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# The fourth dimension: A motoric perspective on the anxiety–performance relationship

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**ABSTRACT**

This article focuses on raising concern that anxiety–performance relationship theory has insufficiently catered for motoric issues during, primarily, closed and self-paced skill execution (e.g., long jump and javelin throw). Following a review of current theory, we address the under-consideration of motoric issues by extending the three-dimensional model put forward by Cheng, Hardy, and Markland (2009) ('Toward a three-dimensional conceptualization of performance anxiety: Rationale and initial measurement development, *Psychology of Sport and Exercise*, *10*, 271–278). This fourth dimension, termed *skill establishment*, comprises the level and consistency of movement automaticity together with a performer's confidence in this specific process, as providing a degree of robustness against negative anxiety effects. To exemplify this motoric influence, we then offer insight regarding current theories' misrepresentation that a self-focus of attention toward an already well-learned skill *always* leads to a negative performance effect. In doing so, we draw upon applied literature to distinguish between positive and negative self-foci and suggest that *on what* and *how* a performer directs their attention is crucial to the interaction with skill establishment and, therefore, performance. Finally, implications for skill acquisition research are provided. Accordingly, we suggest a positive potential flow from applied/translational to fundamental/theory-generating research in sport which can serve to freshen and usefully redirect investigation into this long-considered but still insufficiently understood concept.

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Frequent occurrence of 'choking' under pressure (i.e., performing below one's and others' expectations in consideration of previously demonstrated ability) has led to a high volume of research output in an effort to understand the fragility of technique under high-anxiety conditions (e.g., Baumeister, 1984; Beilock & Carr, 2001; Collins, Jones, Fairweather, Doolan, & Priestley, 2001; Gucciardi, Longbottom, Jackson, & Dimmock, 2010), and attempts to intervene by providing strategies to counter the onset of debilitating mechanisms (e.g., Lam, Maxwell, & Masters, 2009; Mesagno, Marchant, & Morris, 2008; Vine & Wilson, 2010). As such, a practitioner's ability to consistently select the most appropriate intervention is dependent on their level of mechanistic understanding (i.e., declarative knowledge

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of 'what needs to be done' and 'why'). Crucially, practitioners' knowledge is likely to be reliant on ideas presented by theory; therefore, it is important that theory can accurately explain the choking phenomenon.

Consequently, consideration of recent theory to explain the anxiety–performance (A–P) relationship forms the central focus of this article. Specifically, while it is recognized that anxiety impacts at different stages of *perception*, *selection*, and *action* during the performance behavior (cf. Nieuwenhuys & Oudejans, 2012), this article focuses on raising concern that current theory has insufficiently catered for *motoric* issues within the action (execution) stage of performance, this insufficiency being apparent through an under/misrepresentation of important factors.

As a brief overview, we suggest that these under/misrepresented issues fall into two broad categories. The first relates to how the movement is represented within a performer's long-term memory. Specifically, we refer to the level and consistency of automaticity across the different movement components, and a performer's specific confidence in this automaticity during stressful situations. When high, these factors can serve to practically make a skill 'anxiety-proof'; typically, a 'flow' (Jackson, 1996; Swann, Piggott, Crust, Keegan, & Hemmings, 2015) performance would characterize this approach. As will be explained, we refer to these factors as *skill establishment*, later formalized as the fourth dimension in an attempt to extend Cheng, Hardy, and Markland's (2009) three-dimensional model to explain the A–P relationship. The second category relates to the more commonly considered situation in which a performer may consciously focus on controlling aspects of the movement execution. In this case, we explore research which shows that this situation has often been uncritically considered (or at least operationalized during empirical investigation) as *always* negative for performance; the misrepresentation referred to above. In fact, there is considerable evidence to suggest that certain types of self-foci are both positive for performance and an important element in assisting athletes to control potentially negative impacts of anxiety.

Taken together, these under/misrepresentations suggest the need for greater emphasis on motoric issues in the A–P relationship. In organizing this article there are four distinct objectives: (1) we review mainstream A–P relationship theories to provide a brief background of well-researched ideas, followed immediately by prominent contemporary theories which have attempted to overcome an apparent dichotomy between self-focus and distraction mechanisms. This review is not aimed at being comprehensive, but rather to highlight the main trends in choking theory to date; (2) based on these reviews, we introduce an additional motoric dimension (i.e., skill establishment) to extend current conceptualizations of the A–P relationship; (3) using applied research, we clarify a confusion within the literature by assessing circumstances in which conscious control can be positive *or* is likely to lead to a negative performance outcome, therefore considering the importance of skill establishment when explaining self-focus effects; and (4) we raise future considerations within skill acquisition and A–P relationship research.

## Current explanations of the A–P relationship

Until recently there has been a dichotomy between distraction (Eysenck & Calvo, 1992; Eysenck, Derakshan, Santos, & Calvo, 2007) and self-focus (Beilock & Carr, 2001; Masters, 1992) theories to explain the A–P relationship (see Hill, Hanton, Matthews, & Fleming, 2010 for a review of other previous models). In summary, advocates of distraction theories – specifically Attentional Control Theory (Eysenck et al., 2007) – posit that worry inhibits performers' ability to resist distraction from task-irrelevant (threat-related) stimuli. Moreover, worry causes an imbalance between the stimulus- and goal-directed attentional systems. The stimulus-directed system responds to behaviorally relevant sensory events, whereas the goal-directed system regulates expectations, knowledge, and current goals. Worrying results in an increased influence of the stimulus-driven system. To overcome this imbalance and avoid a negative outcome, increased processing resources and storage capacity of the working memory are invested. Consequently, attention allocated to task-relevant stimuli and information processing efficiency is reduced.

