skill like mathematical problem solving, or in reading and remembering text, or in creative problem solving. These domain differences apply both to understanding what causes choking to happen, and also to understanding how to prevent it. Considerable progress has been made on these questions, and in addition, data from neuroimaging suggests a hypothesis about who, among people susceptible to choking, might prove more or less prepared to resist it. In the remainder of this paper I'll summarize some of these findings.

8 The three trolls

Three of the four pressure operators listed above can wreak havoc with performance: Increased Competition for Working Memory, Increased Attention to Task Detail, and Increased Anxiety, The first two are harmful under some conditions despite being helpful under others. The third, Increased Anxiety, almost always spells trouble.

Increased competition for working memory Pressure makes people worry about whether or not they will succeed. These worries often get translated into explicit thought content that competes for space in working memory that could otherwise be devoted to goal structures and task-control information, task-relevant data from perception and memory, and execution commands needed to instigate task-relevant behavioral actions (Beilock et al. 2004a, Beilock, Jellison, Rydell, McConnell, & Carr, 2006; Schmader, Johns, & Forbes, 2008). Such competition is the focus of a class of hypotheses about choking under pressure we have called *distraction theory* (Beilock & Carr, 2001; Beilock et al. 2004a). If a task requires working memory capacity for storage or execution of the task's control structure, for maintenance of information that is needed immediately by the computational steps of that structure, or for generating action commands, then it is a recipe for trouble to occupy working memory with thoughts other than the specific steps and information-processing needs of the task. Thoughts especially likely to intrude when they shouldn't include concerns about incentives, rewards, consequences, and self-presentation, which are the coin of the realm for distraction theory. When performers are under pressure, this "occupying force" of explicit worry vies for space in working memory, potentially degrading performance by causing forgetting of the control structure (the set and sequence of actions to be performed), failure to encode needed information or failure to maintain it, error in action planning and execution, or all three.

Increased attention to task detail The second response to pressure would seem to be the perfect antidote to this problem of distraction. It appears that people in pressure situations tend to want to increase the cognitive control they exert on their task, trying to pay more attention to each of its steps and all of its details so as to avoid making mistakes (Beilock & Carr, 2001; Beilock et al. 2004a; Lewis & Linder, 1997; Masters, 2000; Masters, Polman, & Hammond, 1993; Schmader, Johns, & Forbes, 2008). The more concerned people are to perform successfully and the more worried they are about the possibility of failing, the greater is the motivation to focus attention on step-by-step task details. Of course, if the resources of working memory are diverted to thoughts about incentives, rewards, and consequences, there might not be enough capacity left over to do this. However, if the onslaught of worried thoughts can be staved off, then performance might be saved and success achieved through increased attention to task steps and their details (Lyons & Beilock, 2011; Mattarella-Micke & Beilock 2012).

But will this work? Focusing on step-by-step control certainly seems like a good thing for working-memory-intensive tasks with lots of operations and pieces of information to keep coordinated, but the recipe for success could be quite different if a task can be performed automatically, relying on integrated routines established through past practice (Anderson, 1982, 1987, 1993; Brown & Carr, 1989; Fitts & Posner 1967; Keele & Summers, 1976; Proctor & Dudda 1995) or on retrieval of specific memories of past performances that can be followed as rote roadmaps with minimal working-memory supervision (Logan, 1988, 1990; Klapp, Boches, Trabert, & Logan, 1991). To the extent that automaticity of either of these types applies, then distracting working memory might actually be a boon. It would keep this meddlesome and intrusive cognitive network out of the way, allowing an automated process to run its usually rapid and accurate course without untoward intervention (Beilock et al. 2002; Beilock, Bertenthal, Hoerger, & Carr, 2008). The idea that pressure might entice the performer to pay too much attention to performance, rather than too little as in distraction theory, is the basis for a class of hypotheses about choking called *explicit monitoring theory* or *execution focus theory* (Beilock & Carr, 2001). The label "execution focus theory"best captures what this theory is all about.

