# Understanding performance under pressure:

# anxiety, attention, cognitive biases and the perception of failure

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I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other university.

Signed…………………………..

## Abstract

It is consistently found that heightened anxiety leads to poorer performance in sport environments, with the majority of research reporting that disrupted attentional mechanisms explain the negative anxiety-performance relationship. However, there has been little exploration of why sports performers might become anxious in the first instance. Additionally, the effect these different interpretations of pressure might have on attentional control and performance has not been explored. These two issues drove the main aims of the current thesis, which sought to test the predictions of a new theory developed by researchers in the anxiety-performance area.

First, the thesis systematically collated the evidence in regards to the attentional mechanisms underpinning the anxiety-performance relationship to determine the consensus in the sporting literature, including the challenges and areas of emergent or current research. Second, the thesis addressed the research challenges highlighted in the review by exploring the Attentional Control Theory Sport (ACTS; Eysenck & Wilson, 2016) with the aim to understand what initiates the anxiety response in individuals, in particular through the interpretation of pressure.

The first experimental study examined the cognitive biases element of ACTS and investigated whether attention and interpretive bias as moderating variables of state anxiety are related to trait anxiety and attentional control, with the intention of better understanding what pre-empts experiencing cognitive biases. The second experimental study examined the perception of failure by determining whether perceived probability and cost of failure influenced the experience of state anxiety. Finally, the third experimental study built upon the

aims from the previous studies and examined the hypothesised relationships between cognitive biases, perception of failure and state anxiety, attentional control and performance. This work is the first to empirically examine the theoretically derived predictions of ACTS, through exploring attentional and interpretive biases, perceived probability and cost of failure and the influence on momentary state anxiety, attentional control and performance.

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# Chapter 1: Introduction

## 1.1. Performance under pressure

The topic of pressure and the effects on sport performance is prominent in the sport psychology literature and is continuously expanding (Eysenck & Wilson, 2016; Nieuwenhuys & Oudejans, 2012; Roberts, Jackson, & Grundy, 2017; Wilson, 2008, 2012). Given that athletes in competitive sports need to perform to their optimal standard under pressure, sporting competitions can be considered as potentially threatening situations and can lead to heightened levels of anxiety (pressured). As such, it is unsurprising that researchers and applied psychologists have been focused on understanding the effect of anxiety on performance. In sport settings, anxiety is usually related to the ego-threatening nature of the competitive environment and, “refers to an unpleasant psychological state in reaction to perceived threat concerning the performance of a task under pressure” (Cheng, Hardy, & Markland, 2009, p. 271).

The effects of pressure have been examined across a number of sports (Wilson, 2012), with the majority of research focusing on its negative effects on performance. An early meta-analysis of 48 studies found high levels of competitive anxiety to be a predictor of decreased sport performance (Woodman & Hardy, 2003). These performance disruptions have been termed ‘choking’, defined as “an acute and considerable decrease in skill execution and performance when self-expected standards are normally achievable, which is the result of increased anxiety under perceived pressure.” (Mesagno & Hill, 2013, p. 273). This definition suggests that poor performance via choking occurs when performance is expected to be of a high standard and furthermore identifies the mediating role of increased anxiety in the pressure-performance relationship.

Pressure is typically associated with elevated levels of anxiety in sport performers (Causer, Holmes, Smith, & Williams, 2011; Cooke, Kavussanu, McIntyre, & Ring, 2010; Williams, Vickers, & Rodrigues, 2002; Wilson, Chattington, Marple-Horvat, & Smith, 2007). Anxiety is a complex phenomenon; it is an emotional reaction in response to environmental stimuli. Defined as an aversive state, competitive state anxiety is a specific negative emotional response to competitive stressors, i.e. environmental demands associated with competitive performance (Mellalieu, Hanton & Fletcher, 2008). The term anxiety is also used to refer to the individual differences in anxiety as a personality trait. Individuals who are high in trait anxiety are more predisposed to manifest heightened anxiety states than are non-anxious individuals (Eysenck, 1992; Spielberger, 1966). Both trait and state anxiety can present as cognitive and somatic anxiety characteristics. Cognitive anxiety forming as worries and concern about oneself and the situation, and somatic anxiety forming as physiological symptoms such as sweaty palms and a faster heart rate.

Over the past century, psychologists have tried to identify common mechanisms to explain how anxiety influences performance. In particular, these investigations are with respect to perceptual-motor behaviour in high-pressure sport contexts (e.g. a basketball player taking a decisive free-throw). The sporting literature has adopted an attentional processing perspective, suggesting that the ability to pay attention to, and process visual information are key determinants of successful motor execution (Williams, Singer, & Frehlich, 2002). Research proposes that high levels of anxiety induce changes in attention that make it more difficult to focus on task-relevant information and efficiently coordinate movement, thereby often causing decreases in performance (Eysenck & Wilson, 2016; Nieuwenhuys & Oudejans, 2012, 2017). The most acknowledged theories attempting to explain this anxiety-attention-performance relationship are those that investigate performance disruptions from a self-focus or distraction perspective (see Roberts et al., 2017, for a review). The majority of this research focuses on the negative effects of pressure on performance and as such, examines state anxiety as the mediator in the pressure-performance relationship.

However, research examining success and thriving in high performance environments has become prominent (Brown, Arnold, Reid, & Roberts, 2018) and there have been recent suggestions that as common as choking during performance is, there appears to be just as many examples of 'clutch' performance (Otten, 2009). Defined as "any performance increment or superior performance that occurs under pressure circumstances" by Otten (2009, p. 584), clutch performance, as well as choking, is determined by individual differences in how pressure is interpreted (Eysenck & Wilson, 2016; Nieuwenhuys & Oudejans, 2012). Jones and colleagues introduced the idea that interpretation is important, albeit in the case of ensuing anxiety (Jones, 1991, 1995; Jones & Swain, 1992; Jones, Swain, & Hardy, 1993), and suggested that performers may not always interpret their anxiety symptoms as being debilitative toward performance, but may in fact feel they are necessary (i.e. facilitative). Successful balance beam performances have been associated with gymnasts interpreting cognitive anxiety as more facilitative than debilitative (Jones et al., 1993), whilst elite rugby union players report more facilitative interpretations of competitive anxiety symptoms (Neil, Mellalieu, & Hanton, 2006). Although since this approach, there have been fewer theoretical developments, specifically in regards to the interpretation of pressure.

Furthermore, alternative views suggest that Jones and colleagues' model is confusing facilitative anxiety and mislabelling it with other positive emotions, e.g. self-confidence or challenge (Burton & Naylor, 1997). Instead, the authors propose that pressure can be felt but individuals do not necessarily get anxious. For example, whether anxiety, as a negative emotion, is experienced is proposed as a two-stage process. First, individuals determine what is at stake for them in an encounter; second, they interpret whether they can handle the encounter (Burton & Naylor, 1997; Folkman, 1992; Lazarus, 1991). Thus, anxiety is likely to occur when individuals believe the environmental demands outweigh their coping capabilities. Attentional Control Theory: Sport (ACTS; Eysenck & Wilson, 2016), a sport-relevant theory attempts to build on this two-stage process, similarly suggesting that anxiety is debilitating to performers. However, the theory also seeks to address how and why competitive pressure leads to anxiety in the first place.

ACTS extends the predictions of Attention Control Theory (ACT; Eysenck, Derakshan, Santos, & Calvo, 2007), maintaining that cognitive anxiety 1) impairs processing efficiency more than performance effectiveness; 2) reduces the efficiency of the inhibition function; and 3) reduces the efficiency of the shifting function (Eysenck et al., 2007). In summary, ACT suggests that anxiety leads to disrupted attentional control through an imbalance between the goal-directed and stimulus-driven attentional systems. In turn, attention is increasingly directed towards threatening cues, attentional processing is less efficient and drops in performance occur. However, ACTS is also more explicit than ACT about the initial determinants of anxiety; the role of the feedback loops based on performance failure and errors; the role of motivation in moderating the deployment of effort or processing resources; and the sporadic nature of attentional disruptions in trained sporting performers. To be more concise, ACTS considers variations in performance under pressure and the causal individual differences which influence the interpretation of pressure and the initial experience of state anxiety.

ACTS (Eysenck & Wilson, 2016) postulates that when under pressure, cognitive biases determine whether individuals are likely to experience increased anxiety and successful or unsuccessful performance. Cognitive biases have been theorised to play a critical role in the onset and maintenance of anxiety (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; Hallion & Ruscio, 2011) and the most important present in the form of attention and interpretive biases. Attentional bias occurs when an individual attends disproportionately to a threat-related stimulus rather than a neutral one (Bar-Haim et al., 2007), whereas interpretive bias occurs when an individual interprets an ambiguous situation as threatening (Haller, Raeder, Scerif, Kadosh, & Lau, 2016). Cognitive biases are also likely to increase the extent to which error monitoring occurs in sport. An increased attentional bias might cause a performer to pay more attention to threat cues (e.g., difficult challenges ahead, errors they have made, good performance from an opponent) and an interpretive bias might cause a performer to interpret errors as having an impact on how they will perform subsequently (Eysenck & Wilson, 2016).

Heightened error monitoring and cognitive biases influence perceptions of threat, leading to the experience of anxiety (see Figure 1.1.). ACTS implements Berenbaum's two-phase model of worry and suggests that anxiety (and its cognitive component worry) are influenced by the perceived probability and perceived costs of undesirable outcomes (Berenbaum, 2010). Losing is characterised as an undesirable outcome in a sporting context, and costs of losing are greater in high-pressure situations because more is at stake. Furthermore, perceived probability of losing increases as a function of the number of failure experiences in a competition, and decreases as a function of the number of success experiences (Eysenck & Wilson, 2016).

Moreover, ACTS proposes the pressure-performance relationship as bi-directional in nature (Eysenck & Wilson, 2016). It is suggested that cognitive biases and perceptions of threat often increase state anxiety in competitive sport situations. However, it is also predicted that because of feedback loops based on performance failure and errors, enhanced by error monitoring, failure is anxiety provoking and causes negative effects on performance. In sum, previous performance failure can increase the pressure on subsequent performance attempts and therefore pressure influences performance, and performance also influences pressure (see Figure 1.1.).

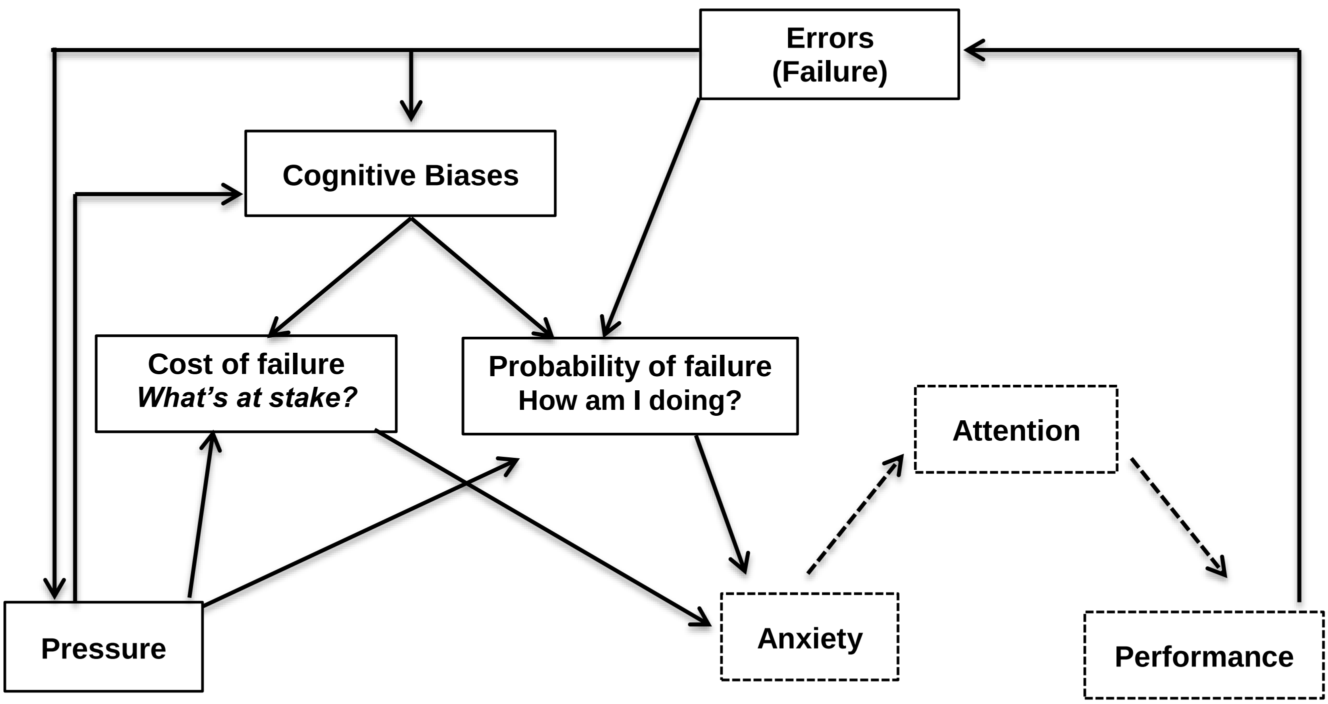

***Figure 1.1.*** *A schematic representation of the bi-directional pressure-performance relationship studied within this thesis, as proposed in the Attentional Control Theory: Sport (ACTS; see bold lines). Cognitive biases influence the perceived probability of failure ("How am I doing?"), as do errors on previous performance attempts. Biases also influence the perceived cost of failure ("What's at stake?"), which is also influenced by the inherent pressure in the situation. Together, it is predicted that these combine to influence anxiety, which will influence performance via attentional mechanisms as outlined originally in ACT (see dashed lines). It is important to note that pressure does not necessarily lead to increased anxiety, it is the influence of cognitive biases and the individuals' perception of probability and cost of failure that determine whether anxiety is experienced.*

The study of performance under pressure has primarily focused on disrupted attentional mechanisms to explain the negative anxiety-performance relationship, however, there is still limited understanding regarding the antecedents of state anxiety and successful and unsuccessful performance, as well as the exact mechanisms involved in the pressure-anxiety relationship in sport. Whilst applied interventions are reported to aid the experience of anxiety for competitive athletes, they are being used without full understanding of the causal mechanisms.

Consequently, the goal of this thesis is to examine performance under pressure and contributes to the extant literature in two main ways. First, the thesis will systematically collate the evidence in regards to the anxiety-performance relationship and underlying attentional mechanisms to provide a sense of where the sporting literature stands in regards to this relationship, including the challenges in the research and areas of emergent or current research. There is yet to be an encompassing systematic review conducted on the anxiety-attention relationship in performing far aiming tasks under pressure. Second, the thesis will attempt to address the research challenges highlighted in the review, in particular exploring the moderators proposed by the ACTS framework to influence the pressure-anxiety relationship and the interpretation of pressure during successful and unsuccessful sporting performance. The theoretically derived predictions of ACTS need to be experimentally tested and this research is the first to empirically examine the predictions proposed in ACTS. The aim is to understand what initiates anxiety responses in individuals, an approach few researchers in sport have considered, for the purpose of providing athletes with a means to recognise and control anxious symptoms during competitive performance.

## 1.2. Structure of the thesis

There is an extensive scope of research examining the anxiety-performance relationship and a wide range of theories and supporting empirical evidence that contributes to the anxiety-attention-performance literature. These theoretical frameworks pose different mechanisms of skill failure when performing under pressure and attention is a consistent variable within the research suggested to underpin the anxiety-performance relationship. Despite this long period of research, and numerous narrative reviews, there is yet to be a systematic inquiry into the anxiety-attention-performance relationship to advance our understanding of the impact of anxiety on attention and performance, the consistency of findings in regards to this debate and important directions for future research.

The aim of study 1 in the thesis was to examine the current state of the literature exploring attentional mechanisms underpinning the anxiety-performance relationship. In order to do this effectively, a systematic review was conducted to examine existing research for the proposed attentional mechanisms responsible for motor skill decrements whilst anxious. Furthermore, the review assessed the efficacy of different theoretical perspectives of the anxiety-performance relationship that implicate attention.

It is noted that in many instances performance failure does not emerge in pressure filled contexts. The ability to perform successfully under pressure is a crucial aspect of sport performance (Mesagno & Mullane-Grant, 2010) and the majority of research considering successful performance under pressure examines potential moderating variables in the anxiety-performance relationship (e.g. Carson & Collins, 2016; Cheng et al., 2009; Nieuwenhuys & Oudejans, 2012). However, to determine the cause of successful performance under pressure, it has emerged that it is important to consider varied research designs and methods in order to be able to test hypotheses proposed by contemporary theories (see chapter 2). The antecedents of state anxiety are still relatively under researched in the sporting literature and ACTS draws from the clinical and mainstream anxiety literature to present assumptions based on a bi-directional relationship between pressure and performance (see 1.1). Whilst maintaining the predictions from ACT (Eysenck et al., 2007; see chapter 2), ACTS adds to the pressure-anxiety relationship by suggesting state anxiety is influenced by perceived probability and perceived costs of future undesirable outcomes (i.e. performance failure). In addition, the perception of failure is further influenced by attention to and interpretation of threatening stimuli, e.g. performance errors. However, research is yet to examine these predictions in their intended context, sport, and thus this provides the basis of the present thesis.

ACTS focuses on two issues; first there is the issue of how pressure (based on the context and performance level) influences the individual's levels of anxiety. Second, there is the issue of how those levels of anxiety influence performance (see Figure 1.1. for complete schematic of ACTS). The majority of research examined and synthesised within the systematic review focused primarily on the second issue. The second part of the thesis (study 2-4) considered the first issue through step-by step examination of the predictions presented in the ACTS framework, with the aim of exploring the proposed relationships between trait anxiety, attentional control, cognitive biases, perception of failure and state anxiety. The first empirical study of the thesis addressed cognitive biases, specifically attentional and interpretive biases, and whether sport-specific trait anxiety and attentional control influences sports performers to display cognitive bias. The second stage of the thesis addressed the perception of failure tenet of ACTS, in the context of perceived probability and perceived cost and whether they influence state anxiety, and finally the thesis investigated ACTS as a whole by examining the influence of cognitive biases and perception of failure on state anxiety in a golf putting task under pressure. As ACTS has yet to be examined experimentally, it was important to test the tenets in stages to establish that the proposed hypotheses and predictions are accurate, in order to then contribute to the literature and produce new knowledge with regards to the theory as a whole.

Study 2 examined cognitive biases, in the form of attentional and interpretive biases. ACTS suggests that cognitive biases alter the perceived probability and perceived costs of poor performance. Cognitive biases have been theorised to play a critical role in the onset and maintenance of anxiety (Bar-Haim et al., 2007; Hallion & Ruscio, 2011). However, whilst ACT was developed to explain the processes of high trait anxious individuals, ACTS is less precise. Therefore, the aim of study 2 was to determine what pre-empts the experience of cognitive biases, specifically whether sport trait anxiety and attentional control influence attentional and interpretive biases. It has been suggested threat perceptions are likely to be influenced by elevated levels of trait emotionality (Berenbaum, Thompson, & Pomerantz, 2007). Additionally, good attentional control is suggested to control the dominant attentional bias (Derryberry & Reed, 2002). An important challenge is to determine the nature of cognitive biases, as a better understanding of these factors can elucidate and inform in regards to the consequences of a bias i.e. state anxiety.

Study 3 examined the perception of failure, one tenet of ACTS, to determine whether the interpretation of the environment (through thoughts, errors or performance) influences state anxiety. Cognitive biases are suggested to alter the perceived probability and perceived cost of failure, which in turn influences the experience of state anxiety. However, there is limited examination of the perception of failure within sporting contexts and the resultant influence on state anxiety. Past research in social anxiety has shown that individuals who believe undesirable outcomes are more likely to occur, and believe the outcomes will be more costly, tend to have higher levels of worry (state anxiety; Berenbaum, Thompson, & Bredemeier, 2007; Berenbaum, Thompson, & Pomerantz, 2007; Butler & Mathews, 1983). Therefore, the aim of study 3 was to examine the role of perception of failure on the experience of competitive state anxiety in a sporting context.

Study 4 built upon the aims of studies 2 and 3 by examining the hypothesised relationships between cognitive biases (attentional and interpretive), perception of failure (perceived probability and cost) and state anxiety in an ecologically valid golf putting task, performed under conditions of artificially induced pressure. In competitive environments, individuals will perceive pressure in different ways and this is likely to vary throughout an event (Eysenck & Wilson, 2016). As such, the aim of study 4 was to examine whether these interpretations of pressure, measured through attentional and interpretive biases and perceived probability and cost of failure predict state anxiety during a pressurised golf putting task.

Finally, chapter 6 brings together the four studies and their findings. The thesis has shown that cognitive processes are crucial to understanding the pressure-performance relationship. In particular, although a consensus is lacking, attentional mechanisms are vital in explaining the anxiety performance relationship. Furthermore, with respect to the antecedents of state anxiety, cognitive biases and the perception of failure are suggested to influence anxiety, however the exact processes in which these interpretations occur still require investigation. Indeed, the thesis provides the first empirical support for an account of the pressure-performance relationship geared towards explaining choke and clutch performance under pressure. Furthermore, the findings indicate the importance of examining performance failure and its consequences in sporting contexts. Support for one of the main tenets of ACTS, perceived probability and cost influence state anxiety, was demonstrated. The combined influence of perceived probability and perceived cost and performance errors (physical or mental) is suggested to have severe consequences for subsequent performance, such as performance breakdowns and increased perceived pressure. However, future research is still necessary in order to advance and extend the findings on ACTS, and this is discussed along with implications, including the application to ‘real world’ sporting competition, of the findings in chapter 6.

# Chapter 2: A systematic review of the anxiety-attention relationship in far-aiming skills

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## 2.1. Abstract

Theoretical accounts of the anxiety and motor performance relationship cite disruptions to attention as a critical mediating factor. The aims of this paper were to (1) systematically review published research examining attentional mechanisms underpinning the anxiety–performance relationship in targeting skills, and (2) subsequently discuss these findings in relation to contemporary theoretical perspectives. Adhering to PRISMA guidelines, three electronic databases (PubMed, PsycInfo, and SPORTDiscus) were searched from inception until June 2017. Thirty-four articles satisfied the inclusion criteria. Overall, the research is of high methodological quality; however, there is a tendency to focus on the historical dichotomy between self-focus and distraction accounts, whereas empirical support for more contemporary theoretical perspectives is lacking. Whilst this review provides further support for the role of attentional disruptions in anxiety-induced performance degradation, the exact mechanisms still lack consensus. In addition, more innovative experimental designs and measures are required to progress our understanding of moderating variables.

## 2.2. Introduction

High-level sport requires individuals to perform at their best when it matters most. However, athletes do not always meet these demands, and impaired performance is often attributed to the associated pressure and anxiety of competition. Within the competitive sporting environment, state anxiety is a common occurrence (Martens, Burton, Vealey, Bump, & Smith, 1990), and is defined as an aversive emotional and motivational state that can develop during potentially threatening, evaluative circumstances (Eysenck et al., 2007). It is characterised as having a mostly negative effect on motor performance (Wilson, 2012), although the processes underpinning the anxiety-performance relationship are still poorly understood (Cheng et al., 2009). Most prevailing theoretical accounts of anxiety and performance make reference to attentional processes, even if a consensus on the role of the specific attentional mechanisms involved is lacking. While numerous opinion pieces and reviews have been written on the topic, we intend to provide a timely systematic review of the literature, to (1) examine the proposed attentional mechanisms responsible for motor skill decrements whilst anxious that have been tested in the existing research, and (2) assess the efficacy of different theoretical perspectives of the anxiety and performance relationship that implicate attention.

### 2.2.1. The role of attention

Attention has been defined as the cognitive system that facilitates the selection of some information for further processing while inhibiting other information from receiving further processing (Smith & Kosslyn, 2007). In explaining the relevance of attention for the performance of sporting skills, two perspectives of attention have been proposed. Filter theories of attention (see Broadbent, 1958) utilise a ‘bottleneck’ metaphor to explain that multiple stimuli cannot be processed at the same time, so information not selected for processing is filtered out. Meanwhile, capacity theories of attention (i.e. Kahneman, 1973; Pashler, 1998) suggest that while the availability of the attentional system is limited, multiple tasks can be performed so long as attentional resources are available. Indeed, both theories propose attention is a selective process and stimuli compete for limited resources (Broadbent, 1958; Treisman, 1960). However, despite more than a century of research in this field, there is still a great deal of confusion about the nature of, and cognitive mechanisms underlying, attention (Moran, 2009).

As such, while it is challenging to define and explicitly measure the construct of attention, there is a general agreement that attention involves selectively processing information; prioritising some aspects of what we are presented with whilst ignoring others (Carrasco, 2011). As research has developed, attention has been deemed to interact with working memory. In particular, research suggests the attentional system determines the information that gains access to working memory and reflects the combined contribution of four processes: working memory, competitive selection, top-down sensitivity control, and automatic bottom-up filtering for salient stimuli (Knudsen, 2007). The top-down system influences bias processing to goal-relevant stimuli and directs the voluntary allocation of attention. In contrast, the stimulus-driven (bottom-up) system triggers shifts in attention by stimuli that are unexpected and initially unattended (Corbetta & Shulman, 2002).

It is suggested that anxiety disrupts the efficiency of this attentional system, leading to impaired performance (Eysenck et al., 2007). In particular, anxiety (in the form of worry) interferes with the mental processes that support performance and adequate attention cannot be directed to task-relevant information (Kahneman, 1973; Sarason, 1984). Consequently, researchers have developed theoretical frameworks in an attempt to explain the anxiety-performance relationship and the underpinning role of attention.

### 2.2.2. Theoretical accounts of the anxiety-performance relationship

Early research on the relationship between anxiety and performance was dominated by descriptive models such as the inverted-U hypothesis (Yerkes & Dodson, 1908) and the catastrophe model (Hardy, 1990). These models lacked a mechanistic focus and subsequent explanations for the negative effect of anxiety on motor performance borrowed heavily from the cognitive psychology literature. For example, distraction theorists (e.g. Eysenck, 1991; Sarason, 1984, 1988; Wine, 1971) propose that anxiety serves as a distractor, drawing attention away from task-relevant information needed for task performance. Processing efficiency theory (PET; Eysenck & Calvo, 1992) is an early distraction-based account that has received support in the sport psychology literature (see Wilson, 2008, for a review). Processing efficiency is based on the relationship between performance effectiveness (the quality of performance as measured against an outcome standard) and the resources used to achieve that performance (Eysenck & Calvo, 1992). Processing efficiency can be reduced by task-irrelevant thoughts such as worries or performance concerns and crucially, is impaired to a greater extent than performance effectiveness. While individuals can compensate for reduced processing efficiency with increased effort in the short-term, this impairment may be an early warning sign of a subsequent drop in performance (Wilson, 2008).

Attentional control theory (ACT; Eysenck et al., 2007) is an extension and development of PET that is more explicit about the detrimental effect of anxiety on processes related to attention. Specifically, a diversion of processing resources from task-relevant stimuli toward task-irrelevant (and particularly threatening) stimuli is predicted to occur due to the disrupted balance between goal-directed and stimulus-driven attentional systems (Corbetta & Shulman, 2002). ACT also relates this disruption to specific functions of the central executive of working memory that are impaired; namely, the inhibition and shifting functions (based on Miyake et al., 2000). As with PET, the predictions of ACT have received support in the sporting literature (see Eysenck & Wilson, 2016; Wilson, 2012 for reviews).

Whereas distraction theories can apply to the performance of any task with cognitive demands, explanations have been developed specifically to reflect anxiety's effect on automated *movement* control. These explanations have been termed self-focus theories and propose that under pressure anxiety increases one's self-consciousness, directing attention towards one's self and one's movements (Baumeister, 1984; Beilock & Carr, 2001; Masters, 1992; Masters & Maxwell, 2008). The theory of reinvestment (also known as the conscious processing hypothesis) suggests that by attempting to consciously control the mechanics of automated skilled behaviour, the fluency associated with expert performance is disrupted (Masters, 1992; Masters & Maxwell, 2008). The explicit monitoring hypothesis (EMH; Beilock & Carr, 2001) proposes a subtly different mechanism and states that when anxious, performance is disrupted by consciously monitoring the step-by-step execution of skill, interrupting proceduralised motor programmes. As with the distraction theories, there has been much support for the predictions of both these self-focus accounts in the sport psychology literature (see Beilock, Carr, MacMahon, & Starkes, 2002; Masters & Maxwell, 2008).

The self-focus versus distraction theory dichotomy has been a feature of the competitive anxiety-sport performance literature (Roberts et al., 2017). Beilock and Carr (2001) suggest that both groups of theories are relevant to different tasks and domains, with self-focus theories being more applicable to sport because of the focus on disruptions to previously automated movements. However, this may be a false dichotomy for a number of reasons. First, even well-practised skills may not be fully automatic and a characteristic of expertise is the ability to flexibly deploy attention to where it might be most useful at that moment (Burke & Yeadon, 2009; Nyberg, 2015). Second, self-focus and distraction perspectives may not be entirely mutually exclusive. For example, a ‘double whammy’ effect (Beilock & Gray, 2007) has been suggested, whereby anxiety initially reduces attention directed towards task-relevant information by overloading working memory, and then encourages performers to consciously attend to skill execution step-by-step. Third, it has also been suggested that self-focus effects may simply reflect increased distractibility. Movement cues may become paradoxically salient when anxious due to interpretational biases, and as such self-focus effects could potentially be subsumed within distraction accounts like ACT (Eysenck & Wilson, 2016).