In contrast, proponents of self-focus theories posit that pressurized situations increase anxiety and self-consciousness about performing well, inducing conscious processing during skill execution. For example, Masters (1992) suggested that consciously *controlling* technique through 'reinvestment' leads to eventual breakdown in performance, where reinvestment refers to the 'manipulation of conscious, explicit, rule based knowledge, by working memory, to control the mechanics of one's movements during motor output' (Masters & Maxwell, 2004, p. 208) or 'the tendency to direct conscious attention to the mechanical details of how the skill should be performed' (Masters, 2008, p. 90). However, Beilock and Carr (2001) later proposed that conscious *monitoring* of the skill is responsible for skill failure. While the distinction between control and monitoring could relate to a number of different things, both hold disruptive potential due to an effortful increase in conscious *awareness* of proceduralized skills which reverses the normally automatic processes governing well-learned execution to a dysfunctional state that is more representative of earlier stage learners (Fitts & Posner, 1967).

Optimistically, however, several proposals have emerged from this dichotomous debate (distraction vs. self-focus) as offering potential resolution. One proposal comes from Beilock and colleagues' research (e.g., Beilock, Bertenthal, McCoy, & Carr, 2004; Beilock & Carr, 2005; Beilock, Kulp, Holt, & Carr, 2004). According to these authors, anxiety can disrupt well-learned skill execution by at least two different mechanisms, creating a 'double whammy' (Beilock, Jellison, Rydell, McConnell, & Carr, 2006, p. 1062) effect. The mechanism depends on the manner in which a task is represented and implemented, coupled with aspects of the pressure situation. Accordingly, anxiety initially reduces attention directed toward task-relevant information by overloading working memory with task-irrelevant worrying thoughts (viz., distraction theories). The second whammy, as a result of such worry, coaxes performers to consciously attend to skill execution in a step-by-step fashion; thus the allocation of attention, even if quantitatively sufficient for the task, is counterproductive. As such, developments from this perspective remain grounded in attentional mechanisms.

Alternatively to Beilock and colleagues' explanation, Cheng et al. (2009) proposed a three-dimensional model to conceptualize the A–P relationship. The cognitive dimension comprises negative responses of worry and self-focused attention to perceived threat. Similarly to Beilock and colleagues' explanation, worry and self-focused attention act separately, since consciously controlling movements as a result of anxious self-focus is not contained within worrying thoughts. Self-focused attention can be directed toward the execution, performance shortcomings, and negative cognitions, usually typified by self-preoccupation with thoughts of 'personal lack' or weaknesses (notably, a lack of general self-confidence). A second dimension represents the influence of physiological responses invoked by the autonomous nervous system in the forms of *autonomous hyperactivity* and *somatic tension*. Whereas autonomous hyperactive responses stem from involuntary muscles associated with the inner organs, leading to cold sweat, elevated heart rate, and breathlessness, somatic tension relates to responses from motor-orientated voluntary muscle groups, such as tension, trembling, and fatigue. Thirdly, and finally, the regulatory dimension refers to the performer's level of perceived control, that is, the perceptions of one's capability to cope and achieve goals in stressful situations (cf. Jones, 1995). It is interesting to consider whether this third element is highly task specific (i.e., self-efficacy) or a more global, 'I can control myself whatever' construct. This specific issue is outside our purpose in the present article, although inspection of the way in which Cheng et al. operationalize this construct should offer some insight. For the present purpose, however, and in this regard, the regulatory dimension relates to favorable expectations and an intended adaptive capacity. Accordingly, the interactions between the cognitive, physiological, and regulatory dimensions are proposed to better predict the A–P relationship.

In presenting these latter explanations, we acknowledge and applaud the significant contributions that have been offered. Indeed, complexity within the human condition is inevitable and something that should always be considered when working with athletes (cf. Collins et al., 2012). As such, formalized models which can present, explain, and realize this complexity within applied environments offer great potential when planning interventions. Crucially, however, upon closer examination of these explanations and other empirical research (e.g., Lohse, Sherwood, & Healy, 2010; Porter, Ostrowski, Nolan, & Wu, 2010; Wulf & Su, 2007), we firstly raise concern that there seems to be an underrepresented dimension, notably, how well-*established* the skill is with the performer (see below). Secondly, and extending this motoric influence, we raise concern over the claims central to, and implicit within, these theories that a self-focus of attention is *always* disruptive toward performance (i.e., referring to the interaction between cognitive and motoric dimensions). Accordingly, as scientist-practitioners we call into question the veracity of these approaches to *optimally* guide both theory-building investigation and applied coaching practice. In order to overcome these limitations, the following section proposes extension of the existing three dimensions, suggesting consideration of a new four-dimensional model.[1] Subsequently, we aim to address the contentious issue and confusion surrounding self-focused attention by considering data from applied literature alongside this new motoric dimension.

## The fourth dimension: Skill establishment

Based on the ideas presented in the preceding sections, we suggest that a more formalized motoric consideration is essential for a comprehensive mechanistic theory of the A–P relationship. For clarity of message, we primarily emphasize the execution of self-paced tasks in this article, where there is, at the least, a compelling case for consideration of motoric factors, notably an uncommon feature in A–P studies to date. Building on the three-dimensional model (Cheng et al., 2009), we suggest that this represents a fourth dimension for inclusion in future work. In contrast to existing theories' predominant focus on factors of emotion, information perception, and nature of attentional focus, skill establishment concerns the structures/representations of the movement on which these other factors act. Specifically, we refer to the level and consistency of automaticity governing the different movement components that comprise a skill, together with a performer's level of confidence in this process under anxiety symptoms (i.e., 'I *know* that the skill is anxiety-proof'). These confer a level of robustness to the skill against negative anxiety effects through a conscious process of trust in the skill (cf. Moore & Stevenson, 1994). Whereas the previous three dimensions directly account for perturbations in close proximity to and during the anxiety episode, skill establishment concerns processes related to motor execution that are developed through long-term training experiences, or at least by repeated good ones (i.e., overlearning of the retrieval process; cf. Bjork & Bjork, 1992), as we explain later in more detail. In this regard, high skill establishment is something that coaches often strive to achieve in their athletes when developing motor skills. Accordingly, exemplar studies from psychological and neuroscientific perspectives are highlighted below to demonstrate these components of skill establishment.