Dealing with two contradictory impacts of being under pressure At this point one might hear the voice of the Zen Master extolling the virtues of letting go of control and going with the flow, advice popularized by Herrigel (1948) in *Zen and the Art of Archery*. But as Persig (1974) pointed out in *Zen and the Art of Motorcyle Maintenance*, there might not always be a flow to go with. This conundrum has been discussed in more academic ways by Cskiszentmihalyi (1990, 1998) and by Myers (2002), and it captures the difficult choices that arise for performers under pressure, as recounted and analyzed from a phenomenological perspective by Ilundain-Agurruza (February 2014a, b). Should they try to pay more attention or should they try to pay less? And to what should their attention be paid when they pay it? Sometimes one needs to pay careful attention, plan a step, carefully gather the information required for that step to be computed, execute that step's computations correctly as the performance progresses, and correctly select the next step in order to proceed through the task, all explicitly and under executive control. But sometimes one needs to go with the flow and let automaticity happen. What factors govern this choice? And once the right choice is made, can it be implemented and sustained so that performance can succeed?

We believe that our research referenced so far in this paper has identified differences among tasks being performed and differences among individuals' performance histories – of primary interest are the amount of experience and practice under the task constraints and motivation conditions currently being faced – that together begin to define the boundaries of when one can and should go with the flow versus when one needs to remain in step-by-step control. In addition, we have tried to understand the perceptual cues that performers use to monitor their performance and determine whether it is proceeding as they intend – whether they are "in control" and can carry on as they are doing or need to institute some sort of mid-course correction (see Dewey & Carr, 2012; Dewey & Carr, 2013; Dewey, Seiffert, & Carr, 2010). I will not review this work here because it has not yet included manipulations of pressure, but it may well be that the cost of failing in such monitoring grows in pressure situations, where the consequences of following effective versus ineffective strategies are magnified.

Troll number 3: increased anxiety and its progeny – excessive motivation, excessive arousal, increased aversion to loss, and increased susceptibility to disengagement At this point we turn to the third potentially negative impact of pressure, which has to do with transitioning from arousal to anxiety, and perhaps even to panic, and with evaluation of incentives, benefits, and risks within the reward system as arousal and anxiety grow. The reward system's "emotional economics" come strongly into play when performance outcomes have high value for the performer.

Levels of task-specific motivation and general arousal increase with the incentive value of the rewards at stake. Arousal levels have long been thought to be related nonmonotonically to performance. This so-called "Yerkes-Dodson Law" (following from Yerkes & Dodson, 1908) is a large and rough-hewn family of functions, often referred to as "inverted U-shaped". There is a tendency for performance to improve as incentive values and arousal increase above very low levels, peaking at some intermediate level and then declining as arousal and incentive increase even further (Eysenck, 1982; Hockey, 1986; Parasuraman, 1986). Both the level of arousal associated with peak performance and the rate of decline from peak performance with further increases in arousal appear to vary with task complexity. The more complex is the cognitive control structure, the data processing and storage demands, or the precision of the required actions, the more likely it is that the decline will be precipitous once it begins.

Though they are very important, the causes of these performance changes remain poorly understood. Improvements with increasing arousal and incentive value appear to be associated with cognitive increases in available attentional capacity and working memory operation, undergirded by increased neural activation in the cortical systems thought to support executive control (Kahneman, 1973; Gilbert & Fiez, 2004; Pochon, Levy, Fossati, Lehericy, Poline, Pillon, et al., 2002; Small, Gitelman, Simmons, Bloise, Parrish, & Mesulam, (2005); Taylor, Welsh, Wager, Phan, Fitzgerald, & Gehring, 2004). Locke and Braver (2008) found that parietal and lateral prefrontal components of executive control systems increased in activation at higher incentive values, and that these increases in activation were generally accompanied by improvements in performance. Further, they found that individual differences in the specific amounts by which performance improved were predicted quite well by activation in particular regions of orbitofrontal cortex and midbrain reward systems. Pochon and colleagues (2002) have suggested that these regions are important in coordinating incentive values with cognitive effort. Thus the improvement-related portion of the Yerkes-Dodson function appears to be associated with cognitive and neural upregulation of executive control systems and their sensitivity to activation in midbrain reward systems.

