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The effect of anxiety on anticipation, allocation of attentional resources, and visual search behaviours

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ABSTRACT

Successful sports performance requires athletes to be able to mediate any detrimental effects of anxiety whilst being able to complete tasks simultaneously. In this study, we examine how skill level influences the ability to mediate the effects of anxiety on anticipation performance and the capacity to allocate attentional resources to concurrent tasks. We use a counterbalanced, repeated measures design that required expert and novice badminton players to complete a film-based anticipation test in which they predicted serve direction under high- and low-anxiety conditions. On selected trials, participants completed an auditory secondary task. Visual search data were recorded and the Mental Readiness Form v-3 was used to measure cognitive anxiety, somatic anxiety and self-confidence. The Rating Scale of Mental Effort was used to measure mental effort. The expert players outperformed their novice counterparts on the anticipation task across both anxiety conditions, with both groups anticipation performance deteriorating under high- compared to low-anxiety. This decrease across anxiety conditions was significantly greater in the novice compared to the expert group. High-anxiety resulted in a shorter final visual fixation duration for both groups when compared to low-anxiety. Anxiety had a negative impact on secondary task performance for the novice, but not the expert group. Our findings suggest that expert athletes more effectively allocated attentional resources during performance under high-anxiety conditions. In contrast, novice athletes used more attentional resources when completing the primary task and, therefore, were unable to maintain secondary task performance under high-anxiety.

In many professional domains performance can be negatively affected by stressors such as anxiety (e.g., Causer, Holmes, Smith & Williams, 2011), fatigue (e.g., Casanova et al., 2013), and injury (e.g., Robbins & Waked, 1998). Anxiety is defined as "an aversive motivational state that occurs in threatening situations" (Eysenck, Derakshan, Santos, & Calvo, 2007, p. 336). It can influence various components of performance, including anticipation (Williams & Elliott, 1999). It is reported that expert athletes reduce the detrimental effects of high-anxiety on performance, possibly by allocating greater attentional resources to the task (Nibbeling, Oudejans, & Daanen, 2012), reinforcing goal-directed visual search strategies (Wilson, Smith & Holmes, 2007), and inhibiting feelings of anxiety (Page, Sime, & Nordell, 1999). However, only a limited number of researchers have investigated the role of expertise in mediating the ability to allocate attentional resources and maintain performance under high-anxiety. We examine this issue using groups of expert and novice badminton players who attempt to anticipate opponent actions when viewing filmed stimuli under high- and low-anxiety

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conditions.

High-anxiety has been shown to decrease performance in many sports and across expertise levels including the anticipation of karate moves by expert and novice martial artists (Williams & Elliott, 1999), basketball free throwing by intermediate level players (Wilson, Vine, & Wood, 2009), and skeet shooting at the elite level (e.g., Causer et al., 2011). Several researchers have explored the key skills underpinning high-level performance in badminton (Alder, Ford, Causer, & Williams, 2014; Alder, Ford, Williams, & Causer, 2016; Duncan, Chan, Clarke, Cox & Smith, 2016), with a variety of factors being manipulated including expertise level (skilled *vs*. less-skilled), type of task (serve, smash) and stressors (anxiety, fatigue). The work has consistently highlighted the effects of expertise (Alder et al., 2014), anxiety and fatigue (Duncan et al., 2016) on performance, as well as the potential to improve performance through perceptual-cognitive training (Alder et al., 2016).

In Attentional Control Theory (ACT; Eysenck et al., 2007), an explanation is provided as to how anxiety can affect performance. The theory highlights how anxiety can have a negative impact both on performance effectiveness and processing efficiency. Processing efficiency can be measured through changes in underlying mechanisms of performance including mental effort (Wilson et al., 2007) and visual search behaviours (Causer et al., 2011; Wilson, Vine et al., 2009; Wilson, Wood, & Vine, 2009). Performance effectiveness may be calculated by dividing the outcome by the processing resources invested in the task. Under high-anxiety conditions, individuals are thought to allocate attentional resources to locating and negating the source of the threat, which increases mental effort, causing a decrease in performance effectiveness in an effort to maintain performance outcome (Derakshan & Eysenck, 2009). Vater, Roca, and Williams (2016) describe how when anticipating opponent actions in a temporally occluded 11 *vs*. 11 soccer test, high-anxiety negatively influenced processing efficiency (as evidenced through increased response times and mental effort) for skilled and less-skilled participants when compared to low-anxiety conditions. However, the effectiveness of performance (i.e., response accuracy) did not change significantly across anxiety conditions.