We should also highlight at this point that skill establishment is not the same as skill level. Skill level implies a measure of performance outcome, whereas skill establishment relates simply to aspects governing motor control, although it would not be unexpected that higher-skilled performers possess more well-established skills, since they are usually more experienced. As an example of this in the applied context, consider the mid-handicap golfer who has a consistent but not necessarily most effective technique; that is, they are sub-elite but very experienced.

## *Automaticity*

From a mechanistic perspective, Logan (1988) proposed automaticity to represent a single-step, as opposed to multi-step, memory retrieval process. With automaticity, attention is shifted from focusing on movement components to higher-order aspects of the skill that are concerned with integration, therefore reducing the number of steps required to retrieve the skill from long-term memory. Contrary to traditional dual-mode views, however, that of movement being either automatic *or* controlled (see Bargh, 1989), automaticity need not necessarily be considered consistent across all components of the skill; that is, different aspects of the movement representation/structure can express higher levels of automatic activation than others. Indeed, this alternative explanation remains possible even when employing Shiffrin and Schneider's (1977) information-processing model, since retrieval *initiation* via conscious processing is a distinct step in the process of execution. In addition, during conscious retrieval of a component from long-term memory, associated components are indirectly processed with reduced or automatic activation thresholds, representing a more efficient integration (or association/chunking) of related skill components as a *holistic* process. Therefore, automaticity should be considered as a *gradual* construct, existing at both temporal and spatial levels during skill execution and, thus, there are multiple routes to achieving higher levels of entire skill activation. In short, successful performance may not *solely* rely on movement components being activated automatically, providing that they are activated correctly. When entire skills *are* highly, if not totally, automatic, however, this corresponds to the flow experiences mentioned earlier (for a review of automaticity from a theoretical and conceptual perspective, see Moors & De Houwer, 2006).

Furthermore, theory has offered detail regarding the structure and storage of movement representations which, in turn, helps to 'unpack' the implications for generating high levels of automaticity. For example, according to Paivio's (1971, 1986) Dual-Coding Theory, a high level of movement automaticity would be present if motor representations (or codes) were predominantly stored using the multisensory nonverbal, as opposed to verbal, coding system. A highly associated network of multisensory codes would ensure a most vivid, and therefore complete, representation of the entire skill, offering a number of different retrieval routes. Finally, strong retrieval cues increase the activation of this network. In fact, access to the nonverbal system may even be facilitated via a referential connection with the verbal system. As such, arousal of a single verbal code could functionally activate others in the nonverbal system through less-conscious attention (see Clark & Paivio, 1991 for a review). We will return to this idea later. Repeated use of this process would increase the likelihood of future activation with greater ease (see also the Bio-informational Theory of emotion and imagery; Lang, 1979). In short, the extent to which a broad network of motor representations are energized by a single stimulus, either consciously or subconsciously mediated, is an important feature of automaticity. Crucially, however, it must be recognized that the storage and activation strength of this network is highly idiosyncratic across athletes; that is, the technique *and* control demonstrated by one athlete is inevitably different to another. Based on this process, we now highlight several domains of study which exemplify these performer characteristics before addressing the second factor within skill establishment, the performer's confidence in automaticity.

### *Mirror neuron system*

Reflecting a neural account of automaticity, the discovery of a mirror neuron system during action observation (di Pellegrino, Fadiga, Fogassi, Gallese, & Rizzolatti, 1992; Rizzolatti et al., 1988; Rizzolatti, Fadiga, Gallese, & Fogassi, 1996) has provided a useful 'tool' for assessing what has been described as one's 'vocabulary of motor acts' (Rizzolatti et al., 1988, p. 491). Indeed, mirror neurons are also functional, since 'our ability to interpret the actions of others requires the involvement of our own motor system' (Kilner & Lemon, 2013, p. 1057).

Perhaps the most important finding from this research, at least when discussing motoric issues, is the association between cortical motor region (e.g., primary motor and premotor cortex) activity and observers' previous experience of executing, not only watching, the skills presented. For example, using fMRI assessment, Calvo-Merino, Glaser, Grèzes, Passingham, and Haggard (2005) compared neural responses from expert ballet and capoeira performers with novices when observing complex routines associated with the two performance styles. Greater blood oxygenated level-dependent responses were found within experts' motor cortex; however, inter-expert differences were also evident when distinguishing between performance style. Performers showed higher activation when observing the style that most closely matched their own motor repertoire. Further reflecting a motoric, as opposed to visual or theoretical knowledge-based, foundation to the mirror neuron system, Calvo-Merino, Grèzes, Glaser, Passingham, and Haggard (2006) then compared professional male and female ballet dancers observing gender-specific and gender-common ballet routines. Despite all participants possessing an understanding and visual representation of the specific moves – since training and performance occur collectively – data showed that neuronal responses depend on observers' motor expertise for sets of overlearned and stereotypic actions; that is, *doing* the behavior. Most interestingly, the same findings are shown when athletes hear familiar versus unfamiliar sports sounds (Woods, Hernandez, Wagner, & Beilock, 2014).