The descending portion of the Yerkes-Dodson function is in some but not all ways a mirror image. At the cognitive level, decreases in performance with high arousal and incentive value appear to be with drops in available attentional capacity and a narrowing of the focus of selective attention. Together these alterations of capacity and attentional scope are sufficient to exclude important task-relevent information, subgoals, and goals (Easterbrook, 1959; Beilock & Carr, 2005; Eysenck, 1982; Gimmig, Huguet, & Caverni, 2006; Hockey, 1986; Kahneman, 1973; Parasuraman, 1986; Welford, 1973). At the neural level, decreases in performance appear to be correlated with increases in activation in some regions of the ventral midbrain when incentive values are large compared to when incentives are smaller but still positive (Mobbs, Hassabis, Seymour, Marchant, Weiskopf, Dolan, & Frith, 2009). These regions differ from the regions of the reward system that are upregulated in the improvement portion of the Yerkes-Dodson function, suggesting that shifts in the relative dominance of particular frontal-striatal circuits may alter attentional and working-memory participation in task performance. Of course such shifts in neural substrate could underwrite corresponding and potentially important alterations in available processing capacity and likely focus of attention.

It appears that variations in the contributions of different reward circuits and concomitant alterations in working memory and attention may be accompanied by a motivational shift from pursuing gains to trying to avoid losses as incentive value increases. Loss aversion is known to alter performance strategies in conservative directions at the cognitive level, slowing reaction times, increasing monitoring for errors, and increasing caution in decision making (e.g., Bishara, Pleskac, Fridberg, Yechiam, Lucas, Busemeyer, Finn, & Stout, 2009; Potts, 2011).

In addition, there appear to be changes in the operation of the reward system that can ultimately influence a more fundamental aspect of strategy – whether to perform at all! Chib et al. (2012) found that striatal regions of the reward system increased in activation as reward value increased, but only up to a point. With further increases the striatum began to deactivate. Furthermore, the amount of deactivation correlated with the magnitude of decrements that were observed in performance. From these findings Chib and colleagues speculated that while the emergence of loss aversion as a motivating goal does alter performance strategies, it may also elicit disengagement from the task, indexed by the observed deactivation in the reward system. That is, if stress is felt in response to evaluations of risk, and the amount of stress grows large enough, performers may begin to shut down and withdraw from the task rather than just shifting strategies within it. Of course, actual withdrawal from the task would hurt performance outcomes well beyond any shift in task strategy!

Complementing Chib et al.'s speculation is an fMRI investigation by Lyons and Beilock (2011), in which participants performed two different tasks, one solving complex mental arithmetic problems and the other solving word anagrams. The tasks occurred in four-problem blocks, with a cue presented prior to each block identifying whether math problems or word problems were coming up next. Activity in the inferior frontal components of the executive control system was measured. Among subjects who described themselves as high-math-anxious, activity in these regions was related to their math performance. Increased activity in response to the cue for math problems, before the problems actually appeared, predicted better performance, particularly when the activity occurred in the immediate vicinity of the inferior frontal junction. Mediation analyses showed that the operative impact of this prefrontal activity was on midbrain striatal structures thought to be involved in behavioral approach/avoidance responses as well as in coordinating pursuit of rewards with cognitive effort. Greater amounts of this preparatory activity were accompanied by better math performance; less of it by worse math performance.

From these findings Lyons and Beilock speculated that people who can (or who will) “ramp up” for math before its onset can control their anxiety-induced tendencies to attend to worries and to give up on the task. To the extent that these tendencies can be fought off, attention can remain on the task and performance can be controlled in a way that proceeds more successfully. Tying chronic math anxiety to performance under pressure, Mattarella-Micke and Beilock (2012) reported that activation around the inferior frontal junction is important in moderating the impact of pressure on math problem solving in a study of choking. Thus while generalized anxiety about a domain or a type of task should not be thought of as the same thing as feeling performance pressure, they may to some degree share impacts and mechanisms.

Mathematical computation, however, is a working-memory intensive performance that benefits from attention and control. It remains to be seen whether the ramping up observed by Lyons and Beilock (2011) and the activation during performance reported by Mattarella-Micke and Beilock (2012) would also ameliorate pressure-related problems in an automated sensorimotor task such as golf putting, in which problems are caused by increased attention to task detail rather than competition for working memory. However, an fMRI comparison of imagined pre-shot planning by expert and relatively less experienced golfers reported by Milton, Solodkin, Hlustik, and Small (2007) shows marked differences, with less experienced golfers generally producing much more activation in cingulate, amygdala, and baslal ganglia – regions involved in the reward-relevant circuitry identified by Mattarella-Micke and Beilock (2012) and Lyons and Beilock (2011). This suggests that further research might produce interesting results. For the moment, it is enough to note how important is the discovery that people can prepare for performance under pressure in different ways, and that this preparation can benefit performance through identifiable neural mechanisms.