Furthermore, researchers have sought to develop new frameworks that seek to go beyond this dichotomy that has grounded the anxiety-sport performance research over the last 30 years. For example, there have been recent attempts to extend Eysenck and colleagues’ ACT to reflect the specific demands of sport. First, Nieuwenhuys and Oudejans (2012) propose an integrated model of anxiety and perceptual-motor performance and suggest that disruption to attentional processes by anxiety not only affects attentional control, but also interpretational processes and emotion-specific behavioural responses. Second, Eysenck and Wilson (2016) consider the individual differences that might determine whether someone experiences anxiety in a pressurised environment. Whilst maintaining the attention disruption element of ACT, attentional control theory: sport (ACTS) suggests that whether increased pressure leads to increased anxiety depends on how cognitive biases alter both an individual's perceived probability of poor performance and the cost of poor performance (Eysenck & Wilson, 2016). Finally, Englert and Bertrams (2015) attempt to integrate ACT with the strength model of self-control (Baumeister, Bratslavsky, Muraven, & Tice, 1998) to reflect the potential influence of self-control on attentional control. Low self-control strength is suggested to determine the degree to which an individual pays attention to threatening stimuli (e.g. anxiety-related worries; Englert & Bertrams, 2012). Englert and colleagues have demonstrated that depleting mental resources (i.e. self-control) with a preceding cognitive activity can affect an individual's ability to resist distraction when performing a sporting task (Bertrams, Englert, Dickhäuser, & Baumeister, 2013; Englert & Bertrams, 2012; Englert, Zwemmer, Bertrams, & Oudejans, 2015).

Alternatively, other models have sought to build upon the two-dimensional approach to anxiety (Martens et al., 1990) that included cognitive and physiological (somatic) components. The three-dimensional model of performance anxiety (Cheng et al., 2009) maintains a cognitive dimension that consists of distraction and self-focus effects, as well as a physiological dimension that includes autonomous hyperactivity and somatic tension. The authors propose that a third, regulatory dimension reflecting perceived control is critical in understanding an individual's perception of their capacity to cope under pressure. Carson and Collins (2016) suggest that a fourth dimension - skill establishment - should also be considered. Skill establishment refers to the level and consistency of movement automaticity, and the specific confidence a performer has in automaticity during stressful situations. It is important to note that while all these contemporary frameworks consider additional mediating and moderating variables (e.g. perceived control, cognitive biases, skill establishment, and self-control) they still acknowledge the importance of attention in understanding the anxiety-performance relationship.

### 2.2.3. Assessment of attention

There is no single gold-standard approach to assessing attention in order to explore the attentional mechanisms highlighted in each of the theoretical approaches described. Several different methods have been used to examine whether attention is disrupted in response to pressure, and these methods can be defined as (1) manipulations of attention and (2) measurements of attention.

#### ***Manipulation of attention***

Focus of attention is sometimes manipulated to mimic attentional disruptions under pressure (Beilock & Carr, 2001; Beilock et al., 2002; Wilson, Chattington, et al., 2007). A self-focus is often induced using explicit instructions relating to skill execution, whilst distraction is often created through a dual-task paradigm (e.g. performing a cognitively demanding task concurrently with the motor task). In this sense, careful experimental manipulation causes subjects to focus on task irrelevant stimuli (i.e. the body or explicit sources of information).

Attention has also been manipulated via the depletion of self-control strength (i.e. the ability to override the automatic tendency to pay attention to threatening stimuli) using transcription tasks, to reflect disrupted attentional control under anxiety (Bertrams et al., 2013; Englert & Bertrams, 2012; Englert et al., 2015). In this research, participants are instructed to transcribe a story and omit certain letters, in an attempt to override writing habits and deplete self-control strength. Self-control strength is required to regulate attention and navigate it from anxiety-related worries (Bertrams et al., 2013). However, it appears to be a limited resource (Baumeister, Vohs, & Tice, 2007) and when depleted, attention can no longer be regulated, information is processed in a bottom-up manner and as a result, performance is impaired .

***Measurement of attention***

*Direct measures*

Advances in eye-tracking technology allow for the more direct, objective measurement of visual attention. It is suggested, by tracking eye movements on tasks where it is possible to specify where visual attention should be directed and how it might shift over time, attentional control can be assessed (Corbetta et al., 1998; Eysenck & Derakshan, 2011). In addition, retrospective self-reported measures (Englert & Oudejans, 2014; Oudejans, Kuijpers, Kooijman, & Bakker, 2011) allow for a direct measurement of attention following task performance. These self-report methods are beneficial on occasions when it is challenging to directly measure focus of attention during competitive sports settings (Oudejans et al., 2011).

*Indirect measures*

Probe reaction times (Lam, Masters, & Maxwell, 2010; Lam, Maxwell, & Masters, 2009) reflect the orientation of attention during task performance. The idea being, if attentional resources are taken up by anxiety-related worries and task-irrelevant information, reaction times on the task will be much slower, i.e. longer probe reaction times. As such, measurement of probe reaction time concurrently with task performance can be an indicator of inefficient or disrupted attentional control. Furthermore, performance process measures examine the inferred effect of anxiety on attention. Objective measures of movement control, such as kinematic measures (Mullen & Hardy, 2000) and muscular activity (tension; Cooke, Kavussanu, McIntyre, Boardley, & Ring, 2011; Cooke et al., 2010) have been shown to reflect changes in the focus of attention; with less efficient movement patterns reflecting less automated movement control (Masters & Maxwell, 2008), i.e. an inward focus of attention on movement.

Finally, changes in heart rate variability (variations in the inter-beat interval; Wilson, Smith, & Holmes, 2007) reflect changes in mental effort and attentional processing (Mulder, 1992), and have also been used to indirectly assess attentional changes when anxious (Mullen, Hardy, & Tattersall, 2005; Wilson, Smith, et al., 2007). The influence of mental effort on performance differs considerably between the self-focus and distraction approaches. From a distraction perspective, increasing mental effort on a task is suggested to be a compensatory mechanism for the distracting effects of anxiety whereby performance is maintained (Eysenck, 1992). From a self-focus perspective, increased effort is suggested to lead to performance decrements as attention is transferred to effortful, controlled processes (Mullen & Hardy, 2000; Mullen et al., 2005).

All of the aforementioned methods for examining attentional mechanisms have been employed to investigate the effects of anxiety across a range of sporting tasks; including, free throws in basketball (Wilson, Vine, & Wood, 2009), golf putting (Beilock & Carr, 2001; Cooke et al., 2010), dart throwing (Englert et al., 2015; Nibbeling, Daanen, Gerritsma, Hofland, & Oudejans, 2012; Nibbeling, Oudejans, & Daanen, 2012), shooting (Causer et al., 2011; Nieuwenhuys & Oudejans, 2010; Vickers & Williams, 2007), penalty taking (Wilson, Wood, & Vine, 2009), baseball (Gray, 2004; Gray & Allsop, 2013), table tennis (Williams, Vickers, et al., 2002) and archery (Behan & Wilson, 2008). A pattern amongst these experimental studies is the use of self-paced, non-interactive and attentionally demanding sporting tasks that rely heavily on the goal-directed attentional system (Eysenck & Wilson, 2016). In general, performance in aiming tasks is more easily measured, and from a cognitive perspective, the tasks provide sufficient thinking time for worry and disruptions to goal-directed attentional control to impair performance under pressure. Consequently, the current systematic review focuses on the influence of anxiety on these self-paced targeting and aiming perceptual-motor tasks.

### 2.2.4. Objectives

The common factor among even the more contemporary frameworks is that attentional disruptions are a critical component of the anxiety-sport performance relationship and both self-focus and distraction elements may play their part. Furthermore, the field lacks an updated encompassing and systematic review that draws together the body of empirical evidence in support of anxiety's influence on attention. As such, the aim of this paper is to systematically review the available evidence that investigates the key attentional mechanisms involved in the anxiety-performance relationship. This will provide a better understanding of the current evidence, and the relative efficacy of the different theoretical perspectives described in section 2.2.2. We aim to review the methodological approach to examining anxiety and attention (how anxiety and attention are measured or manipulated) as well as the broader methodological rigour of the studies (e.g. generalisability, control groups, statistical approach). We will then synthesise this new information into a discussion of how the results relate to the anxiety-performance theories tested. In doing so, we hope to encourage further research that will advance understanding of the relationship between anxiety, attentional mechanisms and performance.

## 2.3. Methods

### 2.3.1. Search strategy and inclusion criteria

An electronic search of the PsycInfo, PubMed, and SPORTDiscus databases was conducted for relevant research related to anxiety and attention, up to and including June 2017. The search was initially conducted in the PsycInfo database (see Table 2.1) and adapted accordingly to the other databases. The researchers independently assessed the eligibility of each retrieved record on the basis of title and abstract. If any information was unclear, the full-text article was screened. The researchers followed the Preferred Reporting of Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines.

***Table 2.1.*** *Database search strategy for PsycINFO 1806 to June Week 4 2017*

| # | Searches | Results |
|---|---|---|
| 1 | anxiety.sh. OR anxiety.mp. OR performance anxiety.mp. OR competitive anxiety.mp. OR pressure.mp. OR competitive pressure.mp. OR performance pressure.mp. OR threat.mp. | 266043 |
| 2 | attention.sh. OR attention.mp. OR attention$ control.mp. OR attention$ disruption.mp. OR attention$ regulation.mp. OR attention$ focus.mp. OR attention$ mechanism.mp. | 240641 |
| 3 | 1 and 2 | 19558 |

Studies included in the review were required to meet the following selection criteria: the research needed to (1) use adult populations in studies which either measured anxiety (i.e. high vs. low state or trait anxiety) or manipulated anxiety (i.e. creating high vs. low pressure conditions); (2) engage participants in a form of target and aiming motor performance task; (3) manipulate attention, or measure attention (directly or indirectly as defined in 2.2.3), and (4) report original research. Studies were excluded from the review on the basis of the following criteria: (1) the study design did not involve a target or aiming motor performance task; (2) there was no measure or manipulation of anxiety or attention; (3) they were focused on training interventions; (4) they were written in a language other than English; (5) they included a clinically anxious population or they tested child populations; (6) they were unpublished material (dissertations, theses, conference proceedings); (7) they were a review paper or commentary. Any discrepancies in the reviewers' decisions to include or exclude a paper were discussed until a consensus was reached.

**2.3.2. Data extraction and quality assessment**

After all relevant articles were obtained, their quality was assessed and data extracted. The data extraction form retrieved the following information from the included studies: article; sample; sport; anxiety manipulation (yes/no); measures taken; type of theory (self-focus or distraction); and findings. Following data extraction, studies were divided into those that manipulate attention (Table 2.4) vs. those that measure attention (Table 2.5; see section 2.3). To ensure accuracy and consistency, discussion and crosschecking of included studies was carried out amongst the authors.

The quality of a study was determined by examining the internal and external validity. No quality assessment instrument has been standardised for laboratory-based observational studies (Uiga, Cheng, Wilson, Masters, & Capio, 2015). However, the current systematic review adapted the Quality Index (Downs & Black, 1998), the checklist for the evaluation of research articles (Durant, 1994) and the appraisal instrument (Genaidy et al., 2007) to assess the quality of the included studies. The maximum score available for the quality assessment was 25, as summarised in Table 2.2, and presented as both a percentage and absolute score, in Table 2.3. The first author performed the quality assessment, and discussed queries in the assessment with the remaining authors.

***Table 2.2*** *Quality assessment items*

| Item Number | Item |
|---|---|
| 1 | Is the hypothesis/aim/objective of the study clearly described? |
| 2 | Are the main outcomes to be measured clearly described? |
| 3 | Have the authors established a theoretical framework for the study? |
| 4 | Is the study design clearly described and appropriate to test the hypotheses? |
| 5 | Are the characteristics of participants in the study clearly described? |
| 6[a] | Is there evidence of attention to ethical issues? |
| 7 | Are the anxiety conditions clearly described? |
| 8[b] | Is the target and aiming motor task clearly described? |
| 9 | Are the main findings of the study clearly described? |
| 10 | Does the study provide estimates of the statistical parameters (e.g. regression coefficients)? |
| 11 | Have actual probability values been reported for the main outcomes except where the probability value is less than 0.001? |
| 12 | Are conclusions substantiated by the data that are presented in the results? |
| 13 | Are results adequately compared to previous studies and in relation |

| | |
|---|---|
| | to theoretical frameworks? |
| 14 | Are the subjects asked to participate in the study representative of the entire population from which they were recruited? |
| 15 | Are those subjects who were prepared to participate, representative of the entire population from which they were recruited? |
| 16 | Were the statistical tests used to assess the main outcomes appropriate? |
| 17 | Do the operational definitions of the variables match the theoretical definitions? |
| 18 | Are the methods of assessing the outcome variables valid? |
| 19 | Is the control group/condition comparable to the exposed group/condition? |
| 20 | Are the methods of assessing the exposure variables valid? |
| 21 | Is the manipulation of the exposure variable successful? |
| 22 | Are the methods of assessing the outcome variables direct measurements? |
| 23 | Are the outcome data reported by levels of exposure? |
| 24 | Can the study results be applied to the eligible population? |
| 25 | Can the study results be applied to other relevant populations? |

*Note:* Items were taken from the evaluation checklist for research articles (Durant, 1994), the Quality Index (Downs & Black, 1998) and the Epidemiological appraisal Instrument (Genaidy et al., 2007), unless otherwise specified.

[a] Additional item to verify attention to ethics (Spencer, Ritchie, Lewis, & Dillon, 2003).

[b] Additional item to verify task

## 2.4. Results

### 2.4.1. Search result

In the first stage of database searching, the search strategy resulted in the retrieval of 736,186 citations. After removing duplicates and screening titles, 575 abstracts were identified. These abstracts were examined against the inclusion and exclusion criteria, resulting in 215 papers identified for full-text review. Full-text articles were examined with respect to the objectives of the systematic review. Reference lists were inspected for further citations and suggestions were accepted should they match the criteria (n=3). A final list of

34 articles was identified as appropriate for the review (see Figure 2.1).

### 2.4.2. Quality Assessment

Quality assessment results ranged from 76-100%, with a mean score of 92.7% (see Table 2.3). Two of the included papers scored in the high (61%-80%) methodological quality range and 32 papers scored in the very high (81-100%) methodological quality range. Overall, studies scored highly in items relating to reporting of study design, the task used, reporting main findings, and substantiating conclusions. The lowest scoring item was direct measurement of outcome variables (item 22), which was only achieved in 10 studies (29.4%). Additionally, the generalisability of findings (item 25) was addressed by only 23 of 34 studies (67.6%). Finally, only 24 of 34 studies (70.6%) reported actual probability values (item 11).

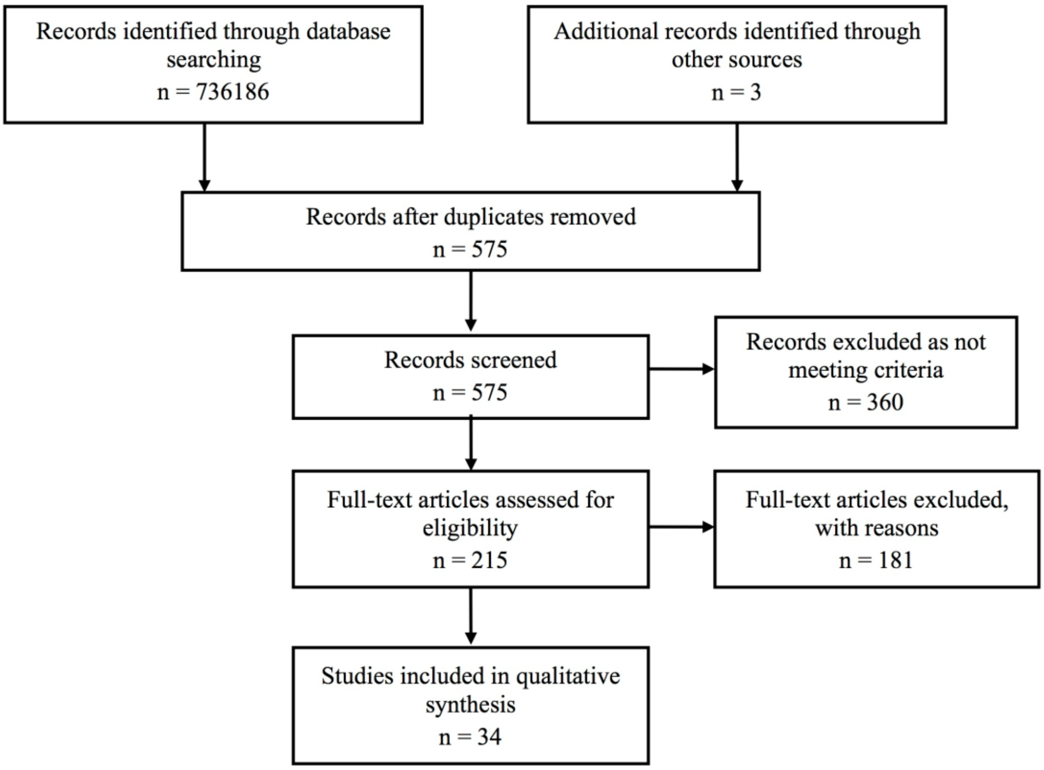


***Figure 2.1.*** *Stages and results of the search process using the four-phase*

*PRISMA flow diagram. Adapted from Moher, Liberati, Tetzlaff, Altman and group* (2009).

***Table 2.3.*** *Quality assessment scores*

| Article | Items | | | | | | | | | | | | | | | | | | | | | | | | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | Raw | % |
| Behan & Wilson (2008) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 22 | 88 |
| Beilock & Carr (2001) (Exp. 3 & 4) | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 23 | 92 |
| Causer, Holmes, Smith & Williams (2011) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 25 | 100 |
| Cooke, Kavussanu, McIntyre & Ring (2010) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 23 | 92 |
| Cooke, Kavussanu, McIntyre, Boardley & Ring (2011) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 24 | 96 |
| Englert & Bertrams (2012) (Exp. 1 & 2) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 22 | 88 |
| Englert, Bertrams, Furley & Oudejans (2015) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 19 | 76 |
| Englert & Oudejans (2014) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 25 | 100 |
| Englert, Zwemmer, Bertrams & Oudejans (2015) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 25 | 100 |
| Gray (2004) (Exp. 3) | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 18 | 72 |
| Gray & Allsop (2013) Exp. 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 24 | 96 |
| Gray, Allsop & Williams (2013) | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 19 | 76 |
| Gucciardi & Dimmock (2008) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 23 | 92 |
| Kinrade, Jackson & Ashford (2010) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 25 | 100 |
| Lawrence, Khan & Hardy (2013) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 24 | 96 |
| Liao & Masters (2002) (Exp. 2) | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 24 | 96 |
| Malhotra, Poolton, Wilson, Uiga & Masters (2015) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 25 | 100 |
| Mullen & Hardy (2000) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 23 | 92 |
| Mullen, Hardy & Tattersall (2005) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 22 | 88 |

| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nibbeling, Daanen, Gerritsma, Hofland & Oudejans (2012) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 25 | 100 |
| Nibbeling, Oudejans & Daanen (2012) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 25 | 100 |
| Nieuwenhuys & Oudejans (2010) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 24 | 96 |
| Otten (2009) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 25 | 100 |
| Tanaka & Sekiya (2010a) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 24 | 96 |
| Tanaka & Sekiya (2010b) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 24 | 96 |
| Tanaka & Sekiya (2011) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 24 | 96 |
| Vickers & Williams (2007) | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 21 | 84 |
| Vine, Lee, Moore & Wilson (2013) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 25 | 100 |
| Wang, Marchant, Morris & Gibbs (2004) | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 23 | 92 |
| Whitehead, Taylor & Polman (2016) (Exp. 2) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 22 | 88 |
| Williams, Vickers & Rodrigues (2002) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 24 | 96 |
| Wilson, Smith & Holmes (2007) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 23 | 92 |
| Wilson, Vine & Wood (2009) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 25 | 100 |
| Wilson, Wood & Vine (2009) | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 25 | 100 |
| Item percentage | 100 | 85.3 | 97.1 | 97.1 | 100 | 100 | 100 | 94.1 | 100 | 100 | 70.6 | 100 | 94.1 | 100 | 97.1 | 100 | 100 | 100 | 97.1 | 88.2 | 88.2 | 64.7 | 94.1 | 97.1 | 67.6 | | |
| Average total score | | | | | | | | | | | | | | | | | | | | | | | | | | 23 | 91.9 |

*Note:* 1 – yes; 0 – no/ unknown;

### 2.4.3. Characteristics of included studies

The main findings of the systematic review are presented in Table 2.4 and 2.5. Out of the 34 studies included in the review, nine studies manipulated attention (Table 2.4); whilst 25 measured attention, either directly or indirectly (Table 2.5). Additionally, a total of twelve studies considered their findings in regards to the distraction approaches (i.e. PET and ACT). A total of eight studies considered their findings in regards to the self-focus approaches (i.e. CPH, EMH and Theory of Reinvestment) and fourteen studies either purposefully compared the difference between self-focus and distraction theories or retrospectively discussed the relevance of their findings to this debate. In thirteen studies participants were male and/or female students or novices, while in eighteen studies participants specialised in the respective tasks (e.g. golfers, baseball players, skeet shooters). Furthermore, in three studies there were two groups of participants; a novice or student group and a trained group who were experienced in performing the respective tasks.

***Table 2.4.*** *Summary of reviewed studies that performed a manipulation of attention*

| Article | Sample | Sport | Anx. | Measures | SF/D | Findings |
|---|---|---|---|---|---|---|
| Beilock & Carr (2001) (Exp. 3 & 4) | 108 (Exp3) undergraduate students<br><br>32 (Exp4) undergraduate students | Golf | Yes | Alphabet arithmetic performance (Exp. 3 only)<br><br>Shot accuracy | SF/D | Exp. 3: Single-task and distraction group significantly declined in putting accuracy, $t(17)= -2.21$, $p< .04$; $t(17)= -3.24$, $p< .005$. Self-conscious group significantly improved in putting accuracy, $t(17) = 1.81$, $p< .09$. All 3 groups improved in high-pressure post-test.<br>Exp.4: Distraction and self-conscious group, performance accuracy increased following 1st low- to high-pressure post-test. Distraction group significantly declined in putting accuracy from 2nd low-pressure post-test to high-pressure, $t(15)= -2.79$, $p< .014$. Self-consciousness group improved in putting accuracy, $t(15)= 4.84$, $p< .001$.<br>Skill-focused training can reduce choking under pressure.<br>Findings support predictions of Explicit Monitoring Theory. |
| Englert & Bertrams (2012) Exp. 1 & 2 | 64 (Exp. 1) amateur male basketball players (22.92 ± 6.11yrs)<br><br>79 (Exp. 2) university students (22.27 ± 3.39 yrs) | Basketball<br><br>Darts | Yes | Self-control strength depletion (transcription task)<br>Free throw success rate<br>SAS-2<br>STAI-SKD<br><br>Self-control strength depletion (transcription task)<br>Average score<br>SAS-2<br>PANAS<br>Anxiety thermometer<br>PANAS-X | D | Exp. 1: Self-control strength (e.g. selective attention) manipulation was successful.<br>State anxiety significantly predicted free throw success rate (lower) at Time 2 in the depletion condition.<br>State anxiety did not significantly predict free throw success rate at Time 2 in the non-depletion condition.<br>Participants low in anxiety did not differ between the two conditions in relation to performance.<br>Effect of ego depletion on performance was stronger as state anxiety increased. Without anxiety, ego depletion did not affect performance.<br>Exp. 2: Self-control strength manipulation was successful.<br>Successful anxiety manipulation.<br>Depleted participants dart performance was significantly lower in anxiety condition.<br>No difference between anxiety and no-anxiety dart performance in non-depleted participants.<br>No main effect of ego-depletion on performance; without anxiety ego depletion did not affect performance.<br>Findings in support of distraction approaches and strength model of self-control. |
| Englert, Bertrams, Furley & Oudejans (2015) | 31 basketball players | Basketball | Yes | Self-control strength depletion (transcription task)<br>Free throws<br>WAI-T (German SAS-2)<br>4-item manipulation check | D | Significant mean differences in manipulation of available self-control strength.<br>Depleted participants paid more attention to distracting stimuli and worse performance in the free throw task – support for assumption that performance differences were caused by differences in momentarily available self-control strength.<br>Distraction mediated the effect of self-control strength on performance.<br>Non-depleted were better able at ignoring distracting stimuli and displayed |

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| | | | | PANAS | | superior performance.<br>Findings support an integration of ACT and strength model of self-control. |
| Englert, Zwemmer, Bertrams & Oudejans (2015) | 28 Dutch right-handed students (23.4 ± 2.5 yrs) | Darts | Yes | Self-control strength depletion (transcription task)<br>Gaze behaviour<br>Average score<br>STAI-T<br>Anxiety thermometer<br>RSME<br>Heart Rate | D | Baseline: depletion did not differ significantly from non-depleted in state anxiety, mental effort, and average HR or dart scores.<br>Significant main effect for ego depletion.<br>Percentage of errors significantly higher in depletion group.<br>Anxiety scores were significantly higher in high anxiety condition.<br>Mental effort scores were significantly higher in high anxiety condition and for depleted group.<br>Higher average HR in high anxiety.<br>Depleted group scored significantly lower in high anxiety, whereas non-depleted did not.<br>Depleted group had a shorter final-fixation in high anxiety, shorter final fixation duration than non-depleted in high anxiety. |
| Gray (2004) Exp. 3 | 12 college division baseball players | Baseball | Yes | Judgement errors<br>Batting performance<br>Movement kinematics | SF | High pressure: drops in performance<br>Lower % of judgment errors pre-test to post-test in skill-focused pressure group, no substantial effect on judgment errors in extraneous dual task group.<br>Changes in batting kinematics, timing variability in swing.<br>Findings support Reinvestment and Explicit Monitoring theories. |
| Gucciardi & Dimmock (2008) | 20 golfers (25.3 ± 12.89 yrs) | Golf | Yes | Absolute error<br>CSAI-2<br>Cue manipulation check | SF/D | No significant effects for anxiety or putting condition and no significant interaction effect.<br>No significant difference between explicit knowledge and task-irrelevant conditions. Significant difference between swing thought condition and both explicit knowledge and task-irrelevant conditions.<br>Support for the principles of CPH. |
| Liao & Masters (2002) Exp. 2 | 12 male & 28 female university students | Basketball | Yes | Reinvestment scale<br>CSAI-2<br>Performance score | SF | Significant performance decrement in self-focus group post-stress, $F(1,19)= 8.93$, $p< .01$. The more technical rules participants had, the worse their performance under stress.<br>Findings support predictions of Reinvestment Hypothesis. |
| Mullen & Hardy (2000) | 18 male golfers (36.3 ± 16.3 yrs) | Golf | Yes | Absolute errors<br>CSAI-2<br>RPE | SF | Absolute error in low-anxiety (irrelevant and relevant) and high-anxiety (relevant) conditions was significantly higher than in the low-anxiety control condition.<br>High anxiety: expended more effort<br>Better putters invested more effort<br>Support for Conscious Processing hypothesis and some support for Processing Efficiency theory |
| Mullen, Hardy & Tattersall (2005) | 24 male golfers (36.3 ± 16.3 yrs) | Golf | Yes | HR variability<br>Error scores<br>CSAI-2<br>Self-reported effort | SF | Putts were significantly less accurate in high anxiety tone counting and shadowing conditions.<br>No significant effects of anxiety on self-reported effort and HRV.<br>Findings support an attentional-based distraction interpretation of anxiety effects, with some conscious processing support. |

*Note:* Anx. – Pressure situations introduced to manipulate anxiety conditions (yes or no); Measure – measures taken (including measures of attention); SF/D– type of theory (SF= self-focus based theory; D= distraction based theory)