Interpreting these findings using Paivio's (1971, 1986) Dual-Coding Theory, this most probably reflects a more complete representation of the movement within the multisensory nonverbal system (since execution relies on more than just visual information processing). Additionally, the higher level of activation relates to the motor representations' high ease of access, since merely observing/hearing the stimuli resulted in distinct activation.

In summary, mirror neuron system activity suggests an index of motoric familiarity, personal meaning, congruence, and automaticity, all of which share similarity with the skill establishment dimension. Findings of consistent perceptual and motoric neural activation within these studies confirm the functional interplay between the two systems when generating skilled movement patterns. As such, we believe this adds to our argument for greater consideration of motor structures/representations when explaining the A–P relationship alongside factors influencing the perceptual system.

### *Especial skills*

Automaticity may also be inferred using performance outcome measures, not only between but also within skills. This can be exemplified by recent study of the *especial skill* (cf. Keetch, Schmidt, Lee, & Young, 2005), 'a highly specific skill embedded within a more general class of motor skills' (Stöckel & Breslin, 2013, p. 536). Predominantly reported in basketball free throwing, the skill is represented by a violation of the negative linear relationship between shot successes and increasing distance, predicted by the force × variability hypothesis (Keetch et al., 2005). At the free throw regulation distance, performance is significantly better than would be predicted using regression analyses. It is currently hypothesized that, following massive amounts of practice, the especial skill could be underpinned by an enhanced parameter specification and selection process (learned parameter hypothesis; Breslin, Hodges, Kennedy, Hanlon, & Williams, 2010), which is mediated by the visual context (visual context hypothesis; Keetch, Lee, & Schmidt, 2008) whereby specific visual cues are encoded as part of the memory representation (Breslin, Schmidt, & Lee, 2012). The suggestion of a more efficient and enhanced memory retrieval process is thus in line with opinion that automaticity involves a single-step mechanism. The fact that visual information might form part of the associative representation network also adds strength to the arguments presented by Paivio (1971, 1986) and Lang (1979), in that sensory information forms an important component of the memory/cell assembly trace. While research in this area is still in its early stages, such findings clearly demonstrate the differential impact on performance success caused by superior motoric functions and, we suggest, skill establishment. However, we should highlight that it is currently unknown through empirical testing whether the especial skill is more resistant to the negative effects of competitive pressure. On the basis of content in this article, our expectation would be that it is.

## *Confidence in the process of automaticity*

Returning to the components of skill establishment, *robust sport-confidence* has recently been conceptualized as 'a set of enduring, yet malleable positive beliefs that protect against the ongoing psychological and environmental challenges associated with competitive sport' (Thomas, Lane, & Kingston, 2011, p. 194). Accordingly, these ideas appear aptly contained within skill establishment, since it suggests a developed mental state which counters the onset of a negative self-focus. Notably, within this multidimensional set of beliefs are 'durable' and 'protective' characteristics. As such, durability indicates a strong, long-lasting, and generally high (but not over or false) level of confidence, whereas the protective characteristic more directly supports the functional role provided when performing under high competitive anxiety. Specifically, the protective characteristic is reported by experienced elite-level performers as enabling resistance to confidence-debilitating factors (e.g., injury, pressure, and high expectation from others), a protective layer, and shock absorption in the day-to-day fluctuations in confidence. Therefore, robust sport-confidence can be viewed as providing long-term security to the single-step memory retrieval process, making the process less likely to suffer motoric faults (that is not to say that the movement is invariant; cf. Müller & Sternad, 2004).

Crucially, however, we suggest that this is the case when robust confidence pertains to aspects of specific skill execution and processes involved in automaticity (i.e., the athlete's imagery/self-focus is able to activate the required motor structures). Indeed, Hays, Maynard, Thomas, and Bawden (2007) highlight that, among world-class athletes, quality skill repetition and overlearning constitute part of a global *preparatory* source of confidence. For example, one athlete reported: 'If I do things correctly in training and get things like skills and techniques right, then I become more confident' (p. 439). Furthermore, skill execution was also reported as a specific type of confidence by 71% of these athletes. In short, when performers are not confident in processes governing a specific motor execution, then emphasis on a negative self-focus is more likely under conditions of high anxiety; that is, a conscious focus on aspects of the movement representation that do *not* generate whole skill activation. As highlighted earlier, such ideas are also supported by the notion of *trust*. According to Moore and Stevenson (1994), trust enables the expression of automaticity by removing thoughts of fear pertaining to skill execution or outcome. Therefore, a high level of trust infers confidence in one's level and consistency of automaticity for that specific skill.

In summary, high-level skill establishment necessitates the combined influence of movement automaticity and confidence in that process; both must be present for optimal security under high-pressure conditions. Additionally, it should be emphasized that a high level of automaticity, and indeed confidence, does not always mean a low level of anxiety (e.g., somatic reaction) or emotional influence (e.g., feeling 'psyched up'). Indeed, anxiety and emotion are often considered essential constructs to achieving an individually optimal performance zone (cf. Hanin, 2007; Ruiz & Hanin, 2004). Finally, in providing a case for motoric consideration, we hope to have qualified our claims of an underrepresentation by existing A–P relationship theory.

Moving forward, we now direct greater attention toward our second concern, the misrepresentation of motoric-related issues. Specifically, the following section addresses self-focus (cognitive dimension) effects on skilled technique during high-anxiety conditions. Additionally, we provide critical insight from motoric factors to interpret contradictory findings between theoretical and applied literature. Accordingly, our interpretation explains *why* a self-focus of attention is *not always* negative. In doing so, we distinguish between two different types of self-focus, one that is 'positive' and another 'negative'. As a precursor, however, we highlight the origins of our particular concern as a state of confusion within the literature.