As well as the proposed reduction in processing efficiency, ACT describes how anxiety alters the contributions of two types of attentional control within working memory, namely the goal-directed and stimulus-driven systems (Baddeley & Hitch, 1974). The *goal-directed system* is involved in cognitive control of visual attention and responses, and is influenced by current goals, expectations, and knowledge. The *stimulus-driven system* is recruited for the detection and direction of attention to relevant, salient or conspicuous events (Corbetta & Shulman, 2002). Under high-anxiety conditions, ACT proposes that attentional control within working memory shifts from the goal-directed system towards the stimulus-driven system. Wilson, Wood et al. (2009) presented evidence supporting this shift in attentional control. These authors examined how experienced soccer players executed penalty kicks under high and low-anxiety conditions. In the high-anxiety condition, players fixated for longer durations on the goalkeeper, indicating recruitment of stimulus-driven control, and shorter durations on the target area, demonstrating a decrease in goal-directed focus, when compared to the low-anxiety condition. The decrease in visual attention toward goal-directed sources was accompanied by a decrement in shooting performance.

An integrated model of anxiety and perceptual-motor performance was presented by Nieuwenhuys and Oudejans (2012) to extend and refine on the propositions put forward in ACT. These authors argue that in addition to the threat-related changes in attentional control as a result of high anxiety outlined in ACT, the ability of an individual to correctly interpret information emanating from visual cues is impaired under high-anxiety. They state that although individuals may attend to task-relevant cues (i.e., remaining goal-directed) they may be unable to perceive key information sources correctly. They further argue that the additional effort that accompanies increases in anxiety, as proposed by ACT, can be allocated to a range of tasks involving working memory. First, the additional effort may be directed to reducing the feelings of anxiety. For example, an athlete experiencing anxiety could use pre-determined imagery techniques and breathing strategies to reduce the feelings of anxiety prior to performance (Page et al., 1999). Second, the additional effort may be directed to reinforcing goal-directed attentional strategies or actively inhibiting stimulus-driven processing. For example, researchers have shown that visual search training (e.g., Chicago Wilson, Vine, Bright, & Masters, 2011), in which participants are provided with information relating to the optimal gaze behaviour, can be effective in controlling the impact of anxiety on attentional control. Moreover, placing individuals into pressurised situations in training that are congruent to those experienced in competition has been shown to result in improved attentional control (Alder et al., 2016).

The effect of anxiety on performance outcome and processing efficiency may further be related to the expertise level of participants (Nibbeling et al., 2012). It is hypothesised that as expertise level increases, so does the ability to better control the detrimental effects of anxiety on performance (Williams & Elliott, 1999). It is thought that experts have domain-specific knowledge structures that result in tasks being completed with fewer demands on working memory (Ericsson & Kintsch, 1995). These lower demands on working memory allow expert athletes to redistribute attentional resources elsewhere, such as when experiencing high-anxiety. In contrast, novices do not have sophisticated domain-specific knowledge structures. Therefore, the high demands of the primary task on working memory do not allow them to redistribute attentional resources under high-anxiety conditions, possibly resulting in decrements to performance outcome when the demands become too great.

In one study, Nibbeling et al. (2012) asked skilled and novice participants to complete a darts throwing task under high- and low-anxiety conditions while carrying out a secondary task of backwards counting. Mental effort and visual search behaviours were measured. In the high-anxiety condition, dart throwing performance was worse for the novice group, but not the skilled group, when compared to the low-anxiety condition. Secondary task performance significantly decreased for both groups in the high- compared to low-anxiety condition. Both groups demonstrated the predicted decrease in processing efficiency, as evidenced by an increase in mental effort and less efficient visual search behaviours, under high- compared to low-anxiety conditions, with this negative change being most pronounced for the less-skilled participants (Eysenck et al., 2007; Nieuwenhuys & Oudejans, 2012). Cocks, Jackson, Bishop and Williams (2016) reported comparable findings in a study in which skilled and less-skilled tennis players anticipated opponent actions under high- and low-anxiety conditions. The skilled players' anticipation performance was superior compared to the