***Table 2.5.*** *Summary of reviewed studies that did not perform a manipulation of attention*

| Article | Sample | Sport | Anx. | Measures | SF/D | Findings |
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| Behan & Wilson (2008) | 20 university students (26.4 ± 5.5 yrs) | Archery | Yes | Gaze behaviour<br>CSAI-2<br>Shot accuracy | D | QE period significantly shorter under high pressure (mean 50.4%) and before inaccurate shots (mean 49.6%). Findings in support of Processing Efficiency Theory. |
| Causer, Holmes, Smith & Williams (2011) | 16 elite-level skeet shooters (24.5 ± 4.4 yrs) | Skeet shooting | Yes | Gaze behaviour<br>MRF-3<br>RSME<br>% target hits<br>Gun barrel kinematics | D | Performance was lower under high (M=62.9 ± 6.8%) compared with low (M= 74.6 ± 8.2%) anxiety conditions.<br>In high anxiety condition: shorter QE duration (M= 403.0 ± 40.4ms), significantly longer QE durations on successful trials (M=417.3 ±29.1ms), later onset of QE (M=276.3± 23.9ms) and earlier QE onset on successful trials (M=245.3 ± 18.9ms). Findings support predictions of Attentional Control Theory. |
| Cooke, Kavussanu, McIntyre & Ring (2010) | 23 male & 35 female undergraduate students (19.6 ± 1.2 yrs) | Golf | Yes | Successful putts<br>RSME<br>CSAI-2<br>Radial error<br>Heart Rate<br>HR Variability<br>EMG<br>Kinematics | D | High pressure: Performance was lower (and in medium pressure), anxiety and effort were greater, increased HR, greater muscle activity.<br>Findings not in support of Processing Efficiency Theory. Reinvestment and Explicit Monitoring Theories could explain findings. |
| Cooke, Kavussanu, McIntyre, Boardley & Ring (2011) | 44 male & 6 female expert golfers (20.3 ± 1.5 yrs) | Golf | Yes | Movement specific reinvestment scale<br>CSAI-2<br>RSME<br>Heart Rate<br>HR Variability<br>EMG<br>Grip force<br>Kinematics | SF/D | High pressure: smaller radial error (and in medium pressure), anxiety and effort increased as pressure did, high conscious processing (and in low pressure) and HR increased.<br>No effects of pressure evident for HRV or muscle activity and significant effects of pressure on impact velocity and Z-axis acceleration. Support for conscious processing and reinvestment theory. |
| Englert & Oudejans (2014) | 34 males & 19 females (29.90 ± 9 yrs) | Tennis | Yes | Serve accuracy<br>Retrospective measures of attention<br>WAI-T (German sport anxiety scale)<br>Serve accuracy | SF/D | Significantly negative relationship between anxiety and serve accuracy. Effect of anxiety on tennis serve was fully mediated by distraction. |

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| | | | | Anxiety thermometer | | |
| Gray & Allsop (2013) Exp. 2 | 20 baseball players (m = 21.7 yrs) | Baseball | Yes | Secondary task accuracy: bat, frequency and ball judgement | SF | Anxiety significantly increased between pre-pressure and pressure, and significantly decreased from pressure to post-pressure.<br>Hot and cold streak groups performed significantly better than normal group under pressure.<br>Bat judgement: task accuracy significantly decreased for hot streak group between equalisation and pre-pressure phases.<br>Frequency judgement: non-significant effects<br>Ball judgement: task accuracy significantly increased for hot streak group between equalisation and pre-pressure phases. Normal groups accuracy remained the same until decreased between pre-pressure and post-pressure phases.<br>Post-pressure phase: players who failed – significantly greater accuracy for bat secondary task, lower accuracy in frequency and lower accuracy in ball secondary task, compared to successful players.<br>Findings support explicit monitoring theories and attentional self-focus assumptions. |
| Gray, Allsop & Williams (2013) | 11 male & 2 female golfers | Golf | Yes | Putting accuracy<br>Kinematics<br>IAMS | SF | Putting errors were significantly larger under pressure for participants 1, 3 and 7 and significantly lower under pressure for 6, 8 and 11.<br>Significant negative correlation between backswing movement time and putting error. Significant positive correlation between velocity impact and putting error.<br>Under pressure: smaller range of stroke amplitudes. Findings support Explicit Monitoring theories. |
| Kinrade, Jackson and Ashford (2010) | 40 males & 23 females (22.87 ± 3.99 yrs) | Golf | Yes | Reinvestment scale<br>CSAI-2R<br>Perceived pressure<br>Mean score | SF | Significant effect of pressure.<br>Mean number of points did not differ significantly between low and high pressure conditions.<br>Reinvestment score was negatively correlated with points scored from low to high pressure.<br>High re-investors scored fewer points under pressure.<br>Significant relationship between public self-consciousness and performance change under pressure. |
| Lawrence, Khan & Hardy (2013) | 15 male university students (18-35 yrs) | Target-directed aiming task | Yes | Directional variability<br>MRF-3<br>RSME<br>Movement time<br>Constant error | SF/D | Exp. 1: Transfer anxiety (high) was significantly greater than acquisition blocks (low).<br>Effort transfer was significantly greater than acquisition blocks.<br>Variable error was significantly greater in transfer.<br>Anxiety negatively affected automatic component of information processing supporting principles of CPH. |

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| | | | | Variable error | | Exp. 2: Transfer anxiety (high) was significantly greater than acquisition blocks (low).<br>Effort transfer was significantly greater than acquisition blocks.<br>No significant difference in movement time or constant error between acquisition and transfer.<br>Variable error significantly increased from acquisition to transfer.<br>Variability was significantly lower at movement end in low compared to high anxiety condition (i.e. accuracy decreased).<br>Findings lend more support to the principles of CPH. |
| Malhotra, Poolton, Wilson, Uiga & Masters (2015) Exp. 1 | 16 male & 14 female undergraduate students (20.48 ± 1.38 yrs) | Golf | Yes | Movement specific reinvestment scale<br>STAI<br>Kinematics<br>Successful putts<br>NASA task load index | SF | High anxiety: high state anxiety scores and perceived effort increased.<br>Low anxiety: movement self-consciousness positively correlated with putting proficiency<br>Anxiety had no effect on putting proficiency<br>Findings do not support Reinvestment Hypothesis, findings support Attentional Control Theory |
| Nibbeling, Daanen, Gerritsma, Hofland & Oudejans (2012) | 11 female & 8 male students (21.6 ± 1.2 yrs) | Darts | Yes | Self-reported attentional focus<br>STAI (Dutch version)<br>Anxiety thermometer<br>RSME<br>RPE<br>Heart Rate<br>Kinematics<br>Dart score<br>Dart time (to throw all 12) | D | High anxiety: perceived mental effort was significantly higher, worry and distracting thoughts mentioned significantly more often, higher stride frequency, shorter stride length and longer contact time, higher heart rate, lower dart scores and time taken to throw all 12 darts was significantly longer.<br>Findings support Attentional Control theory. |
| Nibbeling, Oudejans & Daanen (2012) | 11 male experienced dart players (34.2 ± 9.6 yrs)<br><br>4 female & 5 male students (22.9 ± 1.7 yrs) | Darts | Yes | Gaze behaviour<br>STAI (Dutch version)<br>Anxiety thermometer<br>Heart Rate<br>Average score per dart<br>Dart times (time to throw all 6)<br>RSME<br>RPE | D | Higher anxiety in dual task condition, HR higher in dual task condition, dart times significantly longer in high anxiety condition, dart times did not differ between two groups in dual task condition<br>Students: higher anxiety scores than dart players, lower dart scores in high anxiety condition<br>Dart players: higher HR than students, dart scores did not differ between anxiety levels, at all levels dart players performed better, dart times were longer in single task condition than dual task and students<br>Less counts per minute in high anxiety, response rates did not differ between groups, % of correct counts did not differ significantly between groups |

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| | | | | Secondary task:<br>% of right answers<br>Response rate | | Findings provide support for Attentional Control Theory |
| Nieuwenhuys & Oudejans (2010) | 6 male & 1 female police officer (23.8 ± 2.0 yrs) | Shooting | Yes | Gaze behaviour<br>Anxiety thermometer<br>RSME<br>Heart Rate<br>Mean % of hits<br>Response time<br>Total performance time<br>Head/body orientation | D | High anxiety: anxiety, HR and effort scores were significantly higher, average response and performance times were significantly shorter, participants turned away more, vertical head orientation showed tendency to be lower, participants blinked significantly more often.<br>Findings provide support for Attentional Control Theory |
| Otten (2009) | 90 female & 153 male undergraduate psychology students (20.13 ± 2.44 yrs) | Basketball | Yes | Reinvestment scale<br>Implicit knowledge questionnaire<br>Modified sport confidence inventory<br>CSAI-2<br>Private self-consciousness scale<br>Performance measures | SF | Under pressure, self-focus did not lead to improved performance under pressure, reported 'perceived control' did help performance.<br>Participants performed better under pressure, on average.<br>Reinvesting attention in the task led to greater anxiety. |
| Tanaka & Sekiya (2010a) | 6 male professional golfers (24.7 ± 1.1 yrs), 5 male novices (21.2 ± 0.2 yrs) | Golf | Yes | Retrospective measure of attentional focus<br>STAI Y-1<br>Heart Rate<br>Total putting score<br>Movement kinematics | SF/D | HR showed a significant main effect of block. State anxiety showed no significant main effects or interaction.<br>No significant decrease in putting score from last block of trials to test.<br>No significant main effects or interactions of attention<br>Arm and club movements became slower for expert and novices under pressure<br>Kinematic changes were the same for experts and novices under pressure<br>Neither conscious processing nor distraction scores change for experts or novices from acquisition to test trials.<br>Findings suggest other mechanisms (e.g. strategy modification, emotional responses) in addition to attention factors should be furthered examine to develop understanding of choking phenomena |

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| Tanaka & Sekiya (2010b) | 16 male university students (19.6 ± 0.5 yrs) | Golf | Yes | Retrospective measure of attentional focus<br>STAI Y-1<br>PANAS<br>Heart Rate<br>Movement kinematics<br>EMG | SF/D | State anxiety, negative affect and HR increased significantly from the 15th block to test.<br>No significant changes in putting score from last block to test trials.<br>No change in the degree of attention to movement from the last block of acquisition trials to the test.<br>Results suggest both increased attention to movements and increased attention to distractors played a role in attentional focus in the task. |
| Tanaka & Sekiya (2011) | 20 university students (19.7 ± 0.5 yrs) | Golf | Yes | Retrospective measure of attentional focus<br>STAI Y-1<br>PANAS<br>Heart rate<br>Grip Force<br>Movement analysis (putting)<br>Mean scores | SF/D | HR increased significantly during the 15th block and test block; however state anxiety, positive and negative affect showed no significant change. Significant kinematic changes observed in the pressure condition. No change in grip force during pressure test was observed. Participants' attentional focus was directed to the distracters in the test. Some support for ACT, however distracter and kinematic changes could have occurred under relatively low pressure that doesn't result in performance decrements (T-tests for all performance variables showed no significant changes). Putting scores decreased under pressure in participants whose Q1 (attention to movements) score was relatively high, plus changes in variability of movements, supporting the CPH. |
| Vickers & Williams (2007) | 7 male & 3 female Canadian national biathletes (23.3 ± 4.74 yrs; 22.1 ± 1.01 yrs) | Shooting | Yes | Gaze behaviour<br>CSAI-2<br>RPE<br>Cognitive worry<br>Shooting accuracy<br>Heart Rate | SF/D | High pressure: cognitive anxiety was higher.<br>No differences were found in cognitive worry due to pressure.<br>Highest level of accuracy occurred in 55% power output in both the low-pressure and high-pressure conditions. No significant difference in HR due to pressure. A significant difference in RPE for power output. Mean QE duration was longer on hits than misses<br>Findings support predictions from distraction and self-focus approaches. |
| Vine, Lee, Moore & Wilson (2013) | 50 expert golfers (29.34 ± 14 yrs) | Golf | Yes | Gaze behaviour<br>MRF-3<br>Movement phase durations | D | Preparation was significantly longer in first compared to penultimate putts. QE duration was significantly shorter for final putts. QE component occurring during putting stroke was significantly shorter in final putts. Significantly shorter fixation duration on ball location after contact on final putts.<br>Findings provide support for Attentional Control Theory |
| Wang, Marchant, Morris & Gibbs (2004) | 88 student basketball players (19.3 ± 1.7) | Basketball | Yes | Self-consciousness scale (SCS)<br>CSAI-2<br>Number of successful shots | SF | Manipulation of pressure was successful.<br>Significant decline in performance from LP to HP condition.<br>Private S-C contributed to 24% of variance in performance, somatic A-trait significantly increased the proportion of explained variance. Social anxiety did not significantly contribute. Private S-C with somatic trait anxiety contributed 35% of variance in performance. |

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| Whitehead, Taylor & Polman (2016) (Exp. 2) | 8 male high-skilled golfers (17.5 ± 1.19 yrs; handicap: 2.25)<br><br>8 moderate-skilled golfers (17.25 ± 0.46 yrs; handicap: 9.62) | Golf | Yes | Decision specific reinvestment scale<br>Think Aloud protocol<br>Number of putts | SF | HS golfers: verbalised more shots. Decision reinvestment had a strong positive relationship with technical instruction verbalisations (technical thoughts) when putting. Thought process regressed to less automatic, more technical step-by-step process in putting.<br>Moderate skill: decision reinvestment had a strong positive relationship with technical instruction verbalisations (technical thoughts) during wood/iron shots. Less planning of shots.<br>Strong positive relationship between conscious motor processing and self-consciousness for both high and moderate skill golfers.<br>Findings support reinvestment. |
| Williams, Vickers & Rodrigues (2002) | 8 male & 2 female table tennis players (28.9 ± 8.2 yrs) | Table tennis | Yes | Gaze behaviour<br>Modified CSAI-2<br>Kinematics<br>Performance accuracy<br>PRT<br>RSME | D | High anxiety: high cognitive anxiety and perceived as less facilitative, decrease in self-confidence and perceived as less facilitative and altered gaze more frequently.<br>High performance scores on LWM compared with HWM and under LA. Longer PRT values on HWM and under HA. More mental effort under HA and HWM.<br>Participants spent more time tracking the ball than other areas, and more so in HA than LA in HWM. Shorter movement times were observed in LWM.<br>Findings provide some support for the Processing Efficiency theory |
| Wilson, Smith & Holmes (2007) | 18 golfers (38.6 ± 16.61 yrs) | Golf | Yes | RSME<br>HR variability<br>SAS<br>MRF-L<br>Absolute error<br>Time to initiate backswing | SF/D | HTA golfers reported significantly higher effort in the competitive condition. Significant difference between resting HRV and high pressure HRV and low pressure HRV. HTA golfers took significantly longer to initiate backswing in the high-pressure condition. HTA performance was significantly worse in high-pressure condition.<br>All golfers made significantly more glances at target hole in high-pressure condition.<br>Findings provide more support for predictions of Processing Efficiency theory than Conscious Processing hypothesis |
| Wilson, Vine & Wood (2009) | 10 male university basketball players (20.3 ± 0.9 yrs) | Basketball | Yes | Gaze behaviour<br>MRF-L<br>Free-throw % | D | High threat: higher cognitive anxiety, free throw % accuracy was lower, shorter QE periods, more fixations, shorter fixation durations<br>Long QE period, earlier onsets, less fixations, longer fixation durations for successful shots compared with misses.<br>Findings provide support for Attentional Control Theory |
| Wilson, Wood & Vine (2009) | 14 male university standard football players (20.4 ± 1.1 yrs) | Football | Yes | Gaze behaviour<br>MRF-3<br>Target accuracy<br>Time to prepare shot | D | High threat: increased cognitive anxiety, shots placed significantly closer to the centre of goal, significantly more fixations, significantly longer periods of time fixating on both conditions, longer total fixation duration to goalkeeper, significantly quicker to fixate on goalkeeper<br>Findings provide support for Attentional Control Theory |

*Note:* Anx. – Pressure situations introduced to manipulate anxiety conditions (yes or no); Measures – measures taken (including attention measures); SF/D– type of theory (SF= self-focus based theory; D= distraction based theory)

## 2.5. Discussion

### 2.5.1. Quality Assessment

The scores from the quality assessment have highlighted a number of particular concerns regarding the included studies. Eleven out of 34 studies recommended caution when generalising findings to other relevant populations (item 25), identifying an issue with the extent to which results obtained can be used to make predictions about other situations and populations. As a result, future research may need to consider varied groups of populations and possibly larger sample sizes if findings are to be more generalisable. Furthermore, it is important to recognise that the lab-based nature of the experimental research reviewed means that generalisability of findings to real-world environments (i.e. ecological validity) is also somewhat problematic. For example, while an experimental manipulation designed to cause a self-focus may impair performance, it does not mean that this mechanism actually occurs when sporting performers are anxious (Oudejans et al., 2011).

Moreover, item 22 (direct measures of attention) identified a methodological issue with objectively measuring attention during performance, in particular when examining focus of attention on ‘the self’ in relation to self-focus theories. Twelve studies failed to objectively measure focus of attention. Generally, objective measures consisted of eye tracking variables and self-reported retrospective measures and were mostly evident in research testing distraction-based assumptions (see Tables 2.4 and 2.5). While gaze disruption might reflect distractibility, it is less relevant when trying to determine covert changes in attention (e.g. an individual focusing inappropriately on the mechanics of their movement). Furthermore, although self-reported measures allow the measurement of an internal focus of attention, the extent to which individuals are able to accurately recall and report thoughts and attentional focus is still questioned (Oudejans et al., 2011). Research testing self-focus approaches is therefore more inclined to use indirect measures, such as kinematic and muscle activity measures that may reflect this form of disruption (Masters & Maxwell, 2008). This discussion of the findings from item 22 highlights differences between the designs and methods of the included studies, and consequently the difficulties in comparing tests of the self-focus and distraction accounts.

A number of papers did not present actual *p* values when reporting statistical analyses (item 11). The American Psychological Association (APA, 2010) suggests "when reporting *p* values, report exact *p* values (e.g. $p = .031$) to two or three decimal places. However, report *p* values less than .001 as $p < .001$" (p.114). Reporting actual *p* values (rather than in comparative form; e.g. $p < .05$) as well as reporting effect sizes, should provide greater transparency and enable readers to form their own opinion of the findings based on the evidence provided (Sullivan & Feinn, 2012).

On a more positive note, anxiety was successfully manipulated in 30 studies, with measures of state anxiety in the high-pressure condition significantly higher than those found in a baseline, or low-pressure condition. Multiple methods tended to be employed, including the use of incentives, ego-threatening instructions, and non-contingent negative feedback. Although unlikely to be representative of the high levels experienced during sporting competition, the significant differences in reported anxiety between conditions are sufficient to allow examination of the role of attention when anxious. However, trait anxiety measures were seldom taken (see Englert & Bertrams, 2012, 2015; Englert & Oudejans, 2014; Englert et al., 2015; Wilson, Smith, et al., 2007, for some notable exceptions) and therefore less is known about how individual differences influence the experience of pressure and levels of state anxiety. High trait anxious individuals are more likely to experience higher levels of state anxiety and to worry more in pressured and threatening situations than low trait anxious individuals (Spielberger, 1966). An examination of trait anxiety and other individual differences in how threat is attended to and interpreted is therefore important if we are to better understand variations in performance under pressure (Eysenck & Wilson, 2016; Vine, Moore, & Wilson, 2016).

### 2.5.2. Narrative of findings from included papers

#### *2.5.2.1. Studies performing a manipulation of attention*

Out of the 34 reviewed studies, nine studies placed participants in groups and manipulated attentional focus in an attempt to replicate the attentional disruptions proposed by the relevant theoretical frameworks being tested (see Table 2.4).

*Dual task performance*

In six of the studies, a self-focus was manipulated by providing instructions relating to skill execution, whilst distraction was implemented through concurrent task loading (e.g. a counting task while putting). Individuals performing under self-focus instructions were susceptible to performance decrements (Gray, 2004; Liao & Masters, 2002), and in distraction conditions, effort increased in order to complete the task (Mullen & Hardy, 2000) and there was evidence of less accurate performance(Mullen et al., 2005).

*Self- control strength*

Additionally, three of the nine studies manipulated attention through the use of a transcription task with the aim of depleting self-control. Under anxiety there was evidence of poor attentional control and disrupted performance in ego-depleted individuals (low self-control; Englert & Bertrams, 2012, 2015; Englert et al., 2015). These three studies examined predictions from the distraction approach, implicating reduced self-control strength as a reason for disrupted attentional control during performance. However, as highlighted through the quality assessment (see 2.5.1), whilst results may demonstrate impaired performance, experimentally manipulating attention cannot be used to comparatively assess the distraction and self-focus predictions or how anxiety spontaneously affects attention during task performance under pressure.

*2.5.2.2. Studies measuring attention*

Out of the 34 studies reviewed, 25 of these studies did not manipulate attentional focus (see Table 2.5) and instead used measured attention. 20 studies used either measures of gaze behaviour or self-report, the remainder of the studies (5) used performance accuracy measures (i.e. successful putts, directional variability) to assess changes in attentional control under pressure.

*Gaze behaviour*

Nine of the 25 studies included gaze behaviour measures to assess attentional mechanisms under anxiety. Gaze behaviour provides a more direct, objective measure of attentional control during performance and was used in studies where attentional focus was not explicitly manipulated (i.e. in studies investigating predictions from distraction theories only; Vine, Lee, Moore, & Wilson, 2013). The disrupted attentional processes presented as less stable attentional focus, including shorter quiet eye durations (the final fixation towards a relevant target prior to the execution of movement; Behan & Wilson, 2008; Englert et al., 2015; Vine et al., 2013); an increased number of fixations (Wilson, Vine, et al., 2009; Wilson, Wood, et al., 2009); and longer gaze allocations towards less relevant areas (Causer et al., 2011; Nibbeling, Daanen, et al., 2012; Nibbeling, Oudejans, et al., 2012; Nieuwenhuys & Oudejans, 2010; Williams, Vickers, et al., 2002).

*Self-report*

Furthermore, five of the 25 studies included retrospective, self-report measures of attentional focus whilst six employed reinvestment (or self-consciousness) scales to examine the inferred effect of anxiety on attention. Retrospective reports mentioned distracting thoughts significantly more often (Englert & Bertrams, 2012; Nibbeling, Daanen, et al., 2012; Tanaka & Sekiya, 2011), however, there were reports of increased attention to movements as well as distractors (Tanaka & Sekiya, 2010a, 2010b). Reinvestment scales were presented as the movement specific reinvestment scale, the decision specific reinvestment scale and the self-consciousness scale. Under high pressure, there was evidence of more conscious processing (Cooke et al., 2011), including a greater amount of reinvesting (Kinrade, Jackson, & Ashford, 2010; Otten, 2009), a greater amount of self-consciousness leading to greater performance variance (Wang, Marchant, Morris, & Gibbs, 2004), and disrupted fluency leading to less automatic, step-by-step processing (Whitehead, Taylor, & Polman, 2016).

*2.5.2.3. Studies using performance measures*

All 34 studies included performance measures to assess the potential outcome of anxiety-induced attentional disruptions whether attention was manipulated or not. Findings from studies examining a self-focus approach sought to test the assertion that movement should be less automatic when attention focuses on the step-by-step processes of performance (Whitehead et al., 2016). Increased attention towards one's self and the mechanics of performance resulted in disrupted performance, as well as increases in mental effort and disrupted kinematics (Gray, 2004; Gray & Allsop, 2013; Gray, Allsop, & Williams, 2013; Kinrade et al., 2010; Wang et al., 2004). Furthermore, there was support for distraction-based theories as evidenced by decreased accuracy and response times, as well as increases in mental effort (Causer et al., 2011; Lawrence, Khan, & Hardy, 2013; Williams, Vickers, et al., 2002), changes in heart rate variability (Wilson, Smith, et al., 2007), and decreases in information processing efficiency (via gaze measures; Vine et al., 2013; Wilson, Vine, et al., 2009; Wilson, Wood, et al., 2009). However, while results tended to support the theories being tested, one study (Otten, 2009) - out of the 34 included in the review - found that participants performed better under pressure as a result of increased perceptions of control (Cheng et al., 2009).

*2.5.2.4. Manipulation of anxiety*

One of the inclusion criteria for the review was that participants must perform under low and high-pressure conditions. Nine of these studies also manipulated attentional focus (see 2.5.2.1) to examine the influence of anxiety and attention on performance. The remainder of the studies (25) only used manipulations of evaluative threat and/or incentives to increase state anxiety and examine naturally occurring attentional changes when performing. Thirty studies in the review successfully manipulated anxiety (see Table 2.3), whereas in the remaining four studies, the lack of manipulation check between the low and high-pressure conditions meant that changes in anxiety could not be assessed. The most frequently used (twelve times) measure of anxiety was the Competitive State Anxiety Inventory-2 (CSAI-2; Martens et al., 1990). The Mental Readiness Form-3 (MRF-3; Krane, 1994), the State Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, & Lushene, 1970) and the anxiety thermometer (Houtman & Bakker, 1989) were used in six, seven and six studies, respectively. Furthermore, heart rate was used as an objective measure of state anxiety in ten of the 30 studies. Taken together, the review demonstrates the effectiveness of an experimental approach to examining the anxiety-performance relationship and potential attentional disruptions, even if the reported levels of anxiety are unlikely to be as high as in real, sporting competition.

*2.5.2.5. Theoretical stance of the included papers*

Despite newer theories being proposed in the literature (Carson & Collins, 2016; Cheng et al., 2009; Eysenck & Wilson, 2016; Nieuwenhuys & Oudejans, 2012, 2017), the majority of studies reviewed only considered attentional mechanisms in regards to the existing self-focus and distraction dichotomy. Although some studies made reference to the newer frameworks (see Englert & Bertrams, 2012, 2015; Englert et al., 2015; Otten, 2009), results were still discussed in terms of the dominant self-focus or distraction approaches.

In particular, the review has highlighted a tendency for the self-focus and distraction approaches to employ measures of attention and performance that are biased towards their respective theoretical assumptions. For example, papers examining a distraction approach tailor the objective measures of attentional control (e.g. gaze behaviour) towards these predictions (Vine et al., 2013; Wilson, Vine, et al., 2009; Wilson, Wood, et al., 2009). Similarly, in research examining self-focus predictions, measures of muscle activity and kinematics (Cooke et al., 2011, 2010; Gray, 2004; Gray et al., 2013) provide indirect support of detrimental self-focused attention when anxious. However, Williams, Vickers, et al. (2002) is a notable exception, using both gaze behaviour and kinematics, alongside probe reaction time data in a test of the distraction-based PET (Eysenck & Calvo, 1992). This study aside, notable differences between the designs and methods of the included studies hinder comparisons of the self-focus and distraction accounts.

Moreover, whilst the effects of anxiety on performance were suggested to be wholly mediated by distraction in some cases (Englert & Oudejans, 2014; Wilson, Vine, et al., 2009; Wilson, Wood, et al., 2009), eight of the reviewed papers supported predictions that underpin both the distraction *and* self-focus approaches (Cooke et al., 2011; Mullen & Hardy, 2000; Mullen et al., 2005; Tanaka & Sekiya, 2010a, 2010b, 2011; Vickers & Williams, 2007; Wilson, Smith, et al., 2007). Five other studies rejected support for one theory's assumptions (Beilock & Carr, 2001; Cooke et al., 2010; Gucciardi & Dimmock, 2008; Lawrence et al., 2013; Malhotra, Poolton, Wilson, Uiga, & Masters, 2015) and supported the other (for example, supporting ACT over the reinvestment theory). An over-riding weakness of the literature reviewed was that few studies examined potential inter-individual variables that might mediate the anxiety-attention-performance relationships.

### 2.6. Synthesis and implications

As demonstrated in the narrative above (2.5.2.) it is difficult to draw conclusions as to the specific attentional mechanisms influenced by anxiety in sport settings. Tests of the competing self-focus and distraction-based accounts of this relationship have produced equivocal findings. In particular, it is difficult to compare and contrast findings between studies adopting very different measurement approaches and experimental designs, as well as between studies employing methods that are biased towards authors respective theoretical assumptions; something that holds back our ability to better understand the relative strengths and weaknesses of each approach in explaining the attentional mechanisms underpinning the anxiety-performance relationship.

Attempts at a more fine-grained approach to examining the anxiety-performance relationship may help clarify the current state of knowledge. Specifically, some of the newer models (outlined in the Introduction; Carson & Collins, 2016; Cheng et al., 2009; Eysenck & Wilson, 2016) have started to explore relevant mediating and moderating variables (e.g. perceived control or cognitive biases) which determine how likely it is that an individual will become anxious, and suffer attention and performance disruptions. However, there have been limited attempts at actually trying to test the main tenets of these contemporary frameworks. This may be due to a number of practical factors, including; the complexity of the new models, which make them more suited to opinion pieces as opposed to testable hypotheses and the need for innovative methods to test the proposed moderating variables.

The current review also emphasised the difficulty in objectively measuring focus of attention during performance, and in particular, examining focus of attention on 'the self' in relation to self-focus theories. Consequently, research may need to move beyond manipulated focus conditions and self-report variables taken alongside movement kinematic measures when making inferences about attention disruptions when anxious. For example, more central measures of attention derived from electroencephalography (EEG) recordings (e.g. high-alpha left temporal-frontal connectivity) have been used to assess performance differences during movement tasks under pressure (Cooke et al., 2015, 2014) and have been shown to reflect increased reinvestment in investigations of implicit motor learning (Zhu, Poolton, Wilson, Maxwell, & Masters, 2011), and under high pressure conditions (Gallicchio, Cooke, & Ring, 2016). There is therefore an opportunity for future research to combine objective measures of reinvestment with gaze behaviour measures to test both self-focus and distraction predictions in a way that overcomes some of the difficulties with interpretation between the studies included in this review.