## The nature of self-focused attention: To 'what' and 'how' attention is applied

Within the three-dimensional model, it is suggested that any form of self-focus negatively contributes to the A–P relationship, whereby 'self-focus refers explicitly to an attentional shift towards the self' (Cheng et al., 2009, p. 272). Indeed, within the anxiety measure tested, self-focus is framed as 'I am very conscious of every movement I make' (p. 276). Such definition of self-focus is not unique to this model; for example, reinvestment theory (Masters & Maxwell, 2008) also proposes that consciously controlling mechanics during execution leads to performance breakdown (Masters, 1992). Accordingly, from these explanations, it would appear that successful execution is hindered by a conscious, self-focused intervention.

Somewhat more positively, however, Beilock and colleagues appear to interpret a negative 'self-' or 'skill-focus' as focusing on 'a component process of well-learned performance' (Beilock, Bertenthal, et al., 2004, p. 373) or 'paying *too much* attention to task control and guidance' (Jackson & Beilock, 2008, p. 106 [emphasis added]), which serves to disrupt automatic processes during execution. Indeed, kinematic research supports this suggestion by demonstrating disruption to functional variability when employing a specific *part*-skill focus (Carson, Collins, & Richards, 2014; MacPherson, Collins, & Morriss, 2008). Thus, and in contrast to Cheng et al.'s interpretation, we believe these authors acknowledge *some* role for conscious attention during optimal execution, especially since the attention referred to is explicitly implicated with skill components that are usually run 'offline'. However, it is difficult to garner much more from this attentional strategy, such as the aspects of execution which *do* run 'online', since the majority (if not all) of their studies compare skill-focused and dual-task conditions (e.g., attending to an auditory tone or performing an alphabet arithmetic task; Beilock, Bertenthal, et al., 2004; Beilock & Carr, 2001; Beilock et al., 2006) or executing under time restrictions (e.g., Beilock, Bertenthal, et al., 2004). As such, recommendations on how attention *should* be implemented are generalized to allocating 'attention to aspects of performance that are not directly involved in the online control of skill execution' (Beilock, Carr, MacMahon, & Starkes, 2002, p. 15), including tactical strategy, external visual cues, and employing time-restricted pre-performance routines – in short, non-motoric aspects of the skill. It has even been suggested that 'for real-time execution by experts, there may be truth in the Nike motto "Just do it"' (Beilock, Bertenthal, et al., 2004, p. 379; see also the older and more explicitly applied ideas on trust, cf. Moore & Stevenson, 1994). Therefore, if our interpretation of self-focused attention in these studies is correct, the link between mechanistic understanding and implications for practice is somewhat incoherent. In other words, the authors suggest that paying attention to aspects of skill that are normally subconsciously controlled results in a negative outcome and therefore one should not think about the skill. The confusion has arisen because there has been no recommendation regarding what would happen if the performer attended to aspects of the skill which normally *did* operate under conscious control; would this be positive? Either this explanation shares the same view of automaticity as Cheng et al. (2009) and Masters (1992), suggesting that any self-focus of attention to skilled technique is always negative, or it is incomplete. In developing this idea, we suggest that inclusion of skill establishment could offer a more complete account, especially when considered against our upcoming review of applied and empirical research.

Furthermore, these issues are confounded by variable operationalization of motoric-related issues in A–P studies, for example the coverage of attentional control by a single questionnaire item: 'I am very conscious of every movement I make' (Cheng et al., 2009, p. 276). As another example of this potential ambiguity, Beilock and Gonso (2008) employed an imagery intervention under speeded and actual pace instructions in order to manipulate conscious focus prior to a putting task. However, virtually no detail is provided regarding what the participants focused on during the movement (including the modality in which it was recommended, if any), only that 'participants were told that they would be imaging themselves performing a number of golf putts … in their mind' (p. 925) and only up until ball contact (i.e., not the completed action). As we stress in the next section, *to what* and *how* self-focused attention is applied are crucial pieces to the complex A–P relationship, since they influence the activation level of motor structures/representations in long-term memory. In summary, current explanations of the A–P relationship advocate no facilitative role for self-focused attention, or fail to expand sufficiently when explaining the attentional mechanisms that are/are not harmful to performance.

## An applied perspective on countering anxiety: Positive self-focus

Contrary to self-focused attention disrupting performance under high-anxiety conditions, several studies have in fact found *benefit* from a self-focus (Carson, Collins, & Jones, 2014; MacPherson et al., 2008; Mullen & Hardy, 2010). This indicates, therefore, that the nature of self-focus is more complex than currently being suggested by anxiety theories, and within some experimental studies (e.g., Abdollahipour, Wulf, Psotta, & Palomo Nieto, 2015; Lohse et al., 2010; Weiss, Reber, & Owen, 2008; Wulf & Su, 2007) examining effects of attention on learning and performance; that is, self-focused attention has often been erroneously/too simplistically investigated (cf. Peh, Chow, & Davids, 2011). Recent challenge to the idea that successful execution is devoid of conscious attention is readily apparent within the applied sport (see Toner & Moran, 2014; Winter, MacPherson, & Collins, 2014) and exercise (e.g., Schücker, Knopf, Strauss, & Hagemann, 2014) psychology literature. Conclusions suggest that it is not thinking *per se* that is problematic, but rather *what* the performer thinks about and *how*.