Returning to the tradeoff between competition for working memory and attention to task detail, there is speculation in the neural literature just reviewed that frontal-striatal interactions might influence the extent to which performers rely on executive control systems versus habit systems. Pursuit of these speculations might reveal the secret to the tradeoff between paying too little attention to step-by-step task performance or paying too much. At present, however, the neural research is not sufficiently developed to supply an answer.

9 On the phenomenology of being under pressure

Let us jump from neural to phenomenological. What do people think about when they are under pressure? In the debriefing sessions of some of our studies, we have asked participants to recall what they were thinking during the pressure condition. This method of "retrospective report" is a weak one for discovering all that actually did happen (Ericcson & Simon, 1993). Nevertheless it might be revealing for our particular purposes, since it appears that emotional memories from preceding experiences are more likely to be recalled than are run-of-the-mill or boring aspects of the experience, all else equal (Kensinger & Schacter, 2008; Reisberg & Hertel, 2004). Thus when emotional memories crop up, they provide memorial clues about what was important and engaging to the performer during the experience. Below are three quotes (carefully selected, I must admit) that illustrate the impacts of pressure we have been describing. They are from young women participating in a study of mathematical problem solving, and they are intended to illustrate the range of possible relationships between the content of retrospective report and the performance processes toward which the reports might point:

> Report 1. "I thought about how boys are usually better than girls at math so I was trying harder not to make mistakes, even though I did." This report is consistent both with competition for working memory ("I thought about how boys are usually better than girls at math…") and with increased attention to task detail ("…so I was trying harder not to make mistakes"), but it does not carry any very obvious emotional valence.
>
> Report 2. "I hope I don't look stupid." This report is irrelevant to the task's actual information-processing demands – it does not mention paying attention or devoting effort to the task in general nor does it mention any particular steps in task performance – and it seems both personally meaningful and negatively valent. This is all consistent with competition for working memory. And because it expresses a wish to avoid an outcome that might pose a threat to public image or self-esteem, it suggests loss aversion.
>
> And my favorite: Report 3. "Oh ****. There's no way I can do this." Besides occupying space in working memory and being negatively valent, it is a pretty compelling representation of the potential for disengagement!

Thus retrospective reports on the phenomenology of being under pressure might provide converging evidence on what motivational forces were in effect, and might help in identifying the performers' reactions and adaptations (or maladaptations). We have not made use of retrospective phenomenology beyond the rating-scale judgments of felt pressure and state anxiety described earlier and the informal brief post-experimental debriefings from which I just reported quotes. However, Hill and colleagues have done in-depth structured interviews with high-level performers from golf (Hill et al. 2010a) and team sports, including soccer, rugby, field, hockey, cricket, and volleyball (Hill & Shaw, 2013), who profess to having persistent problems with choking during competitive play.

In these interviews, each participant began with an at-home preparation booklet eliciting recollection of choking events at a detailed level, then went through an individual interview session in which they were asked to describe, evaluate, and explain their experiences of choking, including antecedents, processes and mechanisms, triggering conditions, and any lasting or residual consequences. The reflections generated in these interviews uniformly revealed what respondents perceived to be “catastrophic” drops in performance, well below their normal range of regular better or poorer play. As one player put it, “When you underperform, you do one or two things wrong…but when you choke…I can't play at all…I can't do anything right…the only thing I can do, is get off the field'. And these large-scale performance meltdowns were commonly associated with extreme levels of perceived pressure, anxiety about public scrutiny and evaluation, and fear of failure. As a soccer player put it, “I feel immense pressure when I am one-on-one with the goalkeeper, because it is down to me to make the difference. It is my responsibility…to produce the result for the team…the weight of the team is on my shoulders…all eyes are on me. I hate those situations.” Another athlete said that “I wanted to impress the crowd…but while trying to impress I forgot about the game in hand…I am then focusing on the negative criticism I will get if I don't perform well. I don't want people to think I am rubbish.”