Out of the studies reviewed, only Otten (2009) revealed a performance-improving influence of competitive pressure. While this potential positive outcome is explicitly considered in the contemporary frameworks, the experimental designs of the studies reviewed perhaps did not provide the opportunity to test these newer predictions or the individual variations in response to pressure. Indeed, a limitation of the anxiety-performance research to date has been the use of blocked conditions and grouped data (see Eysenck & Wilson, 2016). In real competitive environments, not only may there be differences in the ways in which individuals perceive pressure, but this is likely to vary during an event. ACTS (Eysenck & Wilson, 2016) suggests that a key factor of the anxiety-performance relationship is its bi-directional nature and the fact that performance errors will likely influence momentary state anxiety. As such, it is important that future studies take a more fine-grained approach to assessing performance and anxiety under pressure; as trying to relate measures of anxiety taken prior to performing a block of trials with the aggregated performance in those trials does not take into account this bi-directional relationship. Whilst research has begun to consider the differences between successful and unsuccessful performance attempts when under pressure (Cooke et al., 2015, 2014; Gallicchio et al., 2016) changes in anxiety are not assessed with the same precision.

Despite the concerns identified above, the findings from the review do suggest that increased anxiety in response to competitive pressure *is* related to impaired attentional control and degraded performance. Interventions designed to improve performers' attentional control therefore have merit, as they are likely to limit both unwanted attention to the self, and/or irrelevant (and especially threatening) stimuli. For example, there is an existing evidence base to support the use of quiet eye training to protect performance of targeting skills under pressure for novices (Moore, Vine, Cooke, Ring, & Wilson, 2012; Vine & Wilson, 2010, 2011) and for experienced performers (Causer et al., 2011; Vine, Moore, & Wilson, 2011; Wood & Wilson, 2011). While quiet eye training requires task-specific knowledge about relevant targets of attention, it might also be possible to train generic functions of working memory to protect performance. Ducrocq and colleagues recently revealed that practicing a computer task designed to train the inhibition function of working memory can improve sport-specific visual attentional control, and subsequent performance, in a high-pressure tennis task (Ducrocq, Wilson, Smith, & Derakshan, 2018; Ducrocq, Wilson, Vine, & Derakshan, 2016).

There are other interventions designed to improve attention in sport, which may also help to mitigate the negative impact of anxiety on performance in targeting tasks (see Moran, 2012). For example, pre-performance routines can help to regulate attentional focus through a sequence of consistent behaviours and thoughts (Cotterill, 2010; Wilson & Richards, 2011). Mental imagery may also improve focus, and has been shown to lessen the impact of competitive pressure on shooting performance (Colin, Nieuwenhuys, Visser, & Oudejans, 2014). Finally, simulation (or habituation) training that replicates key aspects of an impending challenge may also help improve attentional control when anxious. Oudejans and colleagues have demonstrated that training with anxiety can help to improve subsequent performance under pressure in both expert and novice athletes (Oudejans & Pijpers, 2010, 2009) and in police officers (Oudejans, 2008). Importantly, there is early indication that these positive training effects are durable over time (Nieuwenhuys & Oudejans, 2011). While the specific impact on attentional control is less explicit in these interventions, compared to quiet eye training or working memory training, future research is warranted.

## 2.7. Limitations

While this systematic review adopted PRISMA guidelines, the quality assessments commonly used are developed for randomised controlled trials and therefore many items were not applicable to current sport psychology literature. The quality assessment included in this review was adapted from relevant quality assessments (Downs & Black, 1998; Durant, 1994; Genaidy et al., 2007), but there is no overall consensus as to criteria and therefore other researchers may have made different decisions. For example, our decision to exclude studies where target or aiming tasks were not adopted meant that those studies adopting continuous tasks (e.g. flying, Allsop & Gray, 2014; climbing, Nieuwenhuys, Pijpers, Oudejans, & Bakker, 2008; driving, Wilson, Chattington, et al., 2007), which might otherwise have scored highly on the quality assessment criteria, were left out of the current review. However, as the majority of experimental research has used self-paced, non-interactive tasks, it is recommended that the implications discussed (section 2.6.) and conclusions drawn from the systematic review are considered within this context.

## 2.8. Conclusion

The aim of this review was to systematically examine the available evidence with the intent of investigating the key attentional mechanisms (and supporting theory) explaining the anxiety-performance relationship. Overall, the review has established that the most pertinent theoretical accounts of anxiety and sporting performance make reference to attention, even if there is still no shared consensus as to the precise mechanisms, or associated moderating variables. Limitations in the objective measurement of attention and the use of different research designs depending on whether predictions of self-focus or distraction theories were being examined, make comparisons between studies difficult. Future research needs to address these methodological issues, especially if the more complex, contemporary frameworks are to be empirically tested. This research is important if evidence-based interventions and training programmes are to be promoted for athletes seeking to thrive under the pressure of sporting competition.

### 2.9. Future research

Attentional mechanisms play a key role in the anxiety-performance relationship, a statement reinforced by the systematic review. Despite the accumulation of work in this area, a full understanding of the precise attentional mechanisms in the anxiety-performance relationship has been restricted by the lack of consistency in measurement approaches and experimental designs, and a limited opportunity to test the newer predictions. Furthermore, as highlighted in the review there is little to no consideration for differences in individuals' interpretation of pressure, which may play a role in whether an individual becomes anxious and suffers drops in performance. Previous descriptive works have examined the interpretation of anxiety (see Jones, 1995, for an early review) suggesting that it was important to consider whether the intensity of symptoms experienced were interpreted as positive or negative toward upcoming performance. Should an individual feel they're able to cope with the task ahead, facilitative anxiety is likely to occur, however should an individual feel they can’t cope with the task, debilitative anxiety is likely to occur (Jones, 1995).

The facilitative view of anxiety adopted by Jones and colleagues is problematic in that it is somewhat contrary to the definition of anxiety as an aversive state, and may instead reflect a different interpretation of *pressure* (see Burton & Naylor, 1997, for a discussion). ACTS (Eysenck & Wilson, 2016) adopts this view that anxiety will only occur if situational pressure is interpreted in a way that means perceived costs and probability of failure are high. As such, the next study in the thesis will begin to examine moderating variables which may determine how likely it is that an individual will become anxious under pressure, and suffer attention and performance disruptions.

The aim of study 2 was to investigate cognitive biases and specifically whether it is possible to determine which sport performers are more inclined to display biases. ACTS (Eysenck & Wilson, 2016) suggests that the initiation of state anxiety is a result of individuals’ cognitive biases altering the perception of failure. As such, it is important to determine who may be more likely to experience biases in an attempt to inform interventions for individuals struggling to control anxiety symptoms when performing under pressure. Whilst the existence of cognitive biases as an initiator of anxiety is well established within mainstream psychology (Bar-Haim et al., 2007, for a meta-analysis), it has been largely ignored in sport settings.

Researchers *have* considered individual differences in the response to stress in the form of the Biopsychosocial model (BPSM; Blascovich, 2013). The BPSM postulates that challenge and threat states stimulate different physiological and behavioural responses in potentially stressful situations. These specific states are a result of an evaluative process in which situational demands (demand evaluations) are weighed against personal resources (resource evaluations). When resources are perceived to outweigh demands a challenge response occurs, while a threat response occurs when demands are perceived to outweigh resources (Blascovich, 2008). In a similar manner, ACTS postulates that cognitive biases alter individuals' perceptions of failure. If perceived probability and cost of failure is high, anxiety is heightened (Berenbaum, 2010; Berenbaum, Thompson, & Pomerantz, 2007; Eysenck & Wilson, 2016). However, whilst individual differences in the response to stressors have been studied, this individual approach is not really considered in most anxiety-sport performance research. Examining the moderating variables (i.e. cognitive biases) in a sporting context enables researchers to understand the process resulting in individuals becoming anxious initially when performing under pressure.

Consequently, study 2 used methods from social anxiety research in an attempt to test the newly proposed ACTS and uncover individual differences in the experience of anxiety. The study examined differences in sport-specific trait anxiety and attentional control and the resultant influence on cognitive biases. Individuals' trait characteristics are assumed to influence which information they process (Bishop, 2009), therefore it is likely high trait anxious individuals have facilitated detection of threat (Eysenck & Byrne, 1994). Furthermore, the ability to maintain attentional control may mediate difficulties in disengaging attention from threatening stimuli (Eysenck et al., 2007), therefore individuals with good attentional control may be less inclined to process threatening stimuli and suffer performance disruptions. Accordingly, the next experimental study in the thesis examined individuals' sport trait anxiety and attentional control as variables that influence the display of cognitive biases.

## Chapter 3: Sport trait anxiety and cognitive bias in competitive state anxiety

### 3.1. Abstract

There is a large amount of evidence supporting the notion that anxiety is characterised by biases towards threat related stimuli. ACTS suggests that cognitive biases, in the form of attention and interpretive bias, influence state anxiety when performing under pressure (Eysenck & Wilson, 2016). However, an important challenge is to determine the nature of these biases, as a better understanding of these factors informs our understanding of their consequences, mainly increased state anxiety and drops in performance. The aim of the present study was to explore cognitive biases, specifically attention and interpretive bias, to determine whether sport-specific trait anxiety and attentional control inform the experience of these biases. Research has suggested that elevated levels of trait anxiety are likely to influence threat perceptions (Berenbaum, Thompson, & Pomerantz, 2007) and furthermore, attentional control may be the possible mechanism that mediates difficulties in disengaging attention from threat (Eysenck et al., 2007). Individuals appeared to be vigilant towards threat, and sport trait anxiety and attentional control influenced negative and positive interpretations, respectively. These results suggest sport trait anxiety and attentional control play a small causal role in the initiation of cognitive biases, however the results do little to elucidate why individuals become anxious in the first place. Therefore, future research is necessary to consider the role of other performance factors in instigating state anxiety.

### 3.2. Introduction

Given that competitive sport is characterised by high-pressure situations in which individuals are expected to perform at their best, it is unsurprising that researchers and applied psychologists have focused on understanding the effect of anxiety on performance (e.g. Cheng et al., 2009; Eysenck et al., 2007; Nieuwenhuys & Oudejans, 2010, 2017). However, the systematic review (chapter 2) identified a number of gaps within the anxiety-performance literature, including limited experimental examination of newer theoretical predictions. In attempts to consider issues not covered by past theoretical frameworks, these newer theories consider moderating variables that may influence the pressure-performance relationship (see chapter 2, 2.6). In particular, as individuals do not always suffer from performance decrements under pressure (e.g. Otten, 2009) it may be these moderating variables that determine successful or unsuccessful performance.

One such theory is the Attentional Control Theory: Sport (ACTS; Eysenck & Wilson, 2016), which is more explicit about the mechanisms involved in the interpretation of pressure. One aim of the theory is to better understand what initiates state anxiety responses in individuals performing under pressure. ACTS (Eysenck & Wilson, 2016) postulates that when under pressure, cognitive biases determine whether individuals are likely to experience increased anxiety and successful or unsuccessful performance. Cognitive biases have been theorised to play a critical role in the onset and maintenance of anxiety (Bar-Haim et al., 2007; Hallion & Ruscio, 2011) and the most important of these present in the form of attentional and interpretive biases. Attentional bias occurs when an individual attends disproportionately to a threat-related stimulus rather than a neutral one (Bar-Haim et al., 2007) and may cause a performer to pay more attention to threat cues when performing (e.g. difficult challenges ahead, errors they have made, good performance from an opponent). Interpretive bias occurs when an individual interprets an ambiguous situation as threatening (Haller et al., 2016) and may cause a performer to interpret errors as having an impact on how they will perform subsequently. By understanding these cognitive biases we might be able to predict who might choke and under what circumstances.

ACT suggests that it is anxious individuals that have a bias to threat-related stimuli (Eysenck et al., 2007). Beck (1976; Beck, Emery, & Greenberg, 1986) proposed that individuals who are vulnerable to anxiety are characterised by a high level of activation of the cognitive structures (schemata) that are concerned with processing danger-relevant information. According to this view, a processing bias favouring threat stimuli may be a cognitive marker of anxiety vulnerability (i.e. high trait anxiety). Given the prevalent nature of biases in anxiety disorders, it is imaginable that sport trait anxiety would play a role in the occurrence of cognitive biases. Research has suggested that trait characteristics influence information processing (Bishop, 2009) and elevated levels of trait anxiety are likely to influence threat perceptions (Berenbaum, Thompson, & Pomerantz, 2007). Furthermore, there is evidence that high trait anxious individuals exhibit a bias that selectively favours the processing of threat related information (Bar-Haim et al., 2007; Broadbent & Broadbent, 1988; MacLeod & Rutherford, 1992), as well as consistently detect threatening stimuli more rapidly than low trait-anxious individuals (Byrne & Eysenck, 1995).

In a meta-analysis of 33 eye tracking experiments (Armstrong & Olatunji, 2012), anxious individuals initially oriented gaze towards threat more frequently than non-anxious individuals, as revealed by a significant combined effect size for group differences in orienting bias for threat (*g* = .47, $p < .001$). This effect size is consistent with the effect size observed for anxious vs. non-anxious individuals in Bar-Haim et al.'s review (2007) of reaction time measures of attentional bias for threat (*d* = .41). Interestingly, in these two meta-analyses comparing anxious and non-anxious individuals (Armstrong & Olatunji, 2012; Bar-Haim et al., 2007) it has also been found that anxious individuals do not significantly differ from non-anxious individuals in orienting towards pleasant (happy) stimuli (*g* = .11, *p* = .38). Eye movement measures have several advantages over other methods of measuring attentional biases, including being directly observable and ecologically valid (Mogg, Bradley, Field, & De Houwer, 2003). In particular, measurement of first fixations provides a means to examine where anxious individuals may initially attend when faced with threatening stimuli (e.g. Bradley, Mogg, & Millar, 2000; Gamble & Rapee, 2010; Mogg et al., 2003).

Moreover, elevated anxiety vulnerability is associated with a tendency to interpret ambiguous stimuli as threatening (Wilson, MacLeod, Mathews, & Rutherford, 2006) and individuals with higher levels of social anxiety rate negative interpretations of ambiguous social situations as more likely to come to mind than less anxious individuals (Miers, Blöte, Bögels, & Westenberg, 2008). In sport, Oudejans and colleagues have produced some initial research on the effect of pressure on interpretation of action possibilities (see Nieuwenhuys & Oudejans, 2012, 2017). Even when there is no difference in the effective availability of visual information, state anxiety may alter how visual information is interpreted (e.g. Gotardi et al., 2019, driving under pressure; Nieuwenhuys, Cañal-Bruland, & Oudejans, 2012, deciding whether to shoot or not in critical situations; Nieuwenhuys et al., 2008, in a climbing task; Renden, Savelsbergh,

& Oudejans, 2017, police officers decision making during arrest situations) and this interpretive bias may cause individuals to respond based on threat-related inferences instead of task-relevant and objective information. For example, Nieuwenhuys et al. (2008) found that anxious climbers visually scanned the same handholds as when they were not anxious, but chose to grab handholds that were closer to their own body position (with less threat of falling).

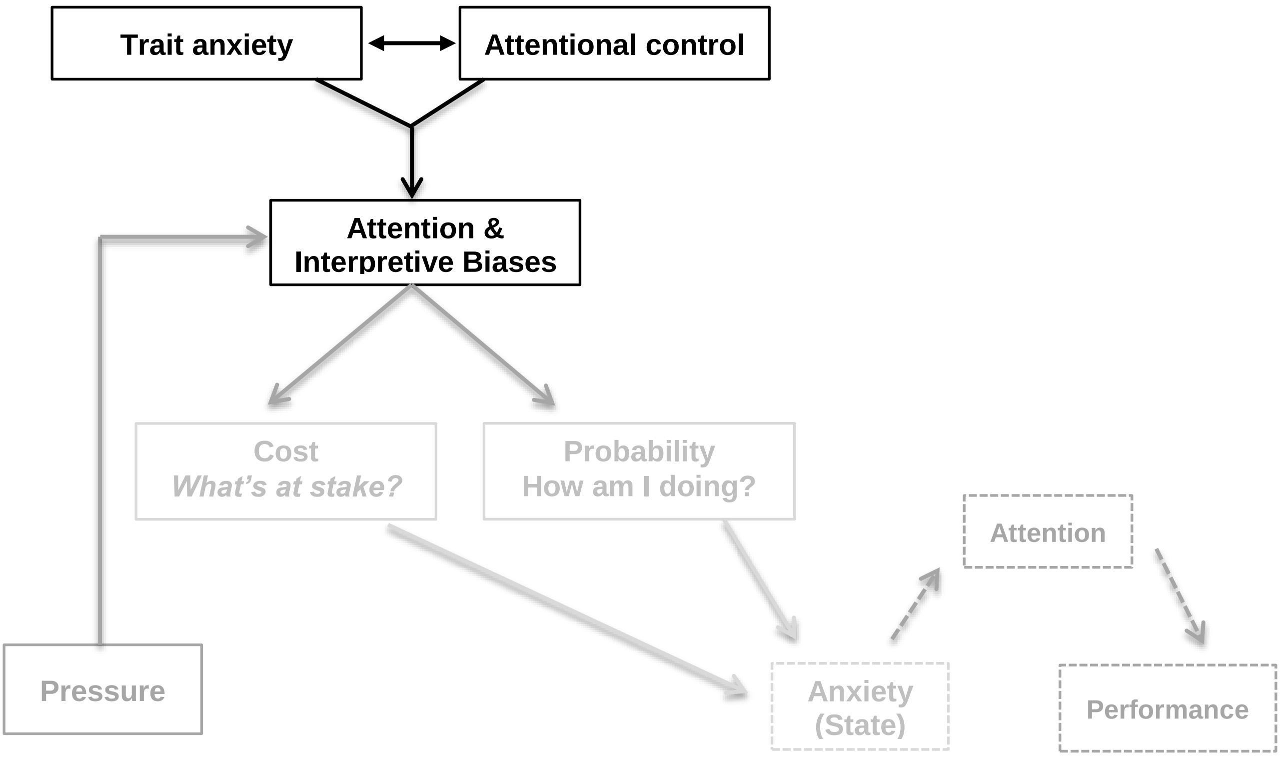


***Figure 3.1.*** *A basic schematic representation of ACTS, including the sport trait anxiety, attentional control and cognitive biases relationship to be examined within this study (black, solid lines). Sport trait anxiety and attentional control are suggested to influence attentional and interpretive biases. Attentional and interpretive bias influence perceived probability and cost of failure, which in turn influences state anxiety (see grey, solid lines). Subsequently, state anxiety will influence performance via attentional mechanisms as outlined originally in ACT (see dashed, grey lines).*

Research using dot probe tasks suggests that anxious individuals are vigilant to threat (see Mogg & Bradley, 1998), however, Derryberry and Reed (2002) have proposed that a facilitated response to threat may also arise from a difficultly to disengage *from* threat, rather than vigilance *to* threat (see also, Fox, Russo, Bowles, & Dutton, 2001; Yiend & Mathews, 2001). Clinical and non-clinical anxiety has been associated with poor attentional control assessed using self-report and imaging methods (e.g. Bishop, Duncan, Brett, & Lawrence, 2004; Derryberry & Reed, 2002). Attentional control may be the possible mechanism that mediates difficulties in disengaging attention from threat (Eysenck et al., 2007). Research has shown that good attentional control allows trait anxious participants to modulate the dominant attentional bias (Derryberry & Reed, 2002; Lonigan & Vasey, 2009; Peers & Lawrence, 2009). In particular, Eldar and Bar-Haim (2010) found that anxious participants that were trained to disengage their attention from threat images displayed increased N2 amplitude (an event related potential component that is associated with increases in attentional control).

There has been less attention given to the role of attentional control in relation to interpretive bias and anxiety (Salemink & Wiers, 2012). A cognitive bias modification study for interpretive bias has indicated that modification training may influence highly socially anxious participants' ability to disengage attention from threat (Amir, Bomyea, & Beard, 2010). Training individuals to interpret information in a positive fashion has also been suggested to partly contribute to symptom improvement and perceptions of attention control, however, the researchers' state further research is still warranted to understand this relationship between attentional control and interpretive bias more thoroughly (Bowler et al., 2012). Additionally, perhaps anxious individuals are able to disengage attention as effectively as non-anxious individuals in certain contexts. However, such disengagement may be less efficient as anxious individuals apply more effort in an attempt to compensate for deficits in attentional control (Berggren & Derakshan, 2013).

Whilst there is support in mainstream research for cognitive biases, this research is focused on anxiety disorders, i.e. individuals who struggle consistently with most stimuli (Bar-Haim et al., 2007; Eysenck, 1992; Mogg & Bradley, 1998). The thesis is more interested in sport performers, and why these otherwise rational individuals who select to play sport and place themselves in ego-threatening situations, sometimes struggle to deal with those scenarios. There is overwhelming evidence in support of the notion that anxiety is characterised by biases towards threat related stimuli (Bar-Haim et al., 2007; Cisler & Koster, 2010). An important challenge is to determine the nature of cognitive biases, as a better understanding of these factors can inform our understanding of their consequences – both ensuing state anxiety and subsequent performance decrements (Eysenck & Wilson, 2016).

With the intention of better understanding what pre-empts experiencing cognitive biases, the aim of the present study was to attempt to determine whether individuals' differences in trait anxiety, specifically sport trait anxiety, and attentional control can be used to determine who is likely to experience cognitive biases in a sport-specific scenario. The extent and impact of cognitive biases is likely to vary for individuals, and for this study we hypothesised that sport trait anxiety and attentional control would predict biases in individuals.

### 3.2.1. Hypotheses

The aim of the current study was to establish whether sport trait anxiety and attentional control are related to attentional bias and interpretive bias. It was hypothesised that sport trait anxiety would significantly predict attentional control.

#### 3.2.1.1. Attentional bias

Research suggests that trait anxious individuals have an attentional bias to threat, therefore it was predicted that 1) sport trait anxiety would significantly predict attentional bias threat scores, 2) attentional control would add to the relationship and sport trait anxiety and attentional control would predict attentional bias threat scores, 3) attentional bias threat scores would indicate an attentional bias *towards* threat.

#### 3.2.1.2. Interpretive bias

It was hypothesised that 1) sport trait anxiety would significantly predict negative interpretations of ambiguous sport scenarios, 2) attentional control would add to the relationship and sport trait anxiety and attentional control would predict negative interpretations, 3) attentional control scores would predict positive interpretations of ambiguous sport scenarios, 4) sport trait anxiety and attentional control would not significantly predict negative, positive and neutral interpretations in non-sport scenarios.

#### 3.2.1.3. Exploratory hypotheses

It has been shown that anxious individuals do not significantly differ from non-anxious individuals in orienting towards pleasant (happy) stimuli (Armstrong & Olatunji, 2012), therefore, the following was explored 1) sport trait anxiety would not predict attentional bias happy scores and 2) attentional bias happy scores would indicate an attentional bias *towards* positive stimuli.

## 3.3. Method

### 3.3.1. Participants

A total of 26 recreationally active or higher level golfers aged between 19-35 yrs (m= 26.6 yrs, SD ± 5.07; 4 females) participated. A required sample size of 26 was calculated using G*power 3.1 software, setting power (1-β err prob.) at .90, alpha (*α* err prob.) at *p* = .05, and using the effect size (*d* = .47) from Koster and colleagues (2004) and (*d* = .67) from Miers and colleagues (2008). Total sample sizes were 32 and 20 respectively, which were averaged to give the required sample size. There is no research, that the author is aware of, examining both attention and interpretive bias, therefore the sample size was calculated using studies examining attention and interpretive bias separately and the mean sample sizes were calculated from each study's required sample size.

All participants had normal or corrected-to-normal vision. Participants were recruited through emails and posters to local and university golf clubs. Informed consent was obtained from all participants prior to participation and a local ethics committee approved the study.

### 3.3.2. Measures

**Sport-Specific Trait Anxiety***.* All participants completed the Sport Anxiety Scale-2 (SAS-2; Smith, Smoll, Cumming, & Grossbard, 2006) prior to the laboratory visit. The SAS-2 is a sport-specific questionnaire that measures individual differences in somatic and cognitive sport trait anxiety in the form of worry and concentration disruption. It comprises of 15 items, answered using four response choices (1 = not at all; 2 = a little bit, 3 = pretty much, 4 = very much), with higher scores indicating high trait (sport) anxiety. In a college sample, alpha coefficients for the somatic, worry and concentration disruption scales were .89, .91 and .84 respectively and the total score alpha was .91 (Smith et al., 2006). The SAS-2 exhibits acceptable internal consistency at both the total score and subscale levels and reliability is similar to that found for the original SAS in older samples (Smith et al., 2006; Smith, Smoll, & Schutz, 1990).

**Attentional Control.** The Attentional Control Scale (ACS; Derryberry & Reed, 2002) is a scale used to assess overall differences in voluntary attentional control. It comprises of 20 items, answered using four response choices (1 = almost never; 2 = sometimes; 3 = often; 4 = always), with higher scores indicating better attentional control. Eleven items were reversed for scoring purposes. The ACS consists of three sub factors related to the abilities to (a) focus attention, (b) shift attention between tasks, and (c) flexibly control thought. The total score of the scale is internally consistent with reliability estimates ranging from $\alpha$ = .71 (Gyurak & Ayduk, 2007) to $\alpha$ = .84 (Ólafsson et al., 2011) and to $\alpha$ = .88 (Derryberry & Reed, 2001).

**Attentional Bias.** The emotional face type dot probe task measured attentional bias and contained 36 face types, in combinations of threat-neutral, happy-neutral and threat-happy. There were 144 trials in total (3 blocks of 48 randomised presentations). The faces were presented in grey scale and positioned against a black background. A trial started with the presentation of a white fixation cross (“+”) for 500ms in the centre of the screen (see Figure 2.2). This was followed by the presentation of two emotional face types centred in the left half and right half of the screen for 500ms. The faces were replaced by a white dot, the dot probe, presented in the centre of either the left or the right half of the screen. Participants were instructed to respond as fast and accurately as possible to the location of the dot probe using the left and right arrow keys once they attended to it. Reaction time data were collected in response to each trial.

Attention bias scores were calculated from a standard formula used in prior research (e.g. Mogg et al., 2000; Roy et al., 2008). For each subject, attention bias scores were calculated for all threat and happy trials. Scores were calculated by subtracting the mean reaction time on trials where the probe replaced the emotional (threat/happy) face stimuli (a congruent trial; see Figure 3.2. below) from the mean reaction time on trials where the probe appeared on the opposite side to the emotional face stimuli (an incongruent trial). Positive values reflect a bias toward the threat/happy relative to the neutral face, whereas negative values reflect a bias away from threat/happy.

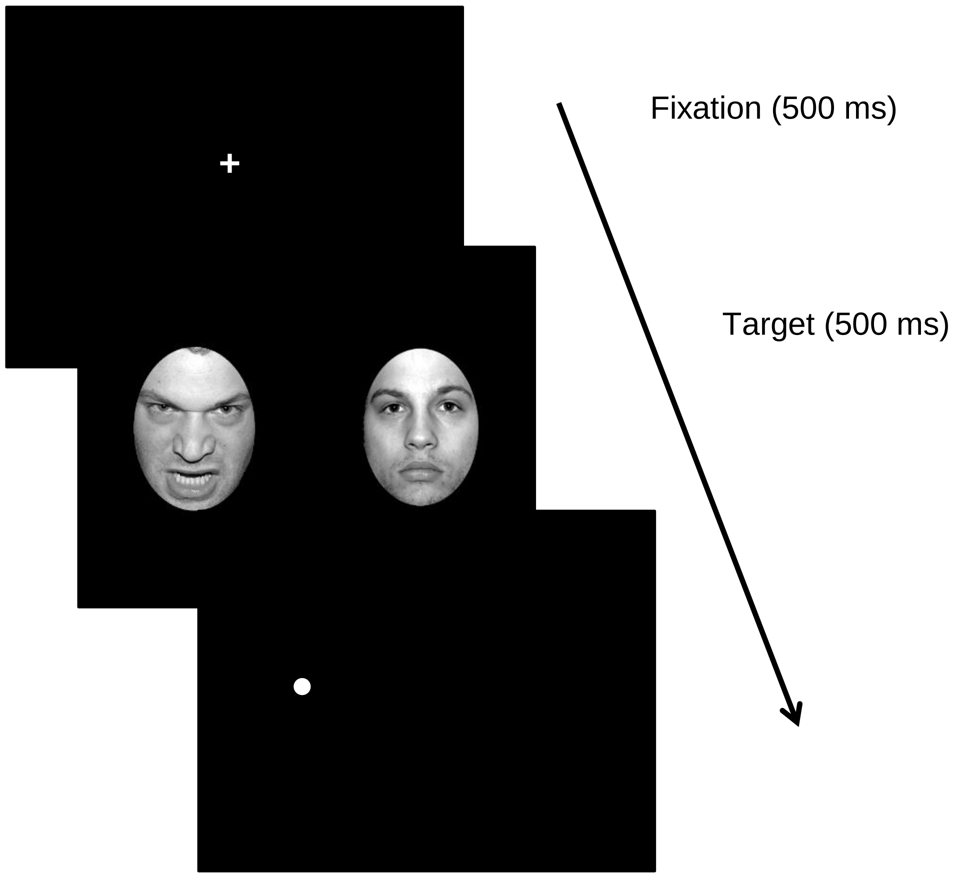

***Figure 3.2.*** *Diagram of the dot-probe task for a congruent-threat trial. Participants are presented with a fixation cross for 500 ms. They are then presented simultaneously with a pair of stimuli, one emotionally salient (e.g. threatening) and one neutral (e.g. non-threatening) for 500 ms. A probe then replaces one of the two stimuli (in this case the threatening stimulus) and the participant is required to respond as accurately and quickly as possible to the probe. An attentional bias towards emotional (threat/happy) stimuli is inferred when participants preferentially attend to emotional cues, resulting in decreased reaction times to probes replacing the emotional stimuli compared to the neutral stimuli.*

**Gaze behaviour.** Each participant was fitted with a Mobile Eye tracker during the dot probe task, which measured the momentary point of gaze at 30 Hz. A *fixation* was defined as a gaze maintained on an object within 1° of visual angle for a minimum of 100 ms (Moore et al., 2012). Attention bias scores were calculated from the eye movement data to create eye movement bias scores (e.g. proportion of fixation frequencies; Bradley et al., 2000; Gamble & Rapee, 2010; Mogg et al., 2003). These bias scores were calculated by taking the number of trials in which the first fixation was on an emotional face (i.e. threat or happy face), and dividing them by the total number of trials with fixations towards an emotional (either threatening or happy) face-type. For example, an eye movement bias score for the threatening face-type was the number of trials when the first fixation was held on a threatening face-type divided by the total number of trials with fixations to threatening face-type and neutral face-type pairs. This score reflects the relative frequency of looking towards the threatening stimuli rather than the neutral stimuli when faced with both. Scores greater than 0.5 indicate an attentional bias for threat or positive stimuli (dependent on the trial type). Proportion of fixation frequencies were assessed in Waechter, Nelson, Wright, Hyatt and Oakman (2014) and they had very good reliability ($\alpha$ = .90).