Addressing the former of these two factors, holistic thoughts which summarize the movement's entirety act as a 'screen' or 'buffer' from maladaptive cognitions and as a positive route to enhanced memory retrieval (Winter et al., 2014). According to MacPherson et al. (2008), temporally accurate rhythmical cues act as a 'source of information' (p. 289) by raising awareness of helpful information about timing.[2] This, in turn, prevents the skill from being processed as fragmented parts, which *does* seem to be an almost uniformly negative self-focus, while maintaining focus on task-relevant information. In other words, focus on rhythmicity acts to entrain the different movement components within the motor memory trace with seemingly *lower* requirement for conscious attention. Indeed, this form of processing remains underpinned by the efficient integration of a cortical and subcortical neural network (MacPherson, Collins, & Obhi, 2009). As such, it is unsurprising that consistently timed movements are most often associated with superior performance outcomes (MacPherson, Collins, Graham-Smith, & Turner, 2013), even when improvements in timing are trained in isolation of the task (Sommer & Rönnqvist, 2009), and holistic rhythm-based cues are reported by highly skilled performers in closed skill sports such as golf (Cotterill, Sanders, & Collins, 2010) and javelin throwing (Collins, Morriss, & Trower, 1999). Addressing *how* a holistic focus might be employed (the latter of our two factors), these are often multisensory, reflecting the use of holistic auditory cues (see also MacPherson et al., 2008). For example, and in line with the auditory mirror neuron research presented earlier (Woods et al., 2014), one tennis player explains:

> If you're really visualizing something long then you are aware of the sounds because different balls have different sounds. Balls sound different when they are sliced; it sounds different than a topspin ball. The sound can be really important because if you imagine what it sounds like to hit a slice backhand, which has a different sound than a topspin, it gets you in the mindset. (Munroe, Giacobbi, Hall, & Weinberg, 2000, p. 131)

Supporting part of an optimally activated and multisensory motor neuronal network (cf. Holmes & Collins, 2001), elite-level performers also attend to holistic proprioceptive cues. For instance, one European Tour professional golfer described 'feelings that are more connected to bigger muscles and to the full motion, rather than [my] little right finger's going to do this or that' (Carson, Collins, & MacNamara, 2013, p. 75). Such a holistic sense of 'feel', according to Toner and Moran (2014), may even be a direct strategy of elite performers to prevent *total* subconscious control, affording adaptability to subtle differences within the performance environment when required (cf. Christensen, Sutton, & McIlwain, in press). Indeed, Bargh (1994) also suggests that movements may only rarely exhibit themselves as totally automatic, reflecting the infrequency of flow states, which is quite apart from the implications of dual-task experiments and current explanations of the A–P relationship. In other words, the low ecological validity of experimental tasks has perhaps overestimated the level of automaticity across *every* aspect of the skills being executed.

Reflecting these various studies and our earlier discussion on multiple routes toward automatic execution, we suggest that holistic thoughts may provide an optimal pathway for activating important components of a skill *as well as* associated subcomponents (cf. Paivio, 1971, 1986), thus making complete and correct retrieval of the whole skill more likely. There is, however, a requirement for these motor components to be firmly represented and associated if they are to activate under such a broad internal self-focus. In contrast, and in spite of our earlier observation that a focus on movement components is usually negative under high-anxiety conditions, it may even be that such a part-skill focus can work *if* the component focused on is crucial to and causative of good performance. As Bortoli, Bertollo, Hanin, and Robazza (2012) explain in the context of target sports, focusing on 'the accurate execution of the core components of the shooting action should "neutralise" the dysfunctional effects of distress' (p. 695). Notably, core components are not those which remain automated (and therefore unchanged) under high-anxiety conditions, but rather those which digress and signify poor performances.[3] Application of this 'action approach' with Olympic-level shooters demonstrated that accurate execution of these skill components by conscious control moderated the A–P relationship (Bortoli et al., 2012). To exemplify the importance of focusing on the correct skill component, and supporting our earlier critique that theory had erroneously misinterpreted foci effects, Beilock, Bertenthal, et al. (2004) showed skilled golfers' performance to degrade when attending to the putter swing path in a skill-focus condition. However, on the basis of later research by Karlsen, Smith, and Nilsson (2008), it appears that the swing path is only accountable for 17% of putting accuracy variance in elite-level golfers. Therefore, it is unsurprising that performance was worse, since the targeted focus was not particularly useful for the outcome (i.e., a negative self-focus). As such, focus on a single causative feature, or switching between them (e.g., switching from gun alignment and sight picture to trigger pull *at the right time and in the right way*; cf. Loze, Collins, & Holmes, 2001), may underpin the majority of successful elite-level performances.

To summarize *to what* attention is directed, a holistic self-focus appears to help activate a broad number of skill subcomponents under low-level consciousness, whereas a core component(s) self-focus works effectively when the other important components remain correctly activated during the anxiety response. Both, therefore, positively prompt athletes toward attaining higher levels of overall automaticity. In addition to benefiting under high-anxiety conditions, a holistic focus of attention appears to also offer a practical solution when attempting executions with reduced conscious control over single aspects of complex skills, for instance during re-automation following a technical refinement (cf. Carson & Collins, 2011, 2014).

Finally, and as briefly addressed already when referring to multisensory information processing, *how* these different stimuli are attended to is an important factor in understanding the A–P relationship (cf. Holmes & Collins, 2001). Crucially, in order to prevent a negative outcome, self-focused attention must resonate effectively with the movement representation/structure *and* be appropriate for the task being performed. For example, by overemphasizing one particular imagery modality when nonverbal codes are best interrelated (Ernst & Banks, 2002; Guillot et al., 2009), applying an inappropriate perspective (White & Hardy, 1995), or focusing on stimuli that are unrepresentative of the motor system's repertoire (e.g., a competitor's technique) can differentially guide the balance of attention required for a specific task (Guillot & Collet, 2008). Reflecting this final example, such a suboptimal effect can be interpreted within the earlier reported mirror neuron findings by Calvo-Merino et al. (2006).