These reflections on real-world competitive performances are reminiscent of the impact of social responsibility, audience, and evaluation in experimental studies such as those of Beilock and Carr (2001). However, Hill and colleague's data also confirm the possibility that while experimental situations may be able to reliably produce underperformance and to successfully model some aspects of choking, they may ultimately fail to capture the sheer magnitude of pressure and anxiety perceived in real-life competition, and are therefore likely to underestimate the anxiety-related consequences that characterize choking in real-life performance.

10 Pursuing the impacts of public scrutiny and evaluation

Even given the caveat, let us consider additional laboratory data. One of the more powerful experimental applications to date of multiple pressure operators has been reported by Mesagno, Harvey, and Janelle (2011) in an attempt to separate the impact of monetary reward from the impacts of public scrutiny and evaluation – factors that figured heavily in the worries, fears, and self-presentation concerns reported by Hill and colleague's athletes. Mesagno et al. recruited elite Australian field hockey players with 5 or more years experience playing at the state or national level. The task was taking penalty shots, with a scoring scheme in place that emphasized accuracy in aiming for locations difficult for a goalie to defend. Shots were taken from the regulation spot, a point directly in front of the net 6.4 m from the goal line. Targets were set up in three corners of the net: lower left, lower right, and upper right from the shooters' perspective, as shown in Fig. 1. One to five points were awarded for each shot that hit a target, with more points for shots that hit closer to the posts.

Each participant took three blocks of shots with 30 shots in each block, and received an accuracy score for each block represented by the total points earned on that block's shots. The first two blocks were portrayed as practice to obtain a baseline measure of low-pressure performance, and the third block was taken under pressure. There were five different pressure conditions, manipulated between groups of participants, with the condition set up and instructions given after completion of the two practice blocks:

Fig. 1 Goal, targets with point scheme visible, and shooting location used by Mesagno et al. (2011). (This is Fig. 1 from Mesagno et al. p 445)

(1) Monetary Incentive Condition: The participant could win money by at least equaling his score from the preceding practice block, plus additional bonus money for each point by which the practice score was exceeded. However, if the score in this Monetary Incentive block fell below the practice score, no money at all would be awarded.
(2) Audience or Public Scrutiny Condition: Performance was observed by five teammates clustered near the shooter.
(3) Video Camera Evaluation Condition: Performance was video-recorded for evaluation by the participant's coach, with the participant told that the evaluation would figure in the coach's decision about who will be chosen to take penalty shots in upcoming games.
(4) Video Camera Placebo Control Condition: Performance was video-recorded, but the participant was told this was only so that the experimenter could score performance accurately and that the video would not be seen by anyone else for any other purpose.
(5) Combination Condition: Monetary Incentive, Audience (Public Scrutiny), and Video Camera Evaluation all together.

In addition to shooting accuracy in each block of trials, represented by the total points earned on the 30 shots, state anxiety was measured after the pressure block using the somatic physiological anxiety scale and the cognitive thought-related anxiety scale from the Revised Competitive State Anxiety Inventory – 2 (Cox, Martens, & Russell, 2003; Martens, Burton, Vealey, Bump, & Smith, 1990). The somatic scale asks about physical reactions such as “I feel jittery”, “My heart is racing”, and “My hands are clammy”. The cognitive scale asks about worries such as “I am concerned that I may not do as well in this competition as I could”, “I am concerned about losing”, and “I'm concerned that others will be disappointed with my performance'.

Scores on the somatic anxiety scale did not vary with pressure condition and were unrelated to shooting accuracy. This is an important finding. Performers felt the physical signs of arousal and nervousness, but the magnitude of these feelings did not discriminate among different kinds of pressure and did not predict how performance would turn out. Cognitive anxiety, however, did vary with pressure condition, increasing in the Audience, Video Camera Evaluation, and Combined Conditions, but actually decreasing in the Monetary Incentive Condition (as well as in the Video Camera Placebo Control Condition). Mediation analyses showed that levels of cognitive anxiety significantly mediated the impact of the various pressure conditions on performance. Greater cognitive anxiety was associated with poorer performance. This is particularly relevant to understanding the performance decrements observed in the Audience and Evaluation Conditions, where cognitive anxiety was greatest. Thus what these performers were thinking (rather than what they noticed about how their bodies were reacting) governed performance under pressure.