**Interpretive bias.** The interpretive bias task was loosely based on the Adolescent's Interpretation and Belief Questionnaire (AIBQ; Miers et al., 2008; Stopa & Clark, 2000; Voncken, Bögels, & de Vries, 2003), however, the social ambiguous situations were adapted to sport ambiguous situations to be relevant to situations golfers may be presented with when competing. The AIBQ contains five social and five non-social ambiguous situations. The social scenarios reflect events that may commonly occur at school, such as giving a presentation in front of your class after which no-one asks a question. The non-social scenarios focus on events which do not have an element of social evaluation and which impact upon the protagonist alone, for example, locking up your bike somewhere but then wondering why you cannot find it later on.

For each item respondents are firstly presented with the situation followed by a specific question to address the ambiguity of the scenario. For example, "You've invited a group of classmates to your birthday party, but a few have not yet said if they're coming. Why haven't they said something yet?" Secondly, three interpretations of the situation, positive, negative and neutral are presented individually and respondents are asked to rate, for each statement separately, how likely it is that it would pop up in their mind. Each interpretation is rated on a five-point Likert scale (1 = does not pop up in my mind, 3 = might pop up in my mind and 5 = definitely pops up in my mind).

The vignette for the current task contained five sport-specific and five non-sport specific scenarios. The sport-specific scenarios reflected events that may commonly occur during a golfing competition and were relevant to the varied skill-set of the individuals participating in the study. The non-sport specific scenarios focused on events that were not relevant to sport, or sport performance and did not reflect a sport-specific interpretational bias. The non-sport specific scenarios were included to account for context specificity. A number of studies have found that socially anxious individuals make significantly more negative interpretations of social situations compared to their non-anxious peers, but do not differ in their interpretations of non-social situations (Amir, Foa, & Coles, 1998; Constans, Penn, Ihen, & Hope, 1999; Huppert, Foa, Furr, Filip, & Mathews, 2003; Voncken et al., 2003; Wilson & Rapee, 2005).

For each item participants were firstly presented with the scenario followed by a question to address the situation. For example, “You have a ten foot putt to win a tournament. What are you thinking?” Secondly, three interpretations of the situation, positive, negative and neutral were presented one after the other, in a randomised order. Participants were asked to rate, for each statement separately, how likely it is that it would pop into their mind. Each interpretation was rated on a five-point Likert scale (1=does not pop up in my mind, 3= might pop up in my mind and 5= definitely pops up in my mind). See Appendix 3 for the sport-specific and non-sport specific scenario and their corresponding interpretations.

Positive, negative and neutral interpretation scores for sport-specific and non-sport specific scenarios were calculated by adding scores from each interpretation/scenario combination and dividing by the number of scenarios (five; Miers et al., 2008). This was the first time the AIBQ had been adapted to fit a sporting scenario; therefore there is little evidence to support the use within the sport literature. However, alphas (α) of the negative, positive and neutral subscales across all 10 items were .63, .54 and .49 respectively.

### 3.3.3. Apparatus

An Applied Science Laboratories Mobile Eye tracker (ASL; Bedford, MA) was used to track eye movements and collect gaze data during the dot probe task. The point of gaze (at 30Hz) is calculated from the image of the pupil, in conjunction with the corneal reflection of the infrared light source. The system includes a recording device (a modified DVCR) and a laptop (Dell Inspiron 6400) installed with Eyevision (ASL) recording software. A circular cursor, indicating the location of gaze in a video image of the scene is viewed in real time on the laptop. The DVCR was linked to the laptop via a 10 m cable, and both were situated on a table to the far right of the participant to minimise distraction. The video data were recorded for subsequent off-line analysis.

The dot-probe task was programmed and presented using E-prime version 2.0 (Psychology Software Tools, Inc.). The programme was run on an HP EliteBook Laptop and reaction time data was collected through E-prime software on the computer.

### 3.3.4. Procedure

All participants provided informed consent prior to participation. Participants were initially asked to complete the SAS-2 and the ACS and then invited into the laboratory for testing. The first task consisted of an emotional face type dot probe task and measured individuals' attentional bias. Participants were asked to sit in front of the laptop and to make sure they were comfortable. The height of the laptop and the screen were arranged to be directly in front of the participants face. They were fitted with the eye tracker and instructed to look at the screen throughout the task with as little head movement as possible. The eye tracker was then calibrated by asking the individual to look at the screen and in turn look at 4 crosses placed at each edge of the laptop screen and one in the centre of the screen.

Participants were presented with instructions regarding the task on the computer screen and advised to ask any questions prior to the start of the task. Participants were instructed to press the button (left or right arrow on the laptop keyboard) as quickly as possible, and to be as accurate as possible. Before starting the dot probe task, participants completed 12 practice trials. A combination of emotional face types were presented to the participant and using the left arrow or the right arrow, participants were asked to indicate which side of the screen the dot probe appeared, previously occupied by an emotional face type.

The task involved completion of 3 blocks of 48 trials, with a break in between each block. Once the participant was ready to begin, the eye-tracker calibration was checked and the participant started the next block by pressing enter on the keyboard. Participants' reaction time and gaze data were collected during the task.

Participants were then given a 5 minute break to stand up and move around before completing the interpretive bias task, consisting of 5 sport-specific scenarios and 5 non-sport specific scenarios. Participants were first presented with a sport-specific scenario, beginning with scenario 1 and ending with scenario 5. They were next presented with the positive, negative and neutral interpretations in a randomised order consistent across participants and rated each interpretation based on how likely it was to pop into their mind. This was repeated for the non-sport specific scenarios. Participants were asked to answer as honestly as possible.

Participants were then debriefed, thanked for their time and any questions were addressed.

### 3.3.5. Data Analysis

Multiple linear regression analyses were run to determine main effects between sport trait anxiety and attentional control and attention bias scores and interpretive bias

A linear regression analysis was also run to determine the relationship between sport trait anxiety and attentional control and duration of fixation and number of fixations. Data analysis was conducted using IBM SPSS Statistics for Macintosh, Version 24.0.

## 3.4. Results

Dot-probe trials with incorrect responses were excluded from further analyses (e.g. Koster et al., 2004; Salemink, van den Hout, & Kindt, 2007). Due to functional issues with the eye tracker, two participants' data was unable to be analysed and was therefore, not included in the attentional bias eye movement scores.

### 3.4.1. Trait Anxiety

Sport trait anxiety scores ranged from 19 to 42 (M = 28.65; SD = 6.57) and attentional control scores ranged from 43 to 64 (M = 52.73; SD = 5.56). Sport trait anxiety did not significantly predict attentional control scores ($p = .736$).

### 3.4.2. Attention bias

The correlations between sport trait anxiety, attentional control and attention bias threat and attention bias happy scores (reaction times) are presented in Table 3.1. As can be seen, none of the correlations were statistically significant.

***Table 3.1.*** *Correlations among the variables*

| **Variable** | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1. Sport Trait Anxiety | - | - | - | - |
| 2. Attentional Control | -.308 | - | -.018 | -.222 |
| 3.Attention Bias Threat | .107 | - | - | .011 |
| 4. Attention Bias Happy | .066 | - | - | - |

*Note: *p<. 05, **p<. 001, ***p<. 005*

Sport trait anxiety and attentional control did not significantly predict attention bias threat scores (reaction time), F (2, 23) = .136, *p* = .874. Sport trait anxiety and attentional control accounted for approximately 1.2% of the variance in attention bias threat scores ($R^2$ = .012; $f^2$ = .012). Neither sport trait anxiety (*p* = .612) nor attentional control (*p* = .940) significantly added to the prediction.

Sport trait anxiety and attentional control did not significantly predict attention bias threat scores (eye movement bias), F (2, 23) = .112, *p* = .895. Sport trait anxiety and attentional control accounted for approximately 1.1% of the variance in attention bias threat scores ($R^2$ = .011; $f^2$ = .001). Neither sport trait anxiety (*p* = .827) nor attentional control (*p* = .787) significantly added to the prediction.

Sport trait anxiety and attentional control did not significantly predict attention bias happy scores (reaction time), F (2, 23) = .598, *p* = .558. Sport trait anxiety and attentional control accounted for approximately 4.9% of the variance in attention bias happy scores ($R^2$ = .049; $f^2$ = .052). Neither sport trait anxiety (*p* = .991) nor attentional control (*p* = .307) significantly added to the prediction.

Sport trait anxiety and attentional control did not significantly predict attention bias happy scores (eye movement bias), $F(2, 23) = .622$, $p = .546$. Sport trait anxiety and attentional control accounted for approximately 5.6% of the variance in attention bias happy scores ($R^2 = .056$; $f^2 = .047$). Neither sport trait anxiety ($p = .990$ nor attentional control ($p = .333$) significantly added to the prediction.

However, attention bias threat scores (reaction time) indicated a bias towards threat, and attention bias happy scores (reaction time) indicated a bias away from happy faces (see Figure 3.3.). Eye movement attentional bias scores did not indicate any bias (see Figure 3.4.).

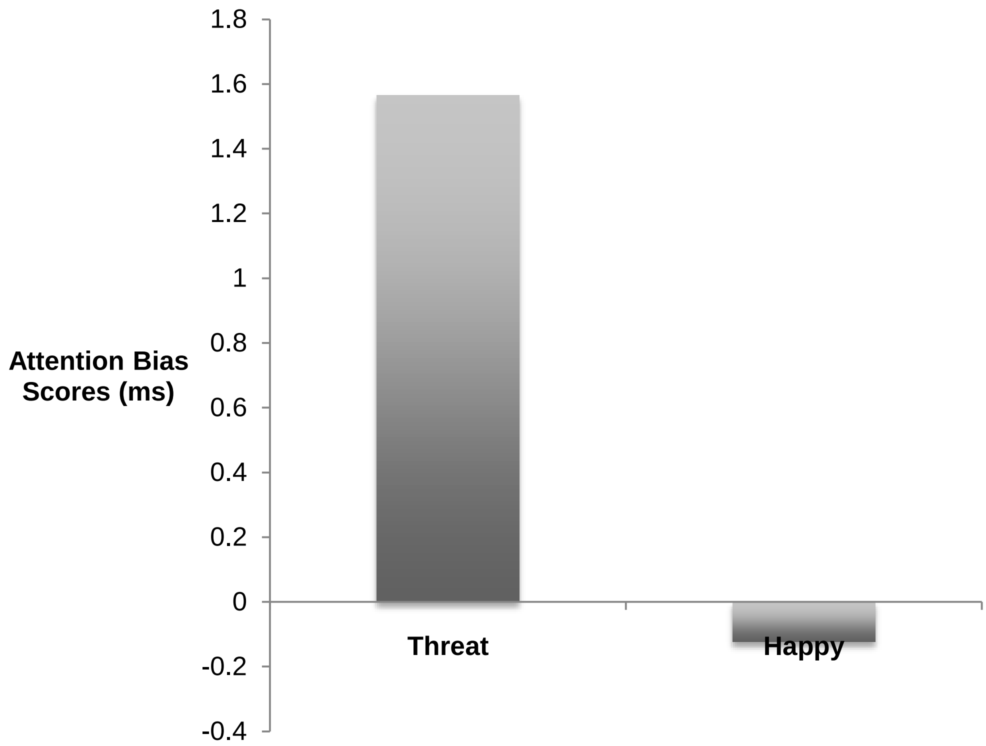


***Figure 3.3.*** *Mean attentional bias scores indicating a bias towards threat on the threat trials (positive score) and a bias away from happy faces on the happy trials (negative score).*

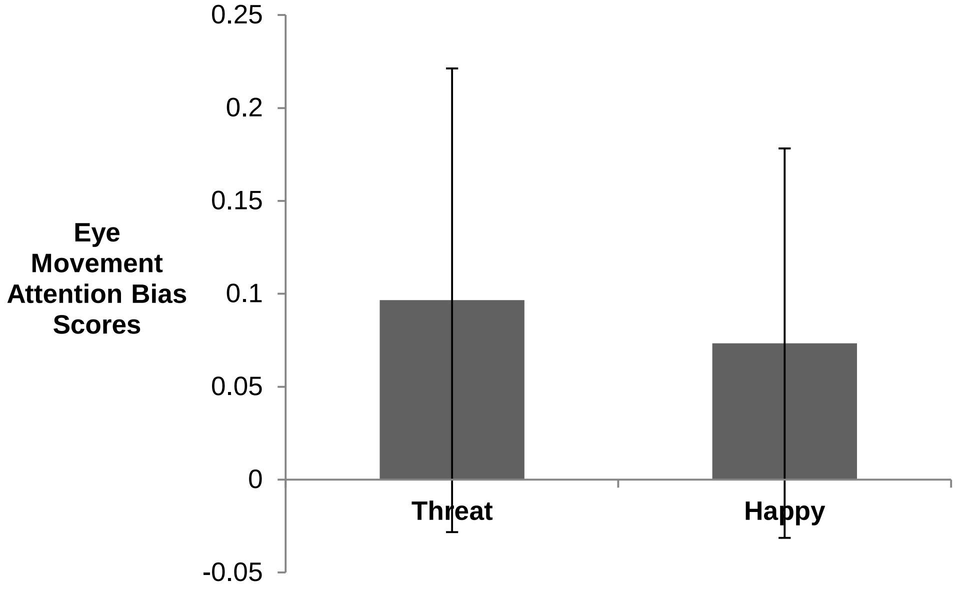


***Figure 3.4.*** *Mean eye movement attentional bias scores indicating no attentional bias on the threat trials or the happy trials (scores must be greater than 0.5 to display a bias).*

### 3.4.3. Interpretive bias

*Negative interpretation scores*

Sport trait anxiety and attentional control significantly predicted negative sport interpretation scores, F (2, 23) = 3.966, $p$ = .033 and accounted for approximately 25.6% of the variance in negative interpretation scores ($R^2$ = .256; $f^2$ = .344). However, only sport trait anxiety added significantly to the prediction, $p$ = .010.

Sport trait anxiety and attentional control accounted for 15.8 % ($R^2$ = .158; $f^2$ = .188) of the variance in negative non-sport interpretation scores, however they did not significantly predict negative non-sport interpretation scores, F (2, 23) = 2.164, $p$ = .138. Similarly, sport trait anxiety ($p$ = .079) and attentional control ($p$ = .148) did not significantly add to the prediction.

***Table 3.2.*** *Regression results for interpretations in sport scenarios*

| **Model** | **NSBeta** | **PSBeta** | **NeuSBeta** |
|---|---|---|---|
| Sport trait anxiety | .063* | -.011 | -.012 |
| Attentional Control | .031 | .043* | -.014 |

*Note: the dependent variable was negative sport interpretations (NSBeta), positive sport interpretations (PSBeta) and neutral sport interpretations (NeuSBeta); * p < .05*

*Positive interpretation scores*

Sport trait anxiety and attentional control significantly predicted positive sport interpretation scores, F (2, 23) = 4.042, *p* = .031 and accounted for approximately 26% of the variance in positive interpretation scores ($R^2$ = .260; $f^2$ = .351). However, only attentional control added significantly to the prediction, *p* = .025.

Sport trait anxiety and attentional control accounted for 9.8% ($R^2$ = .098; $f^2$ = .109) of the variance in positive non-sport interpretation scores, however they did not significantly predict positive non-sport interpretation scores, F (2, 23) = 1.252, *p* = .305. Similarly, sport trait anxiety (*p* = .704) and attentional control (*p* = .128) did not significantly add to the prediction.

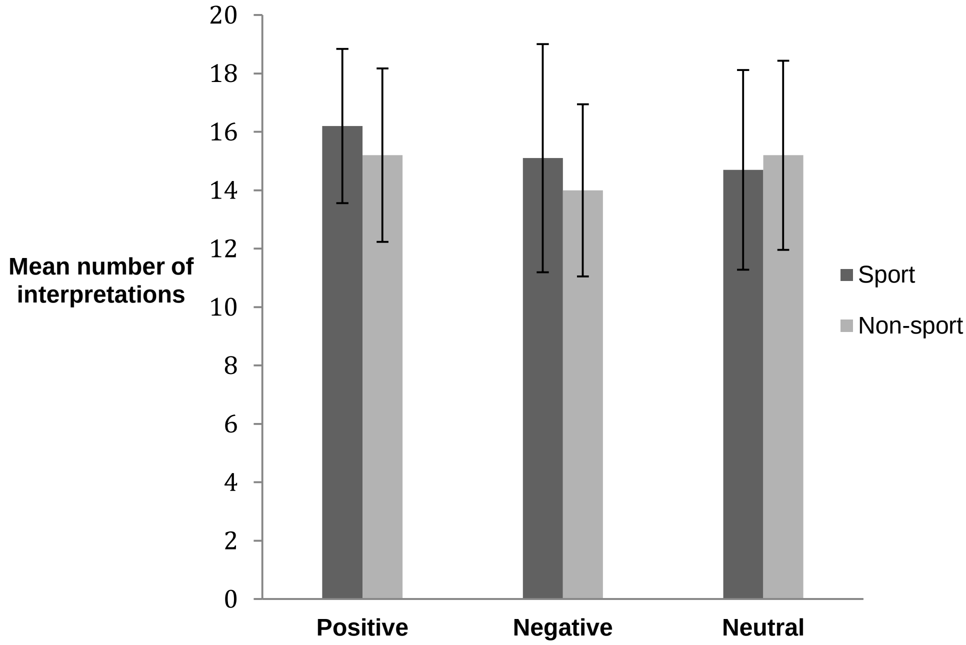


***Figure 3.5.*** *Mean number of interpretations in both sport and non-sport scenarios.*

*Neutral interpretation scores*

Sport trait anxiety and attentional control accounted for 1.9% ($R^2$ = .019; $f^2$ = .019) of the variance in neutral sport interpretation scores, however they did not significantly predict neutral sport interpretation scores, F (2, 23) = .225, *p* = .800. Similarly, sport trait anxiety (*p* = .591) and attentional control (*p* = .594) did not significantly add to the prediction.

Sport trait anxiety and attentional control significantly predicted neutral non-sport interpretation scores, F (2, 23) = 5.099, *p* = .015 and accounted for approximately 30.7% of the variance in neutral non-sport interpretation scores ($R^2$ = .307; $f^2$ = .443). However, only sport trait anxiety added significantly to the prediction, *p* = .005.

## 3.5. Discussion

The study sought to examine the relationship between sport trait anxiety, attentional control and cognitive biases with the intention of furthering our understanding of the reasons why individuals might interpret sporting pressurised situations differently. Cognitive biases are predicted to influence state anxiety by altering the perception of costs and probability of failure (Eysenck & Wilson, 2016). It is important to understand what pre-empts cognitive biases as the extent and impact of these biases varies among individuals and, as suggested by ACTS, biases are the initial variables in the process which instigates the anxiety response and subsequently results in impaired performance. As such, the aim of this study in the thesis was to investigate whether sport trait anxiety and attentional control were factors in determining whether an individual exhibits attention or interpretive biases.

### 3.5.1. Attention Bias

It was hypothesised that sport trait anxiety would significantly predict attentional bias threat scores. Further, it was suggested as an exploratory hypothesis that sport trait anxiety would not predict attentional bias happy scores. The findings suggest that sport trait anxiety does not predict attentional bias scores for threatening or happy images. It is possible that the dot-probe task is not the most appropriate way to explore attentional biases in sport. First, it is a relatively conservative test of whether or not a given stimulus is actually capturing attention (Driver et al., 1999). Second, the task is not situation (sport)-specific, and while angry faces are particularly pertinent for humans (Bradley et al., 2000), anxious individuals have been shown to orient gaze specifically to symptom-related threat as opposed to more generally threatening stimuli (Armstrong & Olatunji, 2012).

Third, findings in the mainstream psychology literature have also been equivocal. Not only do some trait anxious individuals not reveal an attentional bias (Kadosh et al., 2018; Mogg, Bradley, De Bono, & Painter, 1997; Mogg et al., 2000), but bias is sometimes only uncovered under stressful rather than neutral conditions (MacLeod & Mathews, 1988; Mogg, Mathews, Bird, & Macgregor-Morris, 1990). Indeed, it has been suggested that attentional bias is determined interactively by trait and state anxiety (Broadbent & Broadbent, 1988; Farrin, Hull, Unwin, Wykes, & David, 2003; Fox, 1993; Rusting, 1999) and it may be likely that the effects of trait anxiety on the detection of threat may be greater when an anxious state has been induced. Therefore, taking these findings into consideration, in chapter 5 of the thesis where attentional bias is also measured, a high pressure condition was also implemented to determine whether a bias to threat was present and influenced the experience of state anxiety.

However, findings did support the hypothesis that attentional bias threat scores would indicate an attentional bias *towards* threat stimuli on threat trials, yet they did not support the exploratory hypothesis that attentional bias happy scores would indicate a bias *towards* happy stimuli. Instead, finding that attentional bias happy scores indicate a bias *away* from happy stimuli on happy trials (see Figure 3.3.). Research has suggested that observable characteristics of attentional bias include facilitated attention to threat and difficulty in disengagement (Cisler, Bacon, & Williams, 2009; Fox et al., 2001; Fox, Russo, & Dutton, 2002; Koster et al., 2004; Koster, Crombez, Verschuere, & De Houwer, 2006; Mogg, Philippot, & Bradley, 2004). Furthermore, findings from trials with happy stimuli supports the possibility of an attentional bias to threat and suggests participants could experience anxiety symptoms due to their inclination to avoid positive or happy stimuli. However, a clear distinction between preferential attention and failure to disengage attention is difficult to determine in the dot probe paradigm (Fox et al., 2001).

Additionally, the eye movement bias scores do not support the reaction time attentional bias scores or the hypotheses, as there was no evidence of a bias towards or away from threatening or positive stimuli (see Figure 3.4.). These findings are surprising, as it would be expected that a) trait anxiety would predict eye movement attention bias scores and b) there would be evidence of a bias towards threat as anxious individuals orient gaze towards threat more frequently (Armstrong & Olatunji, 2012) and maintain gaze on threatening distractors for longer (Mogg & Bradley, 2005). There may be limitations with using a mobile eye tracker, capturing data at 30 Hz, as opposed to the 200Hz-1000Hz eye trackers that are typically used in cognitive psychology laboratories. We were not able to measure the timing and direction of the first eye movement (saccade) towards the target in as sensitive a way and instead relied on the timing of the first fixation on the target. Additionally, the assessment of eye movements does not take into account covert shifts of attention, which may be important in the dot probe task. For example, Bradley et al. (2000) reported that more than half of their participants made eye movements on less than 10% of all trials.

It was also hypothesised that sport trait anxiety would significantly predict attentional control. The findings from the present study did not support this hypothesis and these results are inconsistent with findings linking high trait anxiety to impoverished attentional control (Derryberry & Reed, 2002). Derryberry and Reed (2002) demonstrated that attentional biases for threatening locations were predicted by high levels of trait anxiety and low levels of attentional control. The lack of findings is surprising considering the plethora of theories, as discussed in the systematic review (chapter 2), suggesting anxiety disrupts attentional control.

Furthermore, the findings in this chapter contrast to basic assumptions of ACT (Eysenck et al., 2007) that cognitive anxiety impairs cognitive control capacity by eroding the efficiency of executive functions. Perhaps, because the SAS-2 is a measure of sport trait anxiety, as opposed to general trait anxiety (i.e. an anxiety disorder), there is no relationship between sport trait anxiety and attentional control as appears to be demonstrated here. Additionally, findings could simply be because participants' sport trait anxiety scores were not high enough (M = 28.65; range 19-42) to find a significant relationship between sport trait anxiety and attentional control. Previous research has examined the subscales of the SAS-2, in two conditions (i.e. depletion and non-depletion of self-control strength, Englert & Bertrams, 2012), making comparisons between the present study and existing research difficult. Further, it is unclear what is deemed as a high sport trait anxiety level across the research. However, O'Rourke, Smith, Smoll and Cumming (2011) collected SAS-2 average scores at 3 time points (29.46, 29.23 and 29.08), while Smoll, Smith and Cumming (2007) found mean SAS-2 scores in a control group to be 24.12, preseason and 27.01, late season, suggesting the average score in the present study was not unusual when compared to other research measuring sport trait anxiety in athletes. Although it is important to note that sport trait anxiety was measured pre- and post-interventions, unlike in the present study.

Findings also suggest attentional control does not predict attentional bias scores, and does not support the hypothesis in the present study. Past research indicates that the combination of high trait anxiety and low attentional control is associated with difficulty in ignoring threat related information (Reinholdt-Dunne, Mogg, & Bradley, 2009). However, similar to the sport trait anxiety findings in this study, it may be that emotional regulation deficiencies cause attentional biases (Derryberry & Reed, 2002; Koster et al., 2004) yet as participants were not under pressure conditions we are unable to support these findings. Research examining attentional control and attentional bias in children has also found that attentional control did not moderate the relations between attentional biases and symptoms of anxiety, although attentional control was negatively associated with anxiety symptoms (Helzer, Connor-Smith, & Reed, 2009).

In addition, the attentional control findings do not support research suggesting that attentional control allows trait anxious individuals to modulate attentional bias (Derryberry & Reed, 2002). Perhaps attentional control is a possible mechanism mediating difficulties in disengaging attention from threat (Eysenck et al., 2007) solely following an increase in state anxiety, i.e. at the anxiety-attention-performance level as proposed in ACT (Eysenck et al., 2007 see Figure 3.1, grey, dashed lines), as opposed to a predictor of cognitive biases. This has been supported in research with children with a low capacity to regulate attention; attentional biases for angry faces were significantly related with state anxiety (Susa, Pitică, Benga, & Miclea, 2012). However, it is important to note the findings above are in child populations and caution should be taken when comparing these findings to findings in the present study.

### 3.5.2. Interpretive bias

Sport trait anxiety influenced negative interpretations, however attentional control did not add to the prediction. Participants were asked to indicate which negative, positive or neutral interpretation they were likely to think of when presented with an ambiguous situation. The findings in the chapter suggest that sport trait anxious participants were likely to have a negative interpretive bias, however attentional control did not influence this bias. These findings support previous research suggesting no moderating role of regulatory control (attentional control) has been observed for the influence of trait anxiety on interpretive bias (Salemink & Wiers, 2012). The sport trait anxiety and negative interpretation findings are similar to a number of studies conducted in the social anxiety literature, whereby socially anxious individuals have been found to make significantly more negative interpretations of social situations compared to their non-anxious peers (Amir et al., 1998; Constans et al., 1999; Huppert et al., 2003; Voncken et al., 2003; Wilson & Rapee, 2005). Furthermore, both clinically anxious and high trait anxious individuals have been found to show threat-related interpretive biases, although in the latter case manipulations are often used to elevate state anxiety prior to task performance. Therefore, it is possible that a combination of high trait and high state anxiety might increase the likelihood of interpretative biases, which may explain why only a small percentage of variance in the negative interpretation scores could be explained by trait anxiety (21.4%).

The lack of findings regarding positive and negative non-sport scenarios suggests that sport trait anxious individuals do not have a bias in general and that biases are content-specific to sport scenarios (Amir et al., 1998; Constans et al., 1999; Stopa & Clark, 2000; Voncken et al., 2003). Furthermore, these findings support the hypothesis that sport trait anxiety and attentional control would not significantly predict negative, positive and neutral interpretations in non-sport scenarios. However, while there was no relationship between neutral interpretations and sport trait anxiety in sporting scenarios, there was in the non-sport scenarios. This relationship suggested that high sport trait anxious individuals are likely to make more neutral (non-sport) interpretations as sport trait anxiety increases. Perhaps the neutral scenarios were not in fact that neutral. Alphas (α) showed scale reliability of .49, suggesting the items are not a closely related set and may not be measuring the same underlying construct. However, on running a Cronbach's alpha test on each of the scales, the values presented were an item be deleted from the interpretive bias questionnaire did not lead to a large improvement in the value. As such, it may be that the test length is too short, therefore reducing the value of the alpha (Streiner, 2003). All alphas for the scales were lower than the recommended value .90 (.63, .54 for the negative and positive scales respectively; Streiner, 2003).