Likewise, a positive self-focus may be applied by attending to motorically appropriate 'mood words' which accurately resonate with the to-be-performed skill. This, therefore, may offer a better balance between verbal and nonverbal retrieval processes explained by Paivio's (1971, 1986) Dual-Coding Theory;[4] that is, activation of a powerfully resonant verbal code serves to automatically activate associated motor networks within the nonverbal system. For instance, Mullen and Hardy (2010) reported consistent benefits from using holistic (e.g., drive, thrust, smooth, glide, and soft) as opposed to part-process goals (e.g., arch back, hips up, wrists firm, and square blade) when executing under anxiety conditions in long jump, basketball free throwing, and golf putting (see also Gucciardi & Dimmock, 2008; MacPherson et al., 2009). Indeed, this idea has been prevalent in the applied literature for many years (cf. Rushall, 1979, 1984; Rushall & Shewchuck, 1989). Crucially, however, considering the individuality of technique, the epitome of mood words must hold personal meaning for each performer and be able to represent the technique if it is intended to optimally aid memory retrieval (e.g., the number of syllables and articulation; MacPherson et al., 2009). As such, verbalized and explicit knowledge about a skill is not *always* detrimental to performance *if* it serves the function of facilitating holistic motoric activation.

Taking these two aspects (what and how) of self-focus together, we suggest that an appropriate motoric consideration can inform a positive self-focus; in contrast, when these two factors are ill-considered the resultant self-focus is most likely negative. Such detailed discussion and interpretation offers important guidance to sport psychologists about the mental requirements of athletes during situations of high competitive anxiety. Of course, we suspect that much of this will not be entirely novel to applied psychologists (cf. Winter & Collins, 2015); after all, is addressing this challenge not the intention of imagery training? Indeed, as applied sport psychologists we actively encourage performers to employ a self-focus by means of mental imagery (Cotterill, 2011; MacPherson et al., 2009) and, from anecdotal evidence at least, it is apparent that elite-level athletes employ a self-focus to positive effect (Clarey, 2014; Collins, 2011). Therefore, it seems, to us at least, erroneous that A–P relationship theory should recommend its non-use. If mental imagery *is* to be employed, however, we reiterate the need for greater motoric consideration when applying these mental skills. Accordingly, we now address the issue of preventing a negative A–P relationship occurring, or at least significantly reducing the likelihood of one when acquiring skills. In contrast to research that aims to explain the A–P relationship, such problem solving has received relatively limited investigation, something we suggest needs to increase.

## Practical future considerations for anxiety and performance within research and coaching practice

Probably the most researched proposal to counter a negative A–P relationship is implicit motor learning (Masters, 1992). The principal assumption of this theory is that performers will not consciously reinvest in explicit, rule-based knowledge to control their movements if they do not accrue such knowledge during the course of learning. As such, an underpinning feature of implicit learning is practicing motor skills without conscious attention directed toward the mechanics involved, particularly through use of verbalized and/or written instructions. Examples of implicit learning within the experimental literature include minimizing errors during early learning (Maxwell, Masters, Kerr, & Weedon, 2001; Poolton, Masters, & Maxwell, 2005), presenting marginally perceptible outcome feedback (Masters, Maxwell, & Eves, 2009), and executing under dual-task conditions (Gabbett, Wake, & Abernethy, 2010; Masters, 1992), all of which are intended to prevent working memory from consciously processing aspects of technique.

Despite the clear origin of this theory, however, we believe that advice to learn a skill in an *entirely* implicit fashion (many aspects, if not most, involved in learning are in fact implicit)[5] is both practically impossible and somewhat misdirecting coaches in their efforts to develop high-level athletes. Firstly, it seems virtually impossible to coach athletes implicitly over long-term time scales, unless the skill is incredibly simple. Therefore, it might work for some limited, laboratory-focused skills and situations (cf. Beek, 2000) but is unlikely to be a practical solution for complex whole body skills that are learned and performed in applied environments. Indeed, Gabbett and Masters (2011) concede that it is not always feasible to employ the laboratory-based methods of implicit learning in applied contexts, which makes us wonder why the technique would ever be suggested in applied settings. Supporting this argument, there is also a lack of exemplifying evidence to demonstrate an athlete achieving world-class or Olympic status through a genuinely implicit learning strategy. Thus, we would question the contribution that implicit learning can make to skill establishment, or to countering the A–P relationship in representative and competitive sport settings.

Secondly, we suggest that the current conceptualization of this coaching dilemma largely presented within the literature is in fact not wholly correct; that being, whether skills should be taught explicitly or implicitly, with mechanics-oriented instruction largely portrayed as common coaching practice (e.g., Porter, Wu, & Partridge, 2010). Indeed, the same argument has also been made regarding the use of an internal or external focus of attention (cf. Peh et al., 2011). At present, there is a strong sense within the literature that implicit knowledge and external cues are good, and that explicit knowledge and internal cues are bad (Masters & Maxwell, 2008; Wulf, 2013), therefore reflecting the view that movements are either automatic *or* controlled. Taking our updated approach provided within the fourth dimension opens up the possibility that both arguments are correct, depending on *what* the athlete focuses on and *how* they focus. Undoubtedly, however, while research continues to largely investigate conditions that degrade performance (i.e., a negative self-focus) versus those that do not (i.e., a positive self-focus), it is unsurprising that such views have been formed. However, in attempting to exploit the ideas contained within the skill establishment dimension, future research should explore the positive self-focus as we have described it (cf. MacPherson et al., 2009) as a strategy for facilitating the acquisition of more well-established motor skills. Based on theory presented within the fourth dimension, coupled with applied evidence supporting the beneficial use of holistic and rhythmical patterns of thought, we suggest that these bodies of knowledge could substantially contribute to such practice while also questioning the received wisdom of the advantages inherent in implicit learning.