11 A reprise on conditions of practice

In light of the results from Mesagno et al. (2011) and Hill and colleagues (2010, 2013) I wish to highlight two sets of findings from my past work with Sian Beilock. The first, reported by Beilock and Carr (2001), illustrates, I believe, how the concept of the action-situation combination as an object of practice is relevant to choking. In Experiment 3 of that paper, we compared training conditions in which novice golfers putted either as a single task, or in a distraction / competition-for-working-memory situation in which putting was combined with a concurrent auditory target detection task, or in a self-consciousness-inducing situation much like Mesagno et al.'s video camera evaluation condition (which, as we have just seen, was able to induce choking – or at least, significant underperformance – in even very skilled and experienced performers). Participants in our self-consciousness-inducing condition were told that their performance was being recorded for analysis by kinesiologists and golf coaches in an upcoming conference at our university on learning to play golf. After 270 putts of practice in one of these three situations, the participant performed two more blocks of 18 trials each, one a single-task condition portrayed as more practice and the other a pressure condition. Our pressure manipulation combined monetary incentive (the participant could win $5 by improving 20 % over the accuracy achieved in the preceding block of 18 practice putts) plus social responsibility (the participant was told that he or she was teamed up with another participant, that both needed to meet the improvement criterion or neither one got the money, and that the teammate had already succeeded, making the participant's performance crucial). Participants who had trained in the single-task and distraction situations "choked" – that is, as a group they performed significantly worse in the pressure block than in the immediately preceding practice block. In contrast, participants who had trained in the self-consciousness-inducing video camera evaluation situation did not choke. Indeed, they performed significantly *better* in the pressure block than in the immediately preceding practice block (see Fig. 2). Thus extensive performance of the requisite action under circumstances that included emotional and motivational components likely to elicit similar kinds of reactions to those induced in the pressure test appeared to "inoculate putters against choking", as we phrased it in the paper. While the match between training conditions and pressure-test conditions was not perfect, the training situation was sufficiently similar to the pressure-test situation to support helpful transfer, or so it

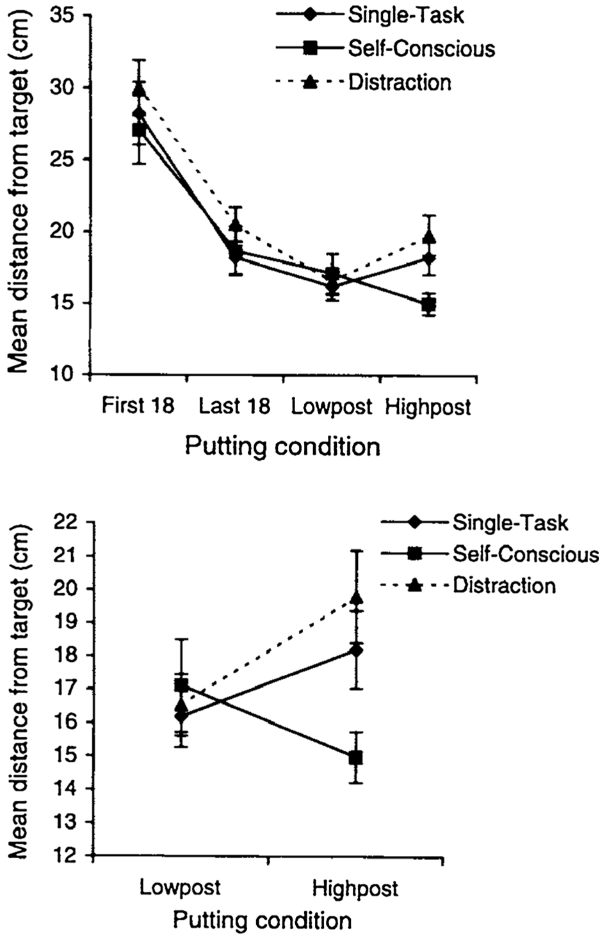

Fig. 2 Putting accuracy during training (labeled "First 18" training putts and "Last 18" training putts) and during the post-training test of performance under pressure, labeled "Lowpost" for the additional-practice low-pressurre block of putts and "Highpost" for the putts taken under the pressure imposition. (This is Beilock & Carr's Figure 8 from Beilock & Carr p 717). Putting took place on an indoor carpeted green, alternating among 9 different locations at three different distances from a target (which was a piece of duct tape about the size of a golf hole). Participants were instructed to make the ball stop on the target and accuracy was measured for each putt as the distance from the target at which the ball stopped. (Even though this task is not exactly the same as putting to a hole in the green, experts are still much better at it than novices, and say that the difference is easy to adjust to – they simply treat the green as a fast one on which a miss is likely to roll on a long distance past the hole)

would appear. Therefore I would like to offer this training study as an illustration of the power of the action-situation combination.