Attentional control scores, but not sport trait anxiety, were shown to lead to positive interpretation scores in sport specific scenarios and this finding supports the hypothesis that attentional control scores would predict positive interpretations of ambiguous sport scenarios. Furthermore, positive interpretations were made most often (see Figure 3.5). These findings may indicate the ability of individuals with good attentional control to control their attention towards positive interpretations and prevent orienting towards threatening stimuli in sporting scenarios. However, as there was no relationship between sport trait anxiety and attentional control it is difficult to suggest that good attentional control enables sport trait anxious individuals to control attention bias to threat.

Furthermore, there is limited research examining interpretive bias and attentional control, with the majority examining attention bias and attentional control for obvious reasons (Bishop, 2007; Derryberry & Reed, 2002). An exception is Salemink and Wiers (2012) who demonstrated that regulatory control (i.e. attentional control) moderated the degree to which state anxiety was associated with a threat-related interpretive bias. In particular, individuals with high levels of state anxiety and low levels of regulatory control had stronger tendencies to interpret ambiguity in a threat-related way. However, regulatory control did not moderate the relationship between trait anxiety and interpretive bias. As such, it is necessary for future research to examine the role of biases and state anxiety, as there appears to be a link between state anxiety and interpretive and attentional bias.

Furthermore, regarding the role of interpretation bias in sport trait anxiety, do the findings obtained with written material generalize to more ecologically valid material such as videos of sport scenarios? A methodology relying on written material (e.g., threat-related and neutral words or sentences) has inherent limitations because of its restricted ecological validity in representing threat situations in sport (Thorpe & Salkovskis, 1997; Veljaca & Rapee, 1998).

Although a number of our hypotheses were not supported, it is important to consider some of the implications from the study. Recent studies have illustrated that interpretation bias in social phobia is related to treatment changes, whereby individuals assessed following behaviour group therapy did not differ from normal control subjects when reporting social anxiety symptoms (Franklin, Huppert, Langner, Leiberg, & Foa, 2005). Wilson and Rapee (2005) also demonstrated treatment was associated with decreased interpretation bias 3 months after treatment concluded. Additionally, training anxious individuals to interpret information in a positive fashion partly contributes to symptom improvement in a cognitive bias modification–interpretation training (CBM-I; Bowler et al., 2012). Furthermore, through modifying patterns of attention to threat (attention toward threat and attention away from threat), MacLeod, Rutherford, Campbell, Ebsworthy and Holker (2002) found that the two attention groups developed differentially biased attention responses in accordance with the assigned threat-target contingency. Both groups responded with an elevation in state anxiety, however, this elevation was greater in those manipulated to attend to threat. These findings suggest, although we may not know the exact causes behind cognitive biases, interventions to reduce and modify biases, may influence state anxiety and improve behavioural outcomes.

### 3.6. Conclusion

The current study is the first to examine the role of cognitive processes as a component of ACTS. Whilst it is clear individuals appear to be vigilant towards threat and there is some element of a relationship between sport trait anxiety and negative interpretations, and attentional control and positive interpretations, this does little to elucidate why individuals become anxious in the first place – one of the main considerations of ACTS. As such, it may be necessary for future research to consider the role of performance in instigating state anxiety, in particular performance failure as suggested by ACTS. To be more specific, ACTS postulates that cognitive biases alter perceived probability and perceived cost of failure. We are able to be more precise and sport-relevant in our measurement of the perception of failure, therefore, perhaps an investigation into these variables may shed more light on the specific predictions of ACTS.

### 3.7. Future research

The aim of this chapter was to examine the cognitive bias component of ACTS and determine what pre-empts cognitive biases on an individual basis. Whilst it appears trait characteristics play a role in the cause of biases, particularly interpretive biases, previous research findings appear to suggest perhaps the interaction of trait and state anxiety is more relevant as a cause of cognitive biases. Furthermore, and as concluded above, it may be more important to consider the influence of interpretations of performance failure on state anxiety and in particular the perceptions of probability and cost of failure in the initiation of state anxiety. It is likely that cognitive biases may moderate the perceived nature and experience of the competitive environment, specifically influencing perceptions of failure and initiating state anxiety. Subsequently, the aim of chapter 4 is to examine these predictions from ACTS and build upon the tentative findings from chapter 3. Specifically, chapter 4 will examine the perception of failure, through perceived probability and perceived cost of failure in sportspersons, and whether these variables, as well as the interaction between the two, influences state anxiety.

# Chapter 4: Antecedents of competitive state anxiety: the role of perceived probability and cost of failure

## 4.1. Abstract

ACTS suggests that the perceived probability and perceived cost of failure associated with performance leads to increased state anxiety. The present study aims to examine this central tenet of ACTS. A sample of 94 undergraduate students described five undesirable outcomes they thought about most often when competing and indicated how likely they thought the outcomes were to occur and should they occur, how upset they would be by them. Perceived probability was significantly associated with state anxiety and the interaction of perceived probability and perceived cost contributed greatly to state anxiety levels. The importance of perceived threat for understanding anxiety when performing under pressure is discussed.

## 4.2. Introduction

Pressure has been linked to the ego-threatening nature of the competitive sporting environment (Wilson, 2012). High levels of pressure are likely to induce anxiety, the subjective evaluation of a situation with regard to one's self-esteem (Eysenck, 1992). There is an emerging consensus that high levels of cognitive state anxiety induce changes in attention that make it more difficult to focus on task-relevant information, which in turn often causes degraded performance (chapter 2; Eysenck & Wilson, 2016; Nieuwenhuys & Oudejans, 2012, 2017). However, despite the majority of competitive anxiety research in sport focusing on these negative influences of anxiety on performance (Roberts et al., 2017), individuals sometimes do perform better under pressure (Otten, 2009; Swann et al., 2017). Indeed, this may be as a result of individual differences in the interpretation of pressure (Nieuwenhuys & Oudejans, 2012), such as the appraisal of situational demands and the probability of success (Berenbaum, Thompson, & Pomerantz, 2007).

As previously mentioned in the thesis, ACTS is more concerned with how and why individuals become anxious in competitive environments in the first instance, as this may explain why some individuals choke and others are clutch. In other words, if someone does not become anxious, they should not experience the impaired attentional control and degraded performance associated with this emotion. ACTS suggests that cognitive biases underpin our experience of pressure and determine whether we become state anxious (Eysenck & Wilson, 2016). Chapter 3 examined attentional and interpretive biases, and whether sport trait anxiety and attentional control were factors which could be used to determine whether an individual is likely to display cognitive biases in the first instance. The findings demonstrated that sport trait anxious individuals are more likely to experience negative interpretive biases and are more vigilant to threat, whilst attentional control is linked to positive interpretive bias.

However, ACTS also suggests a bi-directional relationship exists between pressure and performance, based on feedback loops relating to current performance and future desired performance (Eysenck & Wilson, 2016). Previous performance failure can increase the pressure on subsequent performance attempts (see Figure 4.1) and indeed, research by Nicholls et al. (2005) in elite golfers revealed the most common stressor during competition was physical errors (29.5%). As such, whilst trait characteristics play a role in determining whether cognitive biases, and in turn anxiety is experienced, the interpretation of performance failure will also play a part. ACTS adopts

Berenbaum’s two-phase model of worry to explain the relationship between the perception of failure and state anxiety.

Berenbaum’s two-phase model of worry suggests that anxiety (and its cognitive component worry) are influenced by the perceived *probability* and perceived *costs* of future undesirable outcomes (Berenbaum, 2010; Berenbaum, Thompson, & Pomerantz, 2007). In sporting contexts, perceived failure is an undesirable outcome, and the costs of failure are greater when the individual perceives that more is at stake, such as during a high-pressure moment in a competition. The perceived probability of losing is likely to increase as a function of the number of failure experiences during a match or competition and as a result of interpretive bias. Therefore, the occurrence of mental and physical performance errors are factors that can influence the perceived probability of failure.

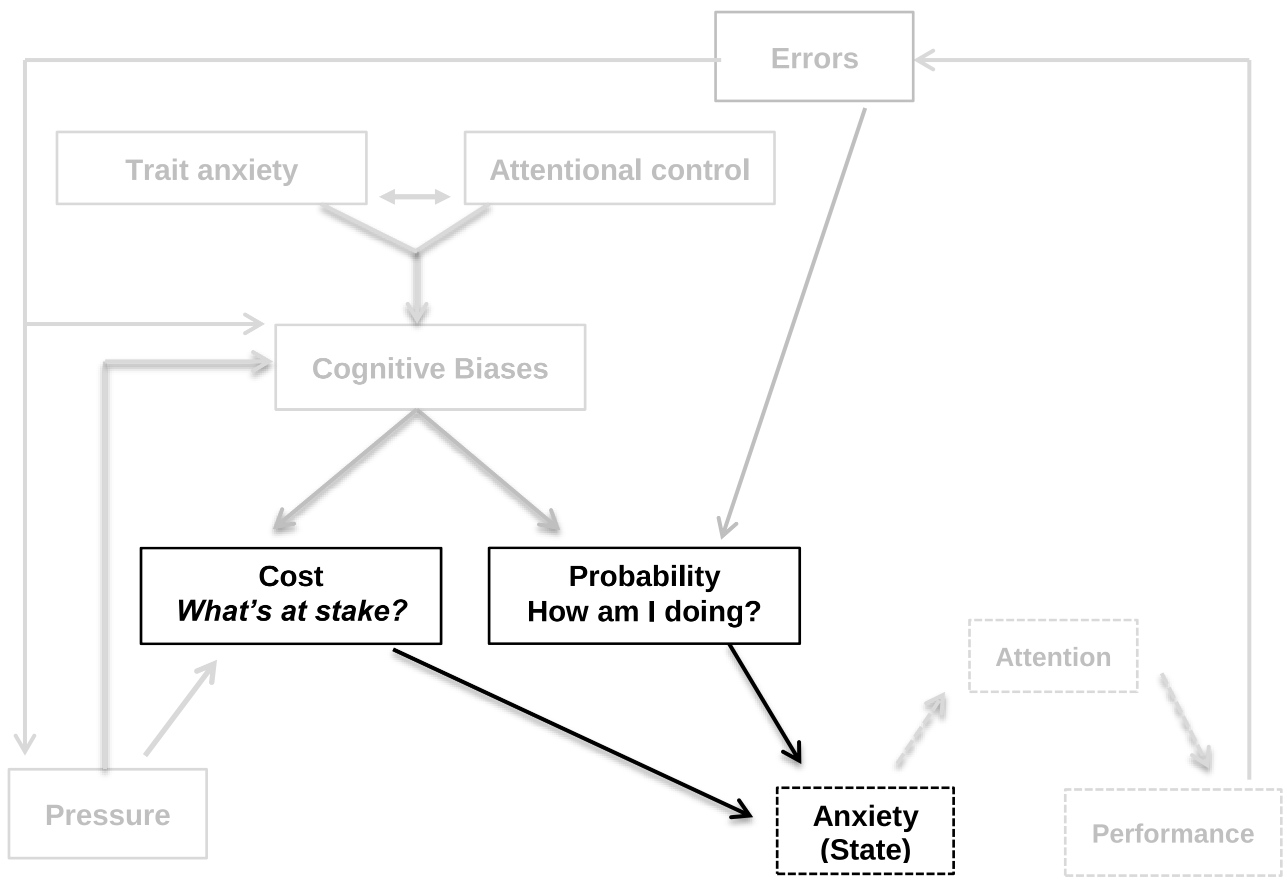

***Figure 4.1.*** *A schematic representation of the pressure-performance relationship, as proposed in the Attentional Control Theory: Sport (ACTS). Trait anxiety and attentional control influence cognitive biases (as tested in chapter 3), which in turn influence the perceived probability of failure ("How am I doing?"), as do errors on previous performance attempts. Biases also influence the perceived cost of failure ("What's at stake?"), which is also influenced by the environmental pressure inherent in the situation. Together, it is predicted that these combine to influence anxiety (see black text for relationship explored in the current study), which will influence performance via attentional mechanisms as outlined originally in ACT (see grey, dashed lines).*

Previous research has shown that individuals who believe undesirable outcomes are more likely to occur, and believe the outcomes will be more costly, tend to have higher levels of worry than do individuals who believe that undesirable outcomes are less likely to occur (Berenbaum, Thompson, & Bredemeier, 2007; Butler & Mathews, 1983). Additionally, the interaction of probability and cost estimates has been found to significantly predict worry above and beyond the direct effects of each (Berenbaum, Thompson, & Pomerantz, 2007). Consequently, the aim of the present study was to examine the role of these perceptions on the experience of competitive anxiety in a sporting context, and as such provide the first test of one of the central predictions of ACTS.

To examine perceived probability and cost, Berenbaum, Thompson and Pomerantz (2007) asked participants to generate a list of five undesirable outcomes they thought about most often (with reference to social anxiety). In contrast, Berenbaum, Thompson and Bredemeier (2007) provided the undesirable outcomes (39 outcomes) for participants and asked how likely the undesirable outcomes were to occur and how bad it would be if they did occur. In the present study, individuals were asked to report (1) undesirable outcomes they often worry about during performance, (2) how probable these outcomes are to occur, and (3) how costly the outcomes would be should they occur. This methodology was based on the research by Berenbaum, Thompson and Pomerantz (2007), who asked participants to *describe* the five undesirable outcomes that they thought about most often, indicate how likely they thought the outcomes were, and how upset they would be by them. The researchers found that perceived probability and perceived cost of undesirable outcomes predicted worry (cognitive anxiety), and that the interaction of between perceived probability and perceived cost predicted worrying above and beyond their independent contributions.

To summarise, the present research focused on perceptions of failure. Based on the predictions of ACTS and previous work by Berenbaum and colleagues it was hypothesised that 1) perceived probability of undesirable outcomes occurring would predict state anxiety scores, 2) perceived cost of undesirable outcomes should they occur would predict state anxiety scores and 3) the interaction of perceived probability and perceived cost would predict state anxiety above and beyond the separate probability and cost estimates.

## 4.3. Methods

### 4.3.1. Participants

A minimum number sample size of 47 was calculated using G*power 3.1 software, setting power (1-β err prob.) at .95, alpha (*α* err prob.) at $p$ = .05, and using the effect size ($f^2$ = .2400794) from Berenbaum, Thompson and Pomerantz (2007). Originally, 136 undergraduate students consented to participate in the study; however, due to incomplete data sets 42 participants were excluded. 94 undergraduate students (37 female, 2 unknown), ranging in age from 18-31 years (M = 19.8; SD = 2.1), participated in the study. Increasing the sample size provides greater power to detect differences and therefore the sample size was doubled. Furthermore, for a small effect size the sample size needed to detect this needs to be larger (Cunningham & McCrum-Gardner, 2007).

Participants were involved in 29 different sports, at either a recreational or higher level (see Figure 4.2). Participants provided written informed consent and the local ethics committee approved the study before testing began.

### 4.3.2. Measures

**Perceived probability and cost.** Participants were asked to describe the content of their worries during sporting competition. Aligned with the design from Berenbaum, Thompson and Pomerantz (2007), participants were provided with the following instructions: “People often think about things they don’t want to happen to them during competition. Some examples of these undesirable outcomes are ‘*this one is not going in either*’ or ‘*I’m not going to be able to win this*’.

Think about the things that generally worry you when competing in *your* sport. In the five boxes below we would like you to list the five undesirable outcomes you think about most often.” In addition, for each of the outcomes they listed, participants were asked to indicate how probable they thought it was that they would actually happen (1 = extremely unlikely; 7 = extremely likely). They were also asked to indicate how upset they would feel if the outcome actually happened (1 = not at all upset; 7 = extremely upset). The five likelihood scores were averaged to form a single perceived probability score, and the five “upset” scores were averaged to form a single perceived cost score.

The statements of worries were collated and separated into categories (see Table 4.3.) with the number of statements and the percentage calculated to determine the most frequent worries participants think about during competition.

Participants were encouraged to consider undesirable outcomes they think about most often whilst competing, as opposed to in a social scenario like in Berenbaum, Thompson and Pomerantz (2007). The current study is the first to attempt to use a similar methodology in a sporting context; however, utilisation of this approach allows researchers to explore potential antecedents of state anxiety and the perception of threat when competing.

**State anxiety***.* The state version of the State-Trait Anxiety Inventory (STAI; Spielberger et al., 1970) was used to measure state anxiety. Perceived probability and perceived cost are suggested to influence the experience of state anxiety, therefore, the SAS-2 (Smith et al., 2006), a trait measure of anxiety, was changed to the state version of the STAI. It consists of 20 statements which participants respond to on a 4-point Likert scale ranging from 1 = *almost never* to 4 = *almost always*. The trait scale of the STAI was not used in the present study, as participants did not satisfactorily complete the trait scale of the STAI during their laboratory visit and the results could not be used.

The state scale was developed as a uni-dimensional measure and scores increase in situations characterised by physical or psychological stress. Internal consistencies for the state scale scores ranged from .83 to .92 for male and female high school college students in the STAI manual (Spielberger et al., 1970). As expected with a characteristic that is state dependent, stability reliability was found to be lower for scores on the state scale (average r = .70; Barnes, Harp, & Jung, 2002). In addition, the STAI state has shown to differentiate between participants in highly stressful situations (e.g. military recruits) and control samples (e.g. student samples; Spielberger, 1983).

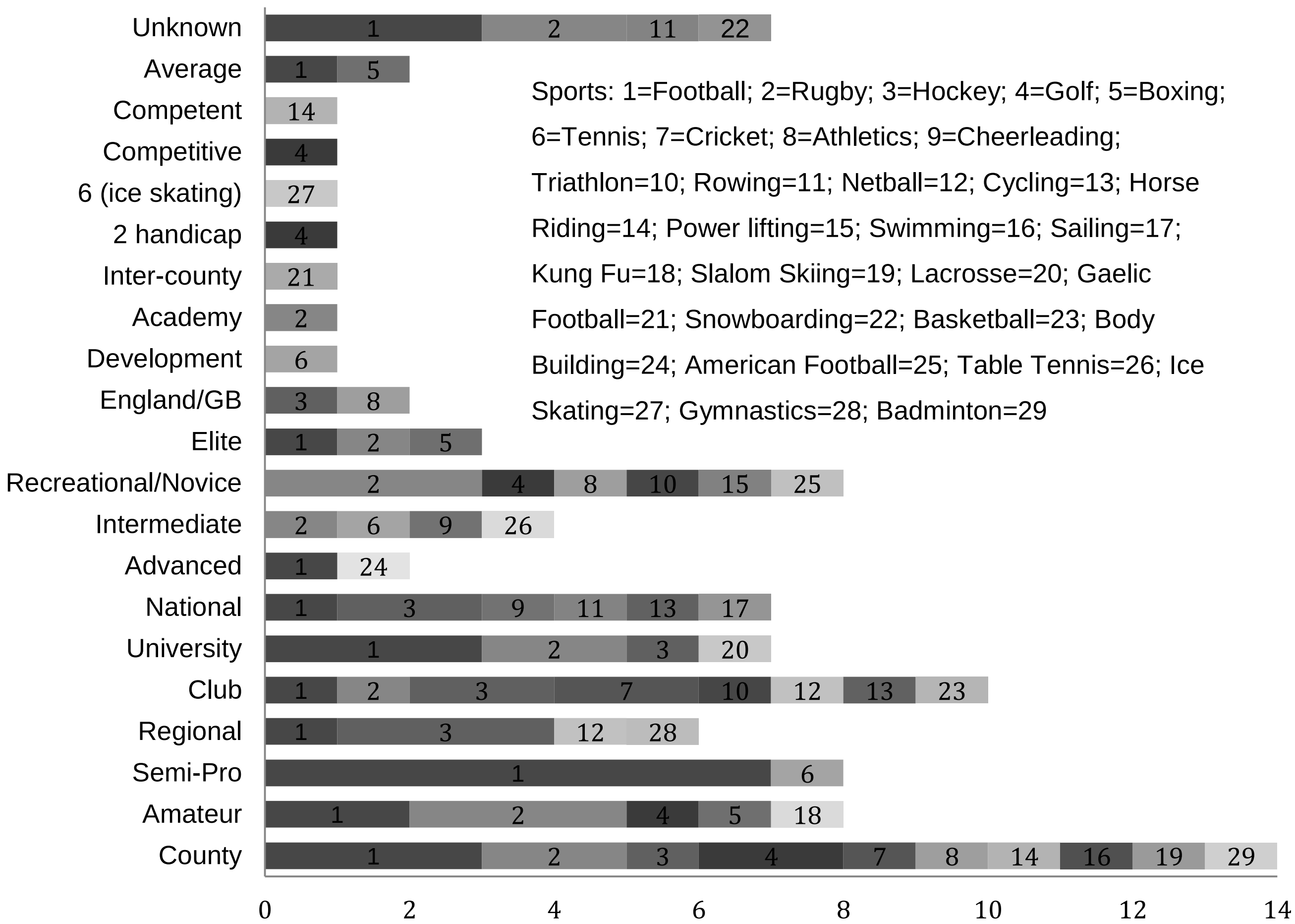


***Figure 4.2.*** *Number of participants playing different types of sports and the level at which each sport was played at, e.g. 3 individuals played football (1) at county level.*

### 4.3.3. Procedure

Participants attended a single meeting individually and completed the questionnaire pack under the supervision of the experimenter. The questionnaire pack consisted of the perceived probability and cost questions and then the state scale of the STAI. Participants were asked to go through the booklet chronologically and to take as much time as they needed. Following completion of the booklet, the experimenter collected it in.

Participants were then debriefed, any questions were answered, and they were thanked for their time.

### 4.3.4. Data Analysis

To examine the influence of perceived probability and perceived cost, as well as the interaction of the two variables, on state anxiety, multiple linear regression analyses were run to determine main and interaction effects between perceived probability, perceived cost and the interaction between perceived probability and cost and state anxiety, as well as to determine the relative contribution of each of the above predictors to the total variance explained. In order to determine whether the interaction of perceived probability and perceived cost predicted state anxiety, an interaction term was created using SPSS software. All assumptions relating to normality, homoscedasity, linearity, normally distributed errors and independent errors were met prior to each analysis. Data analysis was conducted using IBM SPSS Statistics for Macintosh, Version 24.0.

## 4.4. Results

Perceived probability scores ranged from 1.8 to 6 ($M = 3.35$; $SD = .82$) and perceived cost scores ranged from 2.4 to 7 ($M = 4.89$; $SD = .94$). The correlations of the variables are shown in Table 4.1. As can be seen, all correlations, except for the correlation between perceived probability and perceived cost, were statistically significant.

***Table 4.1.*** *Correlations among the variables*

| Variable | 1 | 2 | 3 | 4 |
|---|---|---|---|---|
| 1. State Anxiety | - | - | - | - |
| 2. Perceived probability | .268*** | - | - | - |
| 3. Perceived cost | .241* | .051 | - | - |
| 4. Probability x cost | .825** | .737*** | .196* | - |

*Note: *p<. 05, **p<. 001, ***p<. 005*

Perceived probability, perceived cost and the interaction significantly predicted state anxiety, F (3, 90) = 425.130, p < .0005, and accounted for approximately 93% of the variance of state anxiety ($R^2$ = .934). However, only perceived probability and the interaction of perceived probability and perceived cost added significantly to the prediction, p< .05 (see Table 4.2).

***Table 4.2.*** *Regression results*

| Model | Beta | $sr^2$ |
|---|---|---|
| Perceived probability* | -.741 | 0.246 |
| Perceived cost | .010 | 0.0001 |
| Probability x Cost* | 1.369 | 0.81 |

*Note: the dependent variable was state anxiety; $sr^2$ is the squared semi-partial correlation; * p < .05*

***Table 4.3.*** *Number and percentage of statements obtained from the content of worries*

| Category | Number of statements | Percentage |
|---|---|---|
| Making mistakes/ performing badly | 239 | 50.85 |
| Letting others down e.g. coaches, teammates | 45 | 9.57 |
| Getting Injured | 33 | 7.02 |
| Losing | 31 | 6.60 |
| Performing to best of ability | 29 | 6.17 |
| Others judgments/expectations | 25 | 5.32 |

| | | |
|---|---|---|
| Consequences of mistakes | 23 | 4.89 |
| Opposition | 11 | 2.34 |
| Environment/ equipment e.g. potholes, puncture, temperature | 7 | 1.49 |
| Embarrassing themselves | 6 | 1.28 |
| Substituted too early | 4 | 0.85 |
| Injuring others | 4 | 0.85 |
| Team members not giving 100% | 3 | 0.64 |
| Involved in play | 2 | 0.43 |
| Falling ill e.g. from nerves | 2 | 0.43 |
| Unchallenged/bored | 2 | 0.43 |
| Letting themselves down | 2 | 0.43 |
| Violence | 1 | 0.21 |
| 'What if?' | 1 | 0.21 |

*Note: n = 94*

## 4.5. Discussion

The aim of this study was to examine the impact of how perceptions of performance failure influenced the experience of state anxiety, a main tenet of ACTS (Eysenck & Wilson, 2016), in order to further our understanding of the cognitive response to competitive pressure. Understanding the role of perceptions of failure during performance has important theoretical and empirical implications in terms of understanding the antecedents of state anxiety and practical implications in terms of better-informed interventions.

It was hypothesised that 1) perceived probability of undesirable outcomes occurring would predict state anxiety scores, 2) perceived cost of undesirable outcomes should they occur would predict state anxiety scores and 3) the interaction of perceived probability and perceived cost would predict state anxiety above and beyond the separate probability and cost estimates. The results provided support for hypotheses 1), perceived probability of failure significantly predicted state anxiety and 3), the interaction between perceived probability and perceived cost significantly predicted 81% of additional variance in reported state anxiety. However there was no support for hypothesis 2), perceived cost of failure did not significantly predict state anxiety. These findings are some of the first to provide support for ACTS (Eysenck & Wilson, 2016) and provide a better understanding of how competitive anxiety emerges.

Previous research has documented the influence of perceived probability and cost of negative outcomes in the maintenance of social phobia (e.g. Foa, Franklin, Perry, & Herbert, 1996; Uren, Szabó, & Lovibond, 2004; Voncken et al., 2003), however, the current findings are the first in regards to competitive sport anxiety. Notable differences are evident in the influence of perceived costs between these fields; with Foa and Kozak (1986) finding that perceived costs was the most important contributor to state anxiety in social phobia. Perhaps the perceived costs are not as severe for sports performers, and the probability of subsequent failure (exacerbated by previous errors) may well be a stronger driver of anxiety. Indeed, the most common worry, and most important, reported by participants were statements concerning mistakes and performing badly (50.85%, see Table 4.3), consistent with previous research suggesting distracting thoughts and worries occur most frequently (Gucciardi, Longbottom, Jackson, & Dimmock, 2010; Oudejans et al., 2011).

However, it is unexpected that in a sporting scenario the cost of performing badly is less important in creating state anxiety than the probability of performing badly, as is suggested by the present findings. Indeed, it is thought that most worries and fears are driven by faulty appraisals concerning the expectation of potential future harm (e.g. Beck et al., 1986). Participants were asked to recall worries thought about most often, therefore whilst they were recurring and well known, increasing the validity and reliability of results (cf. Beilock & Carr, 2001; Tenenbaum, Lloyd, Pretty, & Hanin, 2002), perhaps because participants were removed from the event, perceived costs were not as high. Despite following methods adopted in previous research (Berenbaum, Thompson, & Pomerantz, 2007), it is likely that simply asking individuals to reflect on the undesirable outcomes they think of during competition is less meaningful. Participants may also under report the strength of feelings when removed from the stressful environment (Ericsson, 2006), especially since the recall of emotional content is shaped by current feelings and a desire to preserve current self-beliefs (Ochsner & Schacter, 2000). Subsequently, future research could attempt to adopt an experimental design where pressure (and perceived costs and probability of failure) could be manipulated, and as such be more immediate.

Indeed, Nicholls et al. (2005) asked elite golfers to complete a daily diary. They reported many more stressors during an important competition than at other times with the most common stressors being physical errors (29.5%), mental errors (24%) and observing an opponent playing well (13%). The reported stressors are similar to those reported in the current study (see Table 4.3) with making a mistake being the highest worry reported. As such, it seems likely that the missing element could be an important competition and participants perceived costs of undesirable outcomes are higher during these competitions.