In discussing these ideas with several colleagues and through comments received during the peer-review process, the principle of analogy learning was brought to our attention as offering a potential contribution from the implicit learning literature (e.g., Lam et al., 2009; Liao & Masters, 2001; Wing Kai, Maxwell, & Masters, 2009). Accordingly, it is important to address this issue within the context of skill establishment. While we fully support the use of analogies in coaching practice – indeed, they have been employed effectively for many decades (e.g., Christina & Corcos, 1988; Knapp, 1963) – we do not believe that they are underpinned by totally implicit control. Rather, analogies provide performers with a positive self-focus that is explicitly attended to. This attention, however, is directed to a more holistic representation of the skill. In other words, the analogy conveys sufficient information about the entire skill; that is, more information than focusing on a single aspect of the movement. Provided that the analogy contains a high level of meaning to the performer *and* is motorically appropriate for the task at hand (i.e., conveys the important features), it is unsurprising that research has concluded beneficial effects. In advancing future research in this area, it is worth considering how a multisensory analogy (or imagery) might provide a greater number of conscious holistic retrieval cues.

Finally, and in addressing the practice requirements to develop long-term and robust establishment of motoric structures during skill acquisition, we believe that existing literature has plenty to offer. While positive self-foci are clearly what we recommend a learner should be thinking about, doing so in a fashion which promotes more elaborate encoding and retrieval frequency has been supported by many theoretical accounts (Bjork & Bjork, 2006; Guadagnoli & Lee, 2004) and empirical research into motor learning (Schmidt & Bjork, 1992). Indeed, as exemplar variables, manipulating practice schedules, feedback, and demonstration material to better engage the learner's attention with the desired movement has been strongly advocated by research over the years (e.g., Salmoni, Schmidt, & Walter, 1984; Schmidt & Bjork, 1992; Williams & Hodges, 2005). Crucially, when attempting to increase the establishment of a skill (once it has been encoded and stored correctly), however, overlearning of these movements needs to take place in situations that expose athletes to the types of symptoms experienced during anxiety, at least progressively to maintain stimulation during acquisition and to avoid stagnation (Richards, 2011). It is important that these representative conditions are encoded with the motor memory trace; in fact, training under high-anxiety conditions to establish the skill requires deliberate intent on the performer's behalf since attentional resources are compromised (cf. Beilock's first whammy). Indeed, training and succeeding under challenging conditions has been reported by applied sport psychologists as a method of developing and maintaining robust sport-confidence (Beaumont, Maynard, & Butt, 2015).

In summary, we suggest the field of coaching science needs to more critically consider the beneficial reunification of motor control and sport psychology if it is to offer more complete guidance to applied practice, something that has recently been exemplified within applied models of skill refinement (cf. Carson & Collins, 2011). Such an approach serves to capitalize on many decades of good empirical research *and* applied practice without risking conceptual turmoil as a result of reinvention.

## Conclusion

In focusing on motoric elements of performance, we hope to have shown that this fourth dimension of the A–P relationship – how well the skill is established – has been neglected or at least underweighted in the generation of new theory. In short, we believe that sport psychology may have overly focused on emotions and cognition at the expense of movement control (frontal lobe versus motor cortex sport psychology; cf. Collins & Kamin, 2012). The overelaboration/explicit focus issues identified in existing models seem easily solved by motoric and imagery literature (e.g., Paivio's [1971, 1986] Dual-Coding Theory) and by applied interventions which are supported by a range of empirical data (e.g., 'sources of information'; MacPherson et al., 2008) on holistic sensory cues (MacPherson et al., 2009). Accordingly, we suggest that there is a positive potential flow from applied/translational to fundamental/theory-generating research in sport which can serve to freshen and usefully redirect investigation into this long-considered but still insufficiently understood concept.

## Disclosure statement

No potential conflict of interest was reported by the authors.

## Notes

1. When considering alternative A–P relationship theories (e.g., Nieuwenhuys & Oudejans, 2012) it is likely that there could be scope for additional dimensions; the Skill Establishment dimension is only acknowledged as the fourth in relation to Cheng et al.'s (2009) model.
2. Crucially, it must be recognized that such rhythms are individually preferred (MacPherson, Turner, & Collins, 2007), another feature that needs to be catered for if genuinely motoric A–P investigations are to be completed.

3. From a methodological perspective, Bortoli et al. (2012) identified core components initially through athlete self-report and then confirmed/rejected the suggested focus using logistical ordinal regression analysis. This calculates the probability of that component being associated with optimal/suboptimal performance. While we do not take issue with employing this approach, it may also be possible to ascertain such information using the *uncontrolled manifold* approach (Scholz & Schöner, 1999), and through simple measures of intra-individual movement variability (Carson, Collins, & Richards, 2014).
4. Information processed using the verbal system takes place sequentially, whereas processing within the nonverbal system can be achieved in parallel. This distinction makes the nonverbal system better at processing greater amounts of information simultaneously.
5. When learning skill components explicitly using verbal knowledge, knowledge related to many different motor processes is still being generated implicitly (see Beek, 2000).

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