12 A reprise on enactive creativity and how experts adapt to new demands

The second set of findings I want to describe turns away from choking per se. Beilock, Bertenthal, McCoy, and Carr (2004) reported that novice and expert golfers respond very differently to requirements for speed versus accuracy – instructions in a golf-putting task either to execute their putts as rapidly as they could while still trying to make them (with a deadline on each putt of three seconds from stepping up to address the ball until contacting the ball to send it on its way) or to take as much time as they wanted to make the putt as accurate as it could be. Novices took considerably more time and were rewarded with greater accuracy under accuracy instructions, as might be expected from the large literature on speed-accuracy tradeoff. However, experts actually performed better under speed instructions! In post-performance debriefings the novices said that hurrying made them nervous and it didn't give them enough time to plan their action and get properly prepared. Experts, in contrast, said (often with surprise) that hurrying helped because it prevented them from thinking too much and trying too hard to be perfect. Thus something like a “reverse speed-accuracy tradeoff” characterized expert performance on short, easy putts. The phenomenological reports of the experts explaining why this might have happened were completely consistent with the idea that interfering with the emergence of Troll Number Two (Increased Attention to Detail) is helpful to a highly practiced and routinized skill.

Beilock, Bertenthal, Hoerger, and Carr (2008) followed up on these speed-accuracy tradeoffs. Suppose you are either a novice who has played little golf, or a very good golfer, perhaps a scholarship athlete at your college or a single-digit handicapper according to the Professional Golfers Association. And suppose you agree to come in to the laboratory to supply data for an experiment in which you are asked to make a series of short putts, but using a “Funny Putter” which has been distorted, twisted, and reweighted so that it feels and behaves rather differently from the regular putters with which you are highly practiced and highly skilled. How will you perform with this new and unusual “tool of the trade”? If your performance suffers, how well and how quickly will you adapt, and will your status as novice or expert matter to the course of adaptation?

In our experiment, novice and expert golfers performed 100 putts under speed instructions and 100 putts under accuracy instructions using the Funny Putter. Figure 3 shows accuracy on the first 25 putts (labeled “Early” in practice) and the last 25 putts (labeled “Late” in practice). The upper two lines in the graph represent performance by the novices, who improved with practice but showed a consistent advantage under accuracy instructions relative to speed instructions, similar to the accuracy-instructions advantage in the earlier study in which participants were using an ordinary Regular Putter. The similarity in outcome between the two kinds of putters should not be surprising. After all, these participants were novices who had played little or no golf, and for them there wasn't much funny about the Funny Putter, which was not much less familiar to them than a Regular Putter. Performance by experts, in contrast, was *not* the same with the Funny Putter as with a Regular Putter. During the first 25 putts with the Funny Putter they did do better than the novices – after all, they were experts – but they did not show the reverse speed-accuracy tradeoff they had shown in the earlier study. Instead, with the Funny Putter they benefited from accuracy instructions just as did the novices. Adaptation happened fairly rapidly, however. By the last 25 putts an advantage under speed instructions was restored – and this was entirely due to improved performance in the speed condition, as if the automated routines that had been developed over long past practice with regular putters, and had been most clearly revealed under the speed requirement in the earlier study, had been successfully adapted and could now be applied in wielding the funny putter. Early on, however, experts appeared to need the extra time granted by accuracy instructions to plan and prepare for execution, just as did the novices.

These findings make a point with respect to the strengths and weakness of reflection, and the proper places of reflective versus unreflective action, that is consistent with the larger themes of this paper. Unreflective action can carry the day under routine conditions that map well onto the situations in which the skill has been most heavily practiced and most highly automated. Under those conditions, reflection is an unnecessary burden and in sensorimotor skills it can even become actively harmful. But as conditions and demands stray further from those that have been practiced, reflection in the form of intentionally applying one's knowledge and experience to plan and prepare becomes more and more beneficial and perhaps even necessary.