Conversely, perhaps sports people learn early on that costs are not as bad as you think at the time. They are aware that there is always another chance to ‘redeem yourself’ around the corner. For instance, Cognitive Behavioural Therapy, training the way individuals think and behave, has been associated with significant reductions in probability and cost bias (Franklin et al., 2005;

Lucock & Salkovskis, 1988; Poulton & Andrews, 1996; Voncken & Bögels, 2006). Furthermore, interventions designed to help performers develop a rational interpretation of the competitive environment have been shown to aid sporting performance (e.g. Turner & Barker, 2013; Wood, Barker, Turner, & Sheffield, 2018). These interventions may shift athletes' inherent fixation on success and failure and irrational thinking towards constructive goal-directed actions (Wood, Barker, & Turner, 2017). Indeed, there is evidence Rational Emotive Behavioural Therapy (REBT; Ellis, 1957) reduces irrational thought and behaviour in the short term after only one REBT workshop (Turner, Slater, & Barker, 2014a). In addition, exposure to the consequences to negative outcomes (i.e. training under anxiety), target overestimates of the consequences of undesirable outcomes. Antony and Swinson (2000) support the use of behavioural experiments and exposure exercises used to target overestimates of consequences of negative social events. In sport, Nieuwenhuys and colleagues demonstrate that training under anxiety leads to successful performance when under pressure and importantly, there is early indication that these effects are durable over time (Nieuwenhuys & Oudejans, 2010, 2011; Oudejans & Pijpers, 2009).

Notwithstanding the unexpected finding related to perceived costs, the interaction between perceived probability and perceived cost did significantly predict state anxiety, supporting and extending earlier work by Berenbaum Thompson and Pomerantz (2007; see also, Carr, 1974), as well as the hypotheses in this chapter. However, whilst an interaction between perceived probability and cost was found to predict state anxiety in the present study, this is in contrast to findings by Berenbaum, Thompson and Bredemeier (2007). These authors presented participants with undesirable outcomes and found that perceived probability and perceived cost, as separate variables, predicted state anxiety. However, there was no support for the interaction of both variables predicting state anxiety and it is possible that the discrepancy in the findings is due to methodological differences across the studies.

In general, the findings indicate perceived threat causes heightened state anxiety levels as predicted by ACTS. These findings have important implications in regards to reducing anxiety when performing under pressure. Many interventions in sport tend to impact the anxiety-attention-performance relationship (see Figure 4.1. dashed lines) proposed by ACT (Eysenck et al., 2007) and ACTS (Eysenck & Wilson, 2016). These interventions attempt to reduce the effect of cognitive anxiety on performance via improved attentional control (e.g. training general functions of working memory, Ducrocq et al., 2018, 2016;  quiet eye training; Vine et al., 2011). However, the current findings provide some justification for interventions to target the first stages of ACTS (see Figure 4.1) and in particular, pressure and athletes' perceptions of failure and anxiety as REBT, CBT and training under anxiety attempt to accomplish. Based on our findings, interventions could be targeted towards reflecting that (1) specific failures during a competitive event are not interpreted as increasing the probability of losing; (2) high-pressure conditions are not interpreted as meaning that losing would have high costs.

### 4.6. Conclusion

From the findings it is clear that the interaction of perceived probability of failure and perceived cost of failure play a large role in the experience of state anxiety. Future research needs to adopt an experimental approach to the question of how anxiety is influenced, and test the other key tenets of ACTS, especially with regards to the bidirectional nature of the pressure-performance relationship. If probability and cost estimates do contribute to worrying, future research needs to determine why it is that some individuals tend to think that their concerns are more probable and costly. For example, does an individual's previous performance, especially when it includes errors, contribute to perceived probability and cost, as suggested by ACTS? Consequently, it is important future research tests these predictions experimentally in a sporting task to understand how and when the biases influence in order to provide interventions to reduce or eliminate the negative effects on performance under pressure.

### 4.7. Future research

Chapter 3 and 4 have examined separate tenets of ACTS to uncover the variables suggested to initiate state anxiety. Whilst chapter 3 has demonstrated that trait characteristics influence cognitive biases, in particular interpretive bias, the present chapter has demonstrated that the perception of failure determines the experience of state anxiety. However, it is still necessary and important for theoretical and practical purposes to examine ACTS as a whole framework, especially with regards to the bidirectional nature of the pressure-performance relationship.

Consequently, chapter 5 sought to replicate findings from chapter 4 and demonstrate that perceived probability and cost influence state anxiety when performing a sporting task under pressure. This study was proposed to extend the findings of chapter 3 and 4 to an experimental setting by examining cognitive biases and the perception of failure in a sporting context under pressure and further investigate the gaps in knowledge regarding the pressure-performance relationship highlighted in chapter 2.

# Chapter 5: Cognitive biases and the perception of failure as antecedents of competitive state anxiety.

## 5.1. Abstract

ACTS suggests that cognitive biases, enhanced by an individual's tendency to engage in performance monitoring, alter the perceived probability and perceived cost of failure; resulting in an increase in individuals' levels of state anxiety, disrupted attention and ultimately, performance suffers. The aim of the current study was to collectively examine these variables proposed by ACTS, to determine whether they influence each other as predicted. Perceived cost of failure moderated the relationship between pressure and state anxiety, whilst perceived probability of failure moderated the relationship between pressure and performance errors. The findings provide some support for ACTS and recommendations are made for future research to extend support for ACTS in the literature.

## 5.2 Introduction

The thesis so far has focused separately on the components proposed by ACTS (Eysenck & Wilson, 2016) in an attempt to understand the antecedents of state anxiety. Research suggests that under pressure, not all individuals may get anxious and experience suboptimal performance (Otten, 2009). Indeed, pressure fluctuates during performance depending on how important and costly the situation is (Eysenck & Wilson, 2016; Chapter 4). ACTS proposes the importance of understanding how individuals become anxious in the first place and understanding these causes of state anxiety has important theoretical, empirical and practical implications for researchers and applied practitioners alike.

Developing theory allows researchers to better predict what might happen under pressure. Furthermore, by testing theoretical predictions it is possible to uncover the specific relationships and the most appropriate means in which to test these theoretical hypotheses. Practically, it is useful to understand why some individuals do not choke and how others, who may choke under pressure, can be trained to lessen the effect of pressure on performance. As such, the aim of this study is to examine the predictions of ACTS in their entirety to determine the antecedents of state anxiety under pressure.

ACTS postulates that cognitive biases, enhanced by an individual's tendency to engage in performance monitoring, alter the perceived probability and perceived cost of failure. Resultantly, state anxiety increases, attention is disrupted, and performance suffers (Eysenck & Wilson, 2016). The aim of study 4 is to collectively examine these variables during a sporting task under pressure, to determine whether they influence each other, as predicted by ACTS, to increase state anxiety (see Figure 5.1).

In research into social anxiety and phobia, similar to ACTS, Beck (1976) suggested that cognitive biases exacerbate and perpetuate fears via biased processing of social information. Specifically, overestimates of the probability and cost of negative social events result in the perception of social situations as dangerous. Findings from chapter 3 suggest sport trait anxiety and attentional control have some influence over instigating cognitive biases, specifically attentional and interpretive biases (see Figure 3.1.). However, although there was evidence of trait characteristics influencing biases, it appeared more likely that performance errors played a causal role in the pressure-performance relationship.

Further, chapter 4 confirmed that the perception of failure (errors), through examining perceived probability and perceived costs of undesirable outcomes, influence state anxiety (see Figure 4.1.). Collectively, these findings provide some support for ACTS, however it is still necessary and important to replicate these findings and provide further empirical evidence to support the theoretical predictions. Chapters 3 and 4 examined the components of ACTS separately to establish the proposed hypotheses prior to investigating ACTS as a whole framework. Therefore, it is essential for the current study to examine ACTS as a whole and determine the relationships proposed during a sporting task and under pressure.

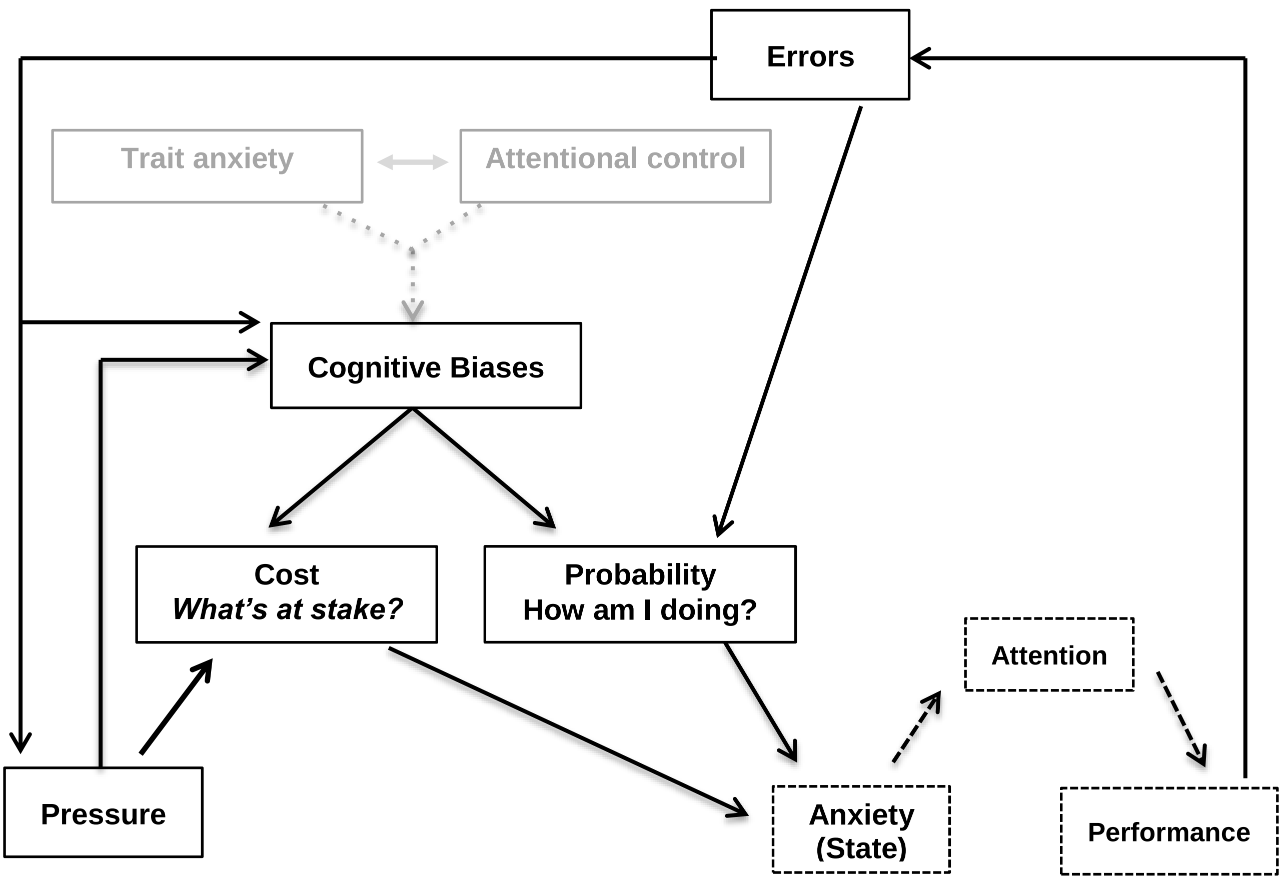


***Figure 5.1.*** *A schematic representation of the pressure-performance relationship, as proposed in the Attentional Control Theory: Sport. Sport trait anxiety and attentional control are suggested to influence cognitive biases*

*(chapter 3, grey lines, not examined in the present study). Cognitive biases influence the perceived probability of failure ("How am I doing?"), as do errors on previous performance attempts. Biases also influence the perceived cost of failure ("What's at stake?"), which is also influenced by the environmental pressure inherent in the situation. Together, it is predicted that these combine to influence anxiety, which will influence performance via attentional mechanisms as outlined originally in ACT (see black, dashed lines).*

Maintaining the focus on the error monitoring (perception of failure) element of ACTS, the present study sought to examine cognitive biases, perceived probability and cost and state anxiety in a) conjunction with each other, b) conjunction with pressure and c) during performance of a sporting task. ACTS highlights the bi-directional nature of the pressure-performance relationship, whereby pressure influences performance but performance (successful or unsuccessful) also influences pressure. This feedback system is partly influenced by cognitive biases. Individuals will be more likely to take note of physical and mental errors due to an enhanced attentional bias, thus they will be more aware of thoughts related to failure, and associated arousal symptoms will become more noticeable and interpreted as negative for performance. Subsequently, this heightened error monitoring influences perceived probability and costs of performance failure and ultimately affects performance.

Furthermore, the present study will also consider the anxiety, attention (through quiet eye duration) and performance relationship maintained from ACT (Eysenck et al., 2007) to ACTS (Eysenck & Wilson, 2016) and examined in chapter 2. The predictions of ACT have received much support in the sporting literature (see Eysenck & Wilson, 2016; Wilson, 2012 for reviews). Additionally, the present study will also examine the influence of cognitive biases and the perception of failure on anxiety, attention and performance. The aim of the present study was to expand and replicate the findings in chapter 4 by examining ACTS as a whole framework, including cognitive biases and the perception of failure. Specifically, the study examined cognitive biases in the form of attention and interpretive biases and perception of failure in the context of perceived probability and perceived cost of failure to determine the relationship with state anxiety and performance in a sport context under pressure.

### 5.2.1. Hypotheses

The aim of this experiment was to explore the predictions from ACTS as a whole, to determine whether cognitive biases and perceived probability and cost of failure influence state anxiety and performance. The following was hypothesised during a competitive golf-putting task;

It was hypothesised that 1) state anxiety would significantly increase from the low to high-pressure condition, 2) performance errors would significantly increase from the low to high-pressure condition and 3) quiet eye duration would be significantly shorter from the low to high pressure condition.

Further, it was hypothesised that state anxiety would significantly predict 1) performance errors and 2) quiet eye duration in the high pressure condition.

It was also hypothesised that 1) cognitive biases would moderate the relationship between pressure, performance errors and quiet eye duration, 2) perceived probability would moderate the relationship between pressure, performance errors and quiet eye duration, 3) perceived cost would moderate the relationship between pressure, performance errors and quiet eye duration and 4) the interaction of perceived probability and cost would moderate the relationship between pressure, performance errors and quiet eye duration.

It was also hypothesised that the perceived cost of failure would be higher in the high-pressure condition than the low pressure condition.

## 5.3. Methods

### 5.3.1. Participants

Twenty-nine golfers (6 female) with a mean age of 22.79 years (SD = 4.03) agreed to take part in the study. A required sample size of 29 was calculated using G*power 3.1 software, setting power (1-β err prob.) at .95, alpha (*α* err prob.) at $p = .05$, and using the effect size ($d = .61$) from Bredemeier and colleagues (2012) as participants were asked to detail perceived probability and cost for a specific timeframe (i.e. the next putt).

All participants reported playing recreational golf or at a higher level (M years of playing = 7.44; 12 handicapped participants), had normal or corrected-to-normal vision and had not partaken in vigorous exercise prior to testing. Five of the participants in this study also took part in study 3.

### 5.3.2. Measures

**State anxiety.** The anxiety thermometer was used to measure state anxiety prior to putting. Participants are asked to indicate on a 10-point Likert-type scale (0 = not anxious at all, 10 = extremely anxious) what their feelings of anxiety are at that particular moment in time. The validity and test–retest reliability of the anxiety thermometer are fair, with correlation coefficients ranging between .60 and .78 (Houtman & Bakker, 1989). Whilst the STAI (Spielberger et al., 1970) was used in study 3, the anxiety thermometer was used in this instance as it provides a quick and reliable way of measuring state anxiety during the putting task with as little disruption as possible. Furthermore, as the study was measuring state anxiety, the trait scale of the STAI and the SAS-2 were not valid measures to continue to use from past experiments as they either did not measure state anxiety, or did not allow for quick, non-disruptive measurement.

**Attentional bias.** Gaze behaviour was used to measure unstructured attentional bias during the testing period (see Marius ’t Hart et al., 2009, for a comparison between free exploration and head-fixed viewing conditions). Eye-tracking technology has provided a new way to examine attentional biases to threat that measures viewing behaviour rather than response times, such as the location, number, and duration of overt eye movements to threatening relative to neutral stimuli (Armstrong & Olatunji, 2012; Yiend & Mathews, 2005). Whilst reaction time is an indirect measurement of attentional bias and findings can be inconsistent, gaze behaviour is a direct and continuous measurement of attention (see Armstrong & Olatunji, 2012, for a review).

Threatening images were placed around the room and the extent to which these objects captured attention was the measure of attentional bias. Threatening images consisted of a man holding up a gun and a woman screaming and these posters were attached to the wall, close to where the individual was putting. Attentional bias was measured at the start of the task for a minimum of 5 minutes to allow for consistent measurement. Naturalistic free-viewing conditions were employed with no on-going task to avoid influencing individuals’ attentional bias. Under free-viewing conditions, eye tracking allows observation of multiple components within a single trial (Armstrong and Olatunji, 2012) and movements are suggested to closely reflect shifts in selective attention (Kowler, 1995). However, it is important to recognise that attentional resources may be allocated covertly and are unregistered by eye tracking (Armstrong and Olatunji, 2012) and therefore, may not be picked up during analysis.

Common indices of attention bias using eye movements include the proportion of fixation frequencies (Gamble & Rapee, 2010) and proportion of viewing time on the emotional stimuli relative to the neutral stimuli (Buckner, Maner, & Schmidt, 2010; Calvo & Avero, 2005; Wieser, Pauli, Weyers, Alpers, & Mühlberger, 2009). These indices are often averaged over a time span and/ or divided into time intervals to understand how attention may change over time (Gamble & Rapee, 2010). Attentional bias scores (e.g. proportion of fixation frequencies; Bradley et al., 2000; Gamble & Rapee, 2010; Mogg et al., 2003) were calculated by dividing the number of fixations directed to the threatening images by the number of total fixations on to objects throughout the measurement of attentional bias at the start of the task. For example, a bias score for threatening images was the number of fixations directed to the threatening images divided by the total number of fixations to neutral and threatening stimuli. This score reflects the relative frequency of looking towards the threatening stimuli rather than the neutral stimuli when faced with both. Scores greater than 0.5 indicate an attentional bias for threat. Proportion of fixation frequencies were assessed in Waechter, Nelson, Wright, Hyatt and Oakman (2014) and they had very good reliability ($\alpha$ = .90).

Gaze was measured using an Applied Science Laboratories (ASL; Bedford, MA) Mobile Eye Tracker. This lightweight system utilizes two features: the pupil and corneal reflection (determined by the reflection of an infrared light source from the surface of the cornea) to calculate point of gaze (at 30 Hz) relative to the eye and scene cameras mounted on a pair of spectacles. A circular cursor, representing 1° of visual angle with a 4.5 mm lens, indicating the location of gaze in a video image of the scene (spatial accuracy of ±0.5° visual angle; 0.1° precision), was viewed by the research assistant in real time on a laptop screen (Dell Inspiron 6400) installed with Eyevision (ASL) recording software. The DVCR was linked to the laptop via a 10 m cable, and this was placed into a bag so the participant could wear it whilst putting. The laptop was situated on a table to the far right of the participant to minimise distraction. The video data were recorded for subsequent off-line analysis. A *fixation* was defined as a gaze maintained on an object within 1° of visual angle for a minimum of 100 ms (Moore et al., 2012). Each putt was subject to frame- by- frame video analysis using Quiet Eye Solutions Vision-in-Action software (Quiet Eye Solutions Inc., Calgary, CA).

**Interpretation bias.** Interpretive bias is often measured by requiring individuals to interpret ambiguous information in the form of sentences or situations (Calvo, Eysenck, & Estevez, 1994; Constans et al., 1999; Richards, Reynolds, & French, 1993) or through modification training (e.g. Mathews & Mackintosh, 2000; Salemink et al., 2007). However, asking individuals to interpret an ambiguous scenario or sentence during a golf putting task is less relevant to the sport and modification training restricts the ability to determine a causal relationship between biases and the perception of failure specifically during the task. Therefore, for the purpose of the present study interpretive bias was measured through a perception task similar to that employed by Witt and colleagues (Witt, Linkenauger, Bakdash, & Proffitt, 2008; Witt, Linkenauger, & Proffitt, 2012; Witt & Proffitt, 2005). Participants were asked to draw their perceived size of the target (golf hole) as an indicator of interpretive bias. Research has found that performance affects the perceived size of an action's target, for example, softball players who are hitting well interpret the ball to be bigger than do players who have more difficulty hitting (Witt & Proffitt, 2005), whilst golfers playing better perceive the hole as bigger than those playing badly (Witt et al., 2008). Furthermore, research has found that cognitive anxiety may alter how visual information is interpreted, even when there is no difference in the availability of visual information. Consequently, this interpretive bias may cause individuals to respond based on threat-related inferences, instead of objective information (Gotardi et al., 2019; Renden et al., 2017). Indeed, it is expected that a negative interpretive bias will influence participants to perceive the hole as smaller than its actual size.

Judgements of hole size were obtained by asking participants to draw replicas of each target (golf hole) projected onto the golf green using PowerPoint loaded onto a laptop. The laptop was placed to the left of the participant at the location of the putting position (i.e. at the putting distance, 2.6 m). These size estimates were taken at the beginning of each putt in both the low and high-pressure conditions. When the vertical and horizontal measurements of circle size differed (i.e. an ellipse was drawn) a mean perceived size was calculated (Wood, Vine, & Wilson, 2013).

The size of the hole varied between large (10.16 cm) and small (5.08 cm) projected targets to vary task difficulty and to maintain novelty of the task. The projected targets also varied in size to ensure putting performance influenced perceived hole size and not just remembered hole size (Witt et al., 2008). The projected targets were also presented in a counterbalanced format for each participant to reduce learning during the task.

**Probability and Cost Estimates.** Perceived probability and perceived cost of failure were measured in a similar manner to study 3. However, the undesirable outcome was provided to the participant and this outcome was missing the next putt, as opposed to general outcomes most often worried about during competition, which was employed in study 3. Whilst this methodology is similar to Berenbaum, Thompson and Pomerantz (2007) and the methodology used in study 3, it has been adapted to be more efficient so it can be employed in between putts and also is relevant to the present task as opposed to tasks in the past.

Probability of failure was measured by asking participants to indicate “how likely” (0 = not at all likely; 6 = almost certain) it was that they would miss their next putt. Cost of failure was measured by asking participants to indicate “how bad” (0 = not bad at all; 6 = horrific) it would be if they did miss their next putt. These scales were pinned to the wall to the left of the individual and they were asked to say their response out loud and a research assistant recorded this.

**Performance.** The medial radial error (the distance in centimetres from the final ball position to the nearest edge of the projected hole) was recorded for each putt as a measure of task performance, and a mean value for each condition computed. A putt that landed inside or broke the projected line of the hole was recorded as “0” (Moore et al., 2012).

**Quiet eye duration.** Gaze was measured using an Applied Science Laboratories (ASL; Bedford, MA) Mobile Eye Tracker. The *quiet eye duration* was operationally defined as the final fixation toward the ball prior to the initiation of the backswing (Vickers, 2007). Research has demonstrated that under conditions of heightened anxiety quiet eye durations are reduced, negatively impacting upon performance (Behan & Wilson, 2008; Causer et al., 2011; Vickers & Williams, 2007; Vine et al., 2013; Wilson, Vine, et al., 2009). Quiet eye onset occurred before the backswing, and quiet eye offset occurred when the gaze deviated off the fixated object by 1° or more for more than 100 ms. A *fixation* was defined as a gaze maintained on an object within 1° of visual angle for a minimum of 100 ms (Moore et al., 2012). Each putt was subject to frame- by- frame video analysis using Quiet Eye Solutions Vision-in-Action software (Quiet Eye Solutions Inc., Calgary, CA). Quiet eye duration was measured throughout the putting task and as a result of the eye tracker being calibrated towards putting; attention bias measures were only collected at the start of the experiment. Therefore, it was difficult to get a clear representation of attention bias during the golf putting task.

### 5.3.3. Procedure

Participants attended the laboratory individually and were given a brief outline of the testing that would take place. Participants were fitted with an eye tracker and asked to sit quietly, under the pretence the equipment needed setting up, whilst attention bias (through gaze behaviour) measures were collected. Following this, participants moved to the artificial putting green and the eye tracker was calibrated whilst participants stood in their usual putting stance. During calibration participants were asked to fixate in turn on one of five golf balls placed in a square, with one in the middle, on the green (Vine et al., 2013; Walters-Symons, Wilson, & Vine, 2017). Participants were then asked to take 3 practice putts to a projected hole (large; 10.16 cm) on the putting green to familiarize themselves with the surroundings and putting whilst wearing an eye tracker. Participants putted using a standard length 90 cm steel-shafted blade style putter and standard size (4.27 cm diameter) white golf balls.

Participants next received the pressure manipulation and were given high or low-pressure instructions in a counterbalanced format. At the beginning of each putt the participant was asked to; replicate the size of the projected target (small, 5.08 cm, large, 10.16 cm) and complete the anxiety thermometer and perceived probability and cost estimates. The research assistant verbally asked the questionnaires and the responses were recorded. Following each putt the research assistant recorded radial error. The participant was asked to prepare for the putt, look down at the ball and were told by the researcher when to proceed. The participant was asked to take 18 putts in total, 9 putts in each condition, to loosely represent a golf course. The procedure was completed for all nine putts. The projected putts varied between small and large projected onto the green.

Following the completion of the first set of 9 putts, the individual was given a 5-minute break whilst all data was saved. The participant was given the other pressure manipulation and the process above was repeated. Following the completion of the experiment, the equipment was removed from the participant and they were fully debriefed and thanked for their participation.

*Pressure manipulation*

Several techniques were used to create high levels of state anxiety for the pressure condition, similar to previous research (see Vine et al., 2011; Vine & Wilson, 2010; Wilson, Vine, et al., 2009). Firstly, a competition was set up between participants whereby they were informed that they were paired with another participant and they were competing against other pairs to be top of the table. Second, they were informed their partner was currently ‘top’ of the table and they need to perform successfully to keep them there. Third, participants were informed that their putts would be recorded and compared to others performance by a golf expert, so were encouraged to perform as best as they could.

### 5.3.4. Data analysis

A paired samples t-test was conducted on the anxiety thermometer scores, performance error scores and quiet eye duration between the low- and high-pressure conditions to determine whether pressure affected state anxiety levels, performance and quiet eye duration.

Furthermore, moderator analyses were conducted to determine whether pressure affected state anxiety, performance errors and QE duration and whether this was moderated by either interpretive biases or the probability and cost of failure. The moderator variables were centered prior to analysis.

Interaction variables were calculated for perceived probability and perceived cost (PP*PC) using SPSS. A new variable was created for the interaction and was created by multiplying two of the variables (e.g. perceived probability x perceived cost) to form the new interaction variable (PP*PC).

## 5.4. Results

### 5.4.1. High and Low pressure conditions

There was a significant difference between state anxiety thermometer scores for the low ($M = 2.65$, $SD = 1.85$) and high ($M = 3.21$, $SD = 2.05$) pressure conditions, $t(28) = -2.695$, $p = .012$; state anxiety increased by $M = -.56$ ($SD = 1.12$).

There was also a significant difference between performance error scores for the low (M = 24.91, SD = 7.49) and high (M = 29.42, SD = 10.54) pressure conditions, t (28) = -3.763, *p* = .001; performance errors increased by M = -4.51 (SD = 6.45).

There was no significant difference between QE duration for the low (M = 689.77, SD = 1045.73) and high (M = 587.23, SD = 1099.66) pressure conditions, t (25) = .495, *p* = .625.

There was no significant difference between perceived cost of failure for the low (M = 689.77, SD = 1045.73) and high (M = 587.23, SD = 1099.66) pressure conditions, t (25) = .495, *p* = .625.

### 5.4.2. State Anxiety

State anxiety did not significantly predict performance errors, F (1, 27) = 3.696, *p* = .065, or quiet eye duration, F (1, 27) = .383, *p* = .541 under high pressure.

Moderation analysis using regression was conducted to determine whether perceived probability of failure, perceived cost of failure and interpretive bias moderated the relationship between pressure and state anxiety, performance errors and quiet eye duration. Due to attentional bias being measured prior to putting, the attention bias scores were excluded from the following analysis.

In the first step, pressure and perceived probability of failure were included. Pressure conditions and perceived probability of failure did not significantly account for the changes in state anxiety, F (2, 55) = 1.560, *p* = .219. An interaction term was created between pressure and perceived probability of failure and was added to the regression model. The interaction term did not significantly account for the changes in state anxiety, F (3, 54) = 1.350, $p$ = .268.

In the first step, pressure and perceived cost of failure were included. Pressure conditions and perceived cost of failure significantly accounted for the changes in state anxiety, F (2, 55) = 4.666, $p$ = .013, $\Delta R^2$ = .145. An interaction term was created between pressure and perceived cost of failure and was added to the regression model. The interaction term significantly accounted for the changes in state anxiety, F (3, 54) = 3.244, $p$ = .029, $\Delta R^2$ = .008.

In the first step, pressure and interpretive bias were included. Pressure conditions and interpretive bias did not significantly account for the changes in state anxiety, F (2, 54) = .587, $p$ = .560. An interaction term was created between pressure and interpretive bias and was added to the regression model. The interaction term did not significantly account for the changes in state anxiety, F (3, 53) = .679, $p$ = .569.

In the first step, pressure and PP*PC were included. Pressure conditions and PP*PC did not significantly account for the changes in state anxiety, F (2, 55) = 1.158, $p$ = .322. An interaction term was created between pressure and PP*PC and was added to the regression model. The interaction term did not significantly account for the changes in state anxiety, F (3, 54) = .975, $p$ = .411.