Nevertheless, the range of situations that can fall under the umbrella of "routine" and "heavily practiced" is likely to grow wider as experience increases and with it the range of situations that might be handled best with unreflective action. Raab and Johnson (2007) asked elite players of team handball (a game much like water polo but played on land) to view videos of real play. At various points the video was paused, and the participant was asked to decide who the player with the ball should pass to next – which pass would best advance play. They were asked first to make a quick decision, and then were given the chance to reflect and change their decisions if they wished. Results showed that the first decisions – the quick ones – about where to pass were superior to altered decisions made after reflection, according to ratings by a panel of high-level coaches. While these first quick decisions were offline and almost certainly more reflective than the decisions an athlete would make during realtime performance, they entice the speculation that going faster – and possibly being "more in the moment" – might be better, at least for experienced athletes. Moving outside the realm of sensorimotor skills, Burns (2004) found that among high-level chess players who compete both in regular chess and in speed chess, the success of speed chess performance predicts rankings in regular chess with high accuracy. While Burns' finding does not show that speeded chess decisions are *better* than reflective ones, it shows that they are quite good. Thus on average it appears that experts can succeed with severely

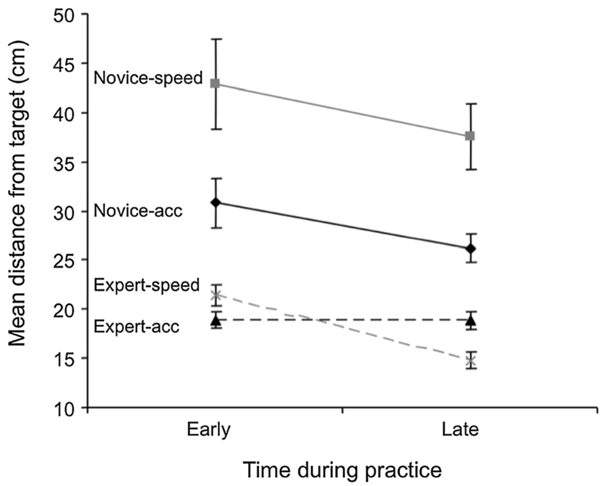

Fig. 3 Putting accuracy with the "Funny Putter" on the first 25 putts (labeled "Early") and the last 25 (labeled "Late") for novices and experts under speed instructions versus accuracy instructions from Beilock et al. (2008)

limited planning time to a greater degree than novices, as demonstrated in a sensorimotor skill by Beilock and colleagues and in a cognitive skill by Burns, and that the advantage of such "unreflective action" grows with experience and achievement as documented by Burns.

13 Conclusion: What should we think about "unreflective action", "absorbed coping", and "automaticity"?

If "absorbed coping" (as in Dreyfus, 2002) supported by "automatic processing" (as in Fitts and Posner 1967, or Beilock and Carr, 2001) means, as Cappuccio says, that "an agent masters a skillful action only when his or her movements are automatized" and that "optimal performances spontaneously spring from thoughtless and almost unaware automaticity", then, as we have seen, the notion is useful and necessary. However, it is by no means the whole story of skilled performance. The situations that allow for automaticity to charactierize action are not always in place. Absorbed coping is a state of mind and a mode of performance that can be entered into when (1) the match between one's skills and the situation's demands is ideal, and (2) the performer is able to let go of reflection enough to allow that match to elicit an effective mix of automatic routines and enactive creativity. However, absorbed coping does not, it seems, characterize the entirety even of excellent performance – sometimes even an accomplished expert needs to think about what he or she is doing. And the capacity demands of enactive creativity are not yet known – nobody has yet done a concurrent-task distraction study of performers being enactively creative! it may be that dealing with new situations at the highest level requires thoughtful engagement even from high-level performers. Nor does absorbed coping characterize the learning situations in which excellent performance is made possible, or the post-performance analyses and deliberate practices by which mistakes are repaired and shortcomings improved. Thus even very high-level athletes do not always operate "in the zone".

That is to say, there is a place for reflective action as well as for unreflective action. It is their well-tuned and context-sensitive coordination that marks the truly great performer.

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