### 5.4.3. Performance errors

In the first step, pressure and perceived probability of failure were included. Pressure conditions and perceived probability of failure significantly accounted for the changes in performance errors, F (2, 55) = 4.800, $p$ = .012, $\Delta R^2$ = .149. An interaction term was created between pressure and perceived probability of failure and was added to the regression model. The interaction term significantly accounted for the changes in performance errors, F (3, 54) = 3.455, $p$ = .023, $\Delta R^2$ = .012.

In the first step, pressure and perceived cost of failure were included. Pressure conditions and perceived cost of failure significantly accounted for the changes in performance errors, F (2, 55) = 7.862, $p$ = .001, $\Delta R^2$ = .222. An interaction term was created between pressure and perceived cost of failure and was added to the regression model. The interaction term significantly accounted for the changes in performance error, F (3, 54) = 5.166, $p$ = .003, $\Delta R^2$ = .001.

In the first step, pressure and interpretive bias were included. Pressure conditions and interpretive bias did not significantly account for the changes in performance errors, F (2, 54) = 1.459, $p$ = .241. An interaction term was created between pressure and interpretive bias and was added to the regression model. The interaction term did not significantly account for the changes in performance errors, F (3, 53) = .971, $p$ = .413.

In the first step, pressure and PP*PC were included. Pressure conditions and PP*PC did not significantly account for the changes in performance errors, F (2, 55) = 2.176, $p$ = .123. An interaction term was created between pressure and PP*PC and was added to the regression model. The interaction term did not significantly account for the changes in performance errors, F (3, 54) = 1.431, $p$ = .244.

### 5.4.4. Quiet eye duration

In the first step, pressure and perceived probability of failure were included. Pressure conditions and perceived probability of failure did not significantly account for the changes in quiet eye duration, F (2, 55) = .239, $p$ = .788. An interaction term was created between pressure and perceived probability of failure and was added to the regression model. The interaction term did not significantly account for the changes in quiet eye duration, F (3, 54) = .226, $p$ = .878

In the first step, pressure and perceived cost of failure were included. Pressure conditions and perceived cost of failure did not significantly account for the changes in quiet eye duration, F (2, 55) = .140, $p$ = .870. An interaction term was created between pressure and perceived cost of failure and was added to the regression model. The interaction term did not significantly account for the changes in quiet eye duration, F (3, 54) = .484, $p$ = .695

In the first step, pressure and interpretive bias were included. Pressure conditions and interpretive bias did not significantly account for the changes in quiet eye duration, F (2, 54) = .611, $p$ = .547. An interaction term was created between pressure and interpretive bias and was added to the regression model. The interaction term did not significantly account for the changes in quiet eye duration, F (3, 53) = .434, $p$ = .729.

In the first step, pressure and PP*PC were included. Pressure conditions and PP*PC did not significantly account for the changes in quiet eye duration, F (2, 55) = .053, $p$ = .948. An interaction term was created between pressure and PP*PC and was added to the regression model. The interaction term did not significantly account for the changes in quiet eye duration, F (3, 54) = .038, $p$ = .990

### 5.5. Discussion

This is one of the first studies to examine ACTS, under pressure conditions, in a sport context and the results raise several important questions and implications for future research and application to sport. The aim of the present study was to examine the predictions of ACTS in a golf putting task to determine whether cognitive biases and perceived probability and cost of failure influence state anxiety and performance under pressure.

The findings demonstrated that state anxiety and performance errors significantly increased from the low to high-pressure conditions (e.g. Englert & Oudejans, 2014; Mullen & Hardy, 2000). These findings confirm that individual's perceived anxiety under pressure and suffered drops in performance. However, quiet eye duration was not significantly different, opposing the hypothesis. Furthermore, state anxiety did not significantly predict performance errors or quiet eye duration in the high pressure condition. These findings are not supported by past results as is evident from research discussed from the systematic review in chapter 3. Whilst the systematic review confirmed that increased anxiety, in response to competitive pressure, is related to impaired attentional control and degraded performance, the present findings are less clear. However, a cause of this may be due to the methodological challenges with the measurements of attentional bias and quiet eye duration (attentional control). This is discussed further in the cognitive biases section below.

### 5.5.1. Cognitive bias

ACTS (Eysenck & Wilson, 2016) suggests that cognitive biases in the form of attentional and interpretive bias influence perceived probability and perceived cost of failure which leads to state anxiety. Therefore, it was hypothesised that cognitive biases would moderate the relationship between pressure, performance errors and quiet eye duration. The findings in this study did not support the hypotheses above.

Attentional biases are suggested to contribute to perceived threat (see Mogg & Bradley, 2005 for a review), however due to the nature of the study design employed it was difficult to accurately measure gaze behaviour between putts, as well as in the high-pressure condition. For example, each participant's gaze was calibrated for looking down at the putting green for the purpose of the quiet eye measure. Therefore, when an individual looked up from the putting green, it was difficult to confirm exactly where they were looking as the eye tracker could not be calibrated for both these elements of the task. As a result of this, the measure of attention bias was taken prior to putting whilst the participant was sitting and the eye tracker could be calibrated for participants' gaze towards the wall. Further, as a consequence of counterbalanced conditions, attentional bias measures were taken prior to the golf putting starting. The lack of findings in this study suggests that more precise measures need to be employed to establish how cognitive bias influences the perception of failure through perceived probability and perceived cost.

Interpretive bias did not have a moderating effect on the relationship between pressure and state anxiety, performance errors and quiet eye duration. It may be possible that the methodology used to measure interpretive biases was not a sensitive enough measure and perhaps interpretive biases manifested in forms that were not measured, i.e. thoughts and images. Indeed, the measure of perception of target size has not been used in interpretive bias research before. However, research has found that performance success or failure affects the perceived size of an action's target, for example, softball players who are hitting well interpret the ball to be bigger than do players who have more difficulty hitting (Witt & Proffitt, 2005), whilst golfers playing better perceive the hole as bigger than those playing badly (Witt et al., 2008). Furthermore, research has also found that anxiety may alter how visual information is interpreted in sporting tasks even though there is no difference in the availability of information (e.g. Gotardi et al., 2019; Renden et al., 2017).

Although there were no significant findings in regards to the influence of cognitive biases (attentional and interpretive) this study does provide information for researchers looking to test the predictions of ACTS and the influence of cognitive biases on perceived probability and cost. Especially considering there is little research in sport that examines the influence of attentional and interpretive biases and perceived probability and cost of failure on state anxiety. Furthermore, whilst it is important to establish a causal relationship between cognitive bias (attentional and interpretive) and state anxiety and performance errors, it may be necessary to look at mainstream psychology research and adopt a modification training study (Grey & Mathews, 2000; Mathews & Mackintosh, 2000; Wilson et al., 2006; Yiend, Mackintosh, & Mathews, 2005). Evidence of a causal link between attention and interpretive bias and state anxiety has been provided by studies in which attentional and interpretive bias have been experimentally manipulated (see Bar-Haim, 2010, for a review). It is necessary for future research to continue to employ novel ways of measuring bias to clarify the relationships proposed by ACTS.

### 5.5.2. Perceived probability and perceived cost of failure

The present study hypothesised that 1) perceived probability of failure would moderate the relationship between pressure, performance errors and quiet eye duration, 2) perceived cost of failure would moderate the relationship between pressure, performance errors and quiet eye duration and 3) the interaction of perceived probability and cost would moderate the relationship between pressure, performance errors and quiet eye duration. It was also hypothesised that the perceived cost of failure would be significantly higher in the high-pressure condition than the low-pressure condition.

Findings from this study suggest perceived cost of failure moderates the relationship between pressure and state anxiety, and pressure and performance errors. Further, perceived probability and perceived cost of failure are suggested to moderate the relationship between pressure and performance errors. However, there were no differences in perceived cost of failure between the low and high-pressure condition. The interaction of perceived probability and perceived cost also did not account for variance in state anxiety, under pressure.

It has been suggested in research that perceived cost is the most important contributor to state anxiety, in social phobia (Foa & Kozak, 1986). Findings from chapter 4 demonstrated that state anxiety is influenced by perceived probability and the interaction of perceived probability and cost. The present study found state anxiety, when under pressure, was moderated by perceived cost of failure. Perhaps because the pressure manipulation asked participants to compete against other participants, the task provided an element of competition that was missing in study 3 and therefore costs were perceived as higher as participants perceived more was at stake should they fail.

Whilst perceived probability did not moderate state anxiety under pressure, the findings suggested that performance errors, under pressure, were moderated by perceived probability and perceived cost of failure. Furthermore, perceived probability of losing is likely to increase as a function of the number of failure experiences during a competition, demonstrating a feedback loop between probability of failure and performance errors. Indeed, these findings indicate the importance placed on success and failure when competing, and the influence that the possibility of failure (perceived probability) and the consequences of failure (perceived cost) can have on an individual's ability to perform under pressure.

The present study also did not replicate the finding that the interaction of perceived probability and cost influenced state anxiety from chapter 4; even if an outcome is perceived as being likely, it will not lead to a large perceived threat if the outcome is considered relatively unimportant. Conversely, if an outcome is considered unlikely, it will not lead to a large perceived threat even if the cost of the outcome is perceived as being quite significant (Berenbaum, Thompson, & Pomerantz, 2007). Berenbaum, Thompson and Bredemeier (2007) also failed to replicate Berenbaum, Thompson and Pomerantz's (2007) interactive finding. One possible explanation for these discrepant findings is that different methods were employed in the studies to measure perceived probability and cost. These methodological differences are discussed further in chapter 6, the general discussion.

The present findings have some implications for the research base and specifically, applied settings. The perception of failure, errors in particular, appear critical to understanding the pressure-performance relationship (Eysenck & Wilson, 2016). Indeed, findings from this study show the significance of associated costs with poor performance in important tasks and it is essential for coaches and sport psychologists to be aware of these perceptions as they may influence the anxiety experienced during competitions. Coaches are then better informed to tailor interventions for individuals based on these findings. Furthermore, training studies under anxiety show individuals *are* able to perform successfully under pressure (Cassell, Beattie, & Lawrence, 2018; Nieuwenhuys & Oudejans, 2010; Oudejans & Pijpers, 2009). However, these studies are largely based on movement planning and there is less consideration for the training of cognitive biases and perception of failure during practice, therefore leaving scope for future experimental studies to inform applied practitioners in the pursuit of appropriate interventions to aid optimal performance under pressure.

## 5.6 Conclusion

In sum, the probability and costs of failure when competing have important effects on sportsperson's cognitions leading to increased anxiety and negative performance effects. The findings provide support for the influence of perceived cost on state anxiety and there is some support for the bi-directional relationship between failure and anxiety. The findings also highlight the necessity for more research to be conducted on this theory, specifically to continue developing novel ways to examine biases and perceptions of failure. In particular through the use of training under anxiety and biases modification in an attempt to develop understanding of cognitive biases and the perception of failure and there precise role in the initiation of state anxiety under pressure. Overall, the study attempts to provide a novel insight into the relationship between cognitive biases, the perception of failure and state anxiety and future research should continue to explore these relationships, why the effects occur and most importantly, how they can be limited.

# Chapter 6: General Discussion

## 6.1 Summary of key findings

Athletes are constantly seeking to thrive under the pressure of sporting competition. The study of performance under pressure has primarily focused on disrupted attentional mechanisms to explain the negative anxiety-performance relationship, however, there is still limited understanding regarding the antecedents of state anxiety and successful and unsuccessful performance, as well as the exact mechanisms involved in the pressure-anxiety relationship in sport.

Consequently, the aim of the thesis was to examine the pressure-performance relationship, specifically the attentional mechanisms in the anxiety-performance relationship, as well as ACTS and cognitive biases and perceptions of failure as moderating variables postulated to influence successful or unsuccessful performance under pressure. First, by collating the evidence in regards to the anxiety-performance relationship and underlying attentional mechanisms to provide a sense of where the sporting literature stands in regards to this relationship, including the challenges in the research and areas of emergent or current research. Second, the thesis considered successful and unsuccessful performance under pressure and the contributing moderators that influence the pressure-performance relationship and in particular, the experience of state anxiety. The theoretically derived predictions of ACTS needed to be examined experimentally and this thesis is some of the first research to empirically examine the predictions proposed. The general aim of the thesis was to understand what initiates the anxiety response in individuals, an approach few researchers in sport have considered, for the purpose of informing athletes, coaches and support teams and providing a means to recognise and control anxious symptoms during competitive performance.

The systematic review (chapter 2) was conducted initially to determine the current state and consensus of the literature base in regards to the anxiety-performance relationship and underlying attentional mechanisms. The review examined existing research for the proposed attentional mechanisms responsible for motor skill decrements whilst anxious and assessed the efficacy of the different theoretical perspectives of the anxiety-performance relationship that implicate attention. From the synthesis in the systematic review, it has been established that there is a large amount of research examining the anxiety-performance relationship that concludes that anxiety causes attentional disruptions that lead to drops in performance when under pressure. However, there is difficulty drawing conclusions as to which specific attentional mechanisms were influenced by anxiety, particularly as comparisons between studies and theoretical assumptions are difficult due to contrasting methods and study designs. Furthermore, there are limited attempts in the literature to provide supporting evidence for more contemporary frameworks, such as the three-dimensional (Cheng et al., 2009) and four-dimensional model (Carson & Collins, 2016) and notably, ACTS (Eysenck & Wilson, 2016), suggesting that performance failure does not always emerge in pressure filled contexts.

Researchers have tried to understand more about anxiety and its related processes by exploring potential mechanisms influencing successful and unsuccessful performance under pressure conditions. The ability to perform successfully under pressure is a crucial aspect of sport performance (Mesagno & Mullane-Grant, 2010) and the majority of research considering successful performance under pressure examines potential moderating variables in the anxiety-performance relationship (e.g. Carson & Collins, 2016; Cheng et al., 2009; Nieuwenhuys & Oudejans, 2012). The aims of the three empirical studies in the thesis were to examine the predictions of ACTS (Eysenck & Wilson, 2016) and specifically, attention and interpretive biases and whether sport trait anxiety and attentional control can determine whether an individual is likely to experience biases; the perception of failure, specifically perceived probability and perceived cost of failure and whether these variables are a predictor of state anxiety; and finally, the predictions of ACTS as a whole, drawing from the findings in both chapters 3 and 4 to examine cognitive biases and the perception of failure as predictors of state anxiety and their influence on attentional control and performance.

Chapter 3 examined attention and interpretation biases, with the aim of determining what influences these cognitive biases. Specifically, whether sport trait anxiety and attentional control influence attentional and interpretive biases. A better understanding of these factors will help to inform interventions attempting to reduce anxiety symptoms and develop techniques for protecting performance from the negative effects of anxiety. Findings indicated that although sport trait anxiety did not predict attentional bias there was evidence of a bias towards threatening stimuli and away from positive stimuli when examining attentional bias reaction times from the dot probe task. Furthermore, sport trait anxiety predicted negative interpretations whilst attentional control predicted positive interpretations.

Chapter 4 examined the perception of failure aspect of ACTS, specifically perceived probability and perceived cost of failure, to determine whether the interpretation of the environment (through thoughts, errors or performance) influenced state anxiety. Cognitive biases, through error monitoring, are suggested to alter the perceived probability and perceived cost of failure, which in turn influences the experience of state anxiety. However, there is limited examination of the perception of failure within sporting contexts and the resultant influence on state anxiety. Findings from chapter 4 indicated that perceived probability of failure and the interaction of perceived probability and cost of failure predict state anxiety in sport performance. The study was an important step towards developing experimental approaches to examine ACTS in a sporting task. This approach contributed to chapter 5 in the thesis.

Chapter 5 aimed to build upon the aims of chapters 3 and 4 by examining the hypothesised relationships between cognitive biases (attentional and interpretive), perception of failure (perceived probability and cost) and state anxiety, attentional control and performance in an ecologically valid golf putting task, performed under conditions of artificially induced pressure. Converse to chapter 4, chapter 5 indicated that perceived cost of failure moderated the relationship between pressure and state anxiety and pressure and performance errors in a golf-putting task. Further, perceived probability of failure moderated the relationship between pressure and perceived probability of failure. However, cognitive biases did not have any moderating effects on state anxiety, performance errors or quiet eye duration. Chapters 4 and 5 provide the first foundations of support for ACTS (Eysenck & Wilson, 2016). Despite limited and contrasting conclusions in the studies, they are an important contribution to the literature and add to the development of experimental approaches to examine ACTS in a sporting task.

### 6.2. Significance and implications of findings

#### 6.2.1. The anxiety-attention-performance relationship

The research examining the anxiety-performance relationship and underlying attentional mechanisms has been a prominent feature of the competitive anxiety literature. It is clear that attentional processes play a vital role in explaining performance disruptions when anxious in the competitive sporting environment. Furthermore, research findings suggest that both self-focus and distraction elements may play their part. It is difficult to draw exact conclusions as to the specific attentional mechanisms influenced by anxiety, however, the systematic review uncovered methodological issues with objectively measuring focus of attention on 'the self', as well as different measurement approaches making comparison between the self-focus and distraction accounts difficult. Moreover, these issues make it difficult to better understand the strengths and weakness of each approach in explaining the anxiety-performance relationship and the attentional mechanism involved, which limits researchers ability to advance experimental research.

However, the findings of the first part of the thesis contribute to the anxiety-performance relationship and provide support and clarity to the knowledge base. Whilst there is difficulty when it comes to providing a specific conclusion in regards to the exact attentional mechanisms influenced by anxiety, findings from the review do confirm that increased anxiety, in response to competitive pressure, is related to impaired attentional control and degraded performance. Indeed, the review also concluded that interventions designed to improve attentional control, such as quiet eye training (e.g. Moore et al., 2012), working memory training (e.g. Ducrocq et al., 2018) and mental imagery (e.g. Colin et al., 2014), likely have worth, as they are designed to reduce unwanted attention on the self and irrelevant, likely threatening, stimuli.

Unfortunately, findings from chapter 5 are less supportive of the conclusions from the systematic review. Quiet eye duration did not significantly differ between the low and high pressure conditions and state anxiety did not significantly predict performance errors or quiet eye duration; although state anxiety significantly increased from the low to high pressure condition. However, pressure was moderated by perceived probability of failure and perceived cost of failure in performance errors, and by perceived cost of failure in state anxiety suggesting it may have been an issue with the measurement of quiet eye duration, which causes the difference in the findings. This is discussed in more detail in 6.4.

Although this is the case, it was also evident that there were elements of the anxiety-performance relationship that were yet to be explicitly considered in experimental studies. In particular, the influence of competitive pressure when performance improves, thus influencing the aims of the second part of the thesis. ACTS (Eysenck & Wilson, 2016) is one of the first theories to address the variables that may instigate state anxiety symptoms, determining whether performance is successful or unsuccessful under pressure. In particular, ACTS considers variations in performance under pressure and the causal individual differences that influence the interpretation of pressure and the initial experience of state anxiety.

The research that followed the systematic review is some of the first to attempt to provide empirical support for the predictions in ACTS. Examining the hypotheses presented in ACTS is important for the advancement of the pressure-performance literature, following a number of gaps highlighted throughout the systematic review. These findings help to determine the factors that lead to anxiety responses under pressure, by better understanding the mechanisms that are influenced and specifically how they are influenced under pressure. Findings addressed three possible mechanisms that determine state anxiety, as suggested by ACTS: cognitive biases, perception of failure and performance errors.

### 6.2.2. Attentional Control Theory: Sport

The findings of the second part of this thesis add to our understanding of ACTS and the further development of this theory. The findings provide support for some of the hypotheses and test the experimental methods and study designs which attempt to examine the proposed hypotheses. Specifically, the findings contribute to our understanding of ACTS by indicating that perceived probability, perceived cost and the interaction of perceived probability and cost predict state anxiety. Although these findings were not consistent across studies, specifically, perceived probability and the interaction of perceived probability and cost predicted state anxiety in chapter 4, whilst only perceived cost predicted state anxiety in chapter 5, the findings are some of the first to provide experimental evidence for one of the key hypotheses in ACTS.

Interestingly, findings did not support a relationship between cognitive biases (attentional and interpretive) and state anxiety and performance errors or between perceived probability and state anxiety. These results were considered relatively surprising based on findings from chapter 3 and 4 indicating the presence of both when examined separately. However, as there is little other evidence in the pressure-performance literature and specifically within sporting contexts, it may be that the predictions made were wrong. Subsequently, it is important future research continues to investigate the role of cognitive biases and the perception of failure and the collective influence on state anxiety under pressure. Indeed, it is also necessary to focus on appropriate methodology, as it may be possible study designs in a clinical anxiety context struggle to transfer to sporting anxiety contexts. For example, many studies investigating perceived probability and perceived cost of undesirable outcomes (failure) examine generalised anxiety disorder or social phobias. Participants are presented with social scenarios where, should a participant have a negative bias, they will suggest negative outcomes are more likely and costly. It could be possible that worries differ between the two contexts as well as the perceptions of how probable and costly the feared outcomes are. For example, individuals with generalised anxiety disorder judge hypothetical undesirable events (e.g. a fire in their home) as being more likely (Butler & Mathews, 1983, 1987; MacLeod, Williams, & Bekerian, 1991). However, participants with sport trait anxiety are likely to be influenced by the pressurised situation they are currently in, and in turn probability and cost estimates vary depending on these situations as opposed to hypothetical situations.

#### 6.2.2.1. Role of cognitive biases

ACTS suggests that cognitive biases have a role in determining whether performance is successful and a performer plays at their best under pressure, or unsuccessful and a performer collapses under pressure. Cognitive biases present in two forms: attentional bias and interpretive bias. The findings from chapter 3 indicate that sport trait anxious individuals are likely to make negative interpretations. Furthermore, individual's with high attentional control influences more positive interpretations (see chapter 3, 3.3). However, findings were inconclusive with regards to sport trait anxiety and the influence on attentional bias, although there was evidence of a bias towards threatening stimuli and away from positive stimuli.

The interpretive bias findings in chapter 3 are supported by research in both social anxiety (Amir et al., 1998; Constans et al., 1999; Huppert et al., 2003; Voncken et al., 2003; Wilson & Rapee, 2005) and sport-related tasks (Gotardi et al., 2019; Nieuwenhuys et al., 2012, 2008; Renden et al., 2017). The findings provide evidence that in a benign situation, sport trait anxious individuals are more inclined to make threatening interpretations, as well as direct their attention towards potentially negative outcomes.

Should individuals have good attentional control, attention is likely to be directed toward positive stimuli. Indeed, it could be possible that good attentional control reduces vigilance to threatening stimuli as research suggests that higher regulatory control reduces attentional and interpretive biases (Salemink & Wiers, 2012). However, there is less evidence examining the relationship between interpretive biases and attentional control (Salemink & Wiers, 2012), as well as research into cognitive biases (both attentional and interpretive) in a sporting context at the pressure-state anxiety level, as opposed to the anxiety-performance level. The attentional bias findings in the present thesis do not support previous findings (see Bar-Haim et al., 2007; Cisler & Koster, 2010 and chapter 3) and whilst these previous findings are the majority, past research has also been unable to replicate an attentional bias for trait anxious individuals (Mogg et al., 1997, 2000).

While it is expected that sportspersons will make more negative interpretations in high-pressure than low-pressure situations, the extent and impact of these biases will vary across individuals (Eysenck & Wilson, 2016). Furthermore, sportspersons who interpret pressure of competitive situations as non-threatening experience less anxiety and are generally more successful. However, there was little evidence in chapter 5 that indicated the presence of attentional bias or interpretive bias during the putting task. Indeed, cognitive biases did not appear to moderate state anxiety, performance errors or quiet eye duration in the fourth study of the thesis, which included a pressure manipulation during a golf putting task, as postulated by ACTS. Whilst self-report state anxiety thermometer measures suggested that the pressure manipulation was successful, it is possible the pressure manipulation was not strong enough to initially engage perceptions of threat in participants; therefore participants were unlikely to attend to threat and interpret scenarios as threatening, in turn experiencing less anxiety (Eysenck & Wilson, 2016).

Based on the findings from this thesis regarding cognitive biases it appears the relationship between anxiety and cognitive biases is not a straightforward one, and attentional biases do not increase purely as a function of individual anxiety level (Kadosh et al., 2018). Indeed, it has been suggested that the adverse effects of failure on internal processes and performance (cognitive and motor) are greater among individuals with anxious personalities (Saltz, 1970; Weinberg, 1978). Therefore, it may be that in a pressurised competitive environment, biases may be in response to errors made by the individual. Whilst the studies have attempted to test the theoretical predictions in ACTS, there is limited clarity on the role of cognitive biases and the specific influence on perception of threat (perceived probability and perceived cost of failure). It is likely a combination of trait anxiety characteristics and a pressurised, competitive environment influence when individuals experience cognitive biases, yet their influence subsequently on state anxiety still needs to be uncovered in the sporting literature.

Furthermore, while it is suggested that cognitive biases influence perceived probability and perceived cost of failure in ACTS (Eysenck & Wilson, 2016), as far as the author is aware there is no research, specifically in a sporting context, which explores this relationship. Therefore, it is difficult to draw from past conclusions when analysing the results found in the studies. However, although there were limited findings in regards to the influence of cognitive biases (i.e. only chapter 3 found support for interpretive biases where sport trait anxiety and attentional control predicted negative interpretations and positive interpretations, respectively), the studies provide information for researchers looking to test the predictions of ACTS and the influence of cognitive biases on perceived probability and cost. In particular, it is necessary for future research to continue to employ novel ways of measuring bias to clarify the relationship between cognitive biases and the perception of failure in the cause of state anxiety. Particularly considering that there is little research in sport that specifically examines the influence of attentional and interpretive biases and perceived probability and cost of failure on state anxiety when performing a sporting task under pressure.

However, there may be a solution to measuring cognitive biases, in particular to determine the influence of attentional and interpretive bias on performance. The attentional components that underlie attentional biases have been the most contested theoretical issue, with contrasting accounts of increased attention towards threat (Armstrong & Olatunji, 2012). Based on the findings in the current thesis and potential methodological difficulties with measuring attentional bias during performance highlighted in chapter 5, it may be necessary for research to determine the influence of cognitive biases through attentional and interpretive bias modification training (Grey & Mathews, 2000; Mathews & Mackintosh, 2000; Wilson et al., 2006; Yiend et al., 2005). Computerized training paradigms have been developed to experimentally manipulate interpretive and attentional biases. ACTS states that performers who display attentional biases to threat will be more likely to 'notice' physical and mental errors due to an enhanced attentional bias to threat cues. Furthermore, performers who display an interpretive bias will be more likely to interpret these errors as having an impact on how they will subsequently perform (Eysenck & Wilson, 2016). By training individuals towards a positive attentional bias and making threatening stimuli less salient, researchers can investigate and compare the perception of failure, state anxiety and errors during performance to participants who have been trained to repetitively direct their attention towards negative and threatening stimuli. Therefore, interventions can be tailored to those experiencing negative anxiety effects under pressure and individuals can be trained towards positive stimuli to influence perceived pressure and moderating variables that initiate state anxiety.

#### 6.2.2.2. Role of perception of failure

The perception of failure is one of the main concepts from ACTS and probability of failure and cost of failure contribute to the perception. Perceived probability and cost of failure were examined in chapter 4 and chapter 5 by asking individuals to rate how likely they were to experience an undesirable outcome and how costly it would be should the undesirable outcome occur. The studies examining the perception of failure are the first to do so in the context of a sporting task. According to ACTS, heightened error monitoring due to attentional and interpretive biases influences perceptions of threat leading to the experience of anxiety (e.g. Berenbaum, 2010; Berenbaum, Thompson, & Pomerantz, 2007). Previous research has shown that individuals who believe undesirable outcomes are more likely to occur, and believe the outcomes will be more costly, tend to have higher levels of worry than do individuals who believe that undesirable outcomes are less likely to occur (Berenbaum, Thompson, & Bredemeier, 2007; Berenbaum, Thompson, & Pomerantz, 2007; Butler & Mathews, 1983) Importantly, the findings in this thesis indicate that the perception of failure (threat), through measures of perceived probability of failure and perceived cost of failure, predict state anxiety and moderate performance drops.

The findings provide a better understanding of how competitive anxiety emerges and have important implications in regards to reducing anxiety when performing under pressure. However, when the perception of failure was examined across the two studies, findings were unable to be replicated. Chapter 4 found that perceived probability and the interaction between perceived probability and cost predicted state anxiety. However, chapter 5 found that only perceived cost, under pressure, predicted state anxiety. This issue is not just present in the current thesis but with research by Berenbaum and colleagues who failed to replicate their findings across two papers (Berenbaum, Thompson, & Bredemeier, 2007; Berenbaum, Thompson, & Pomerantz, 2007). Indeed, this raises issues with the methodology used in the study designs and creates questions regarding why two studies found interaction effects and two did not.

The perception of failure is a critical component of ACTS in terms of understanding how individual’s state anxiety might be influenced under pressure (Eysenck & Wilson, 2016). It may be the lack of pressure manipulation in all studies except chapter 5 in the thesis, which causes the discrepancy amongst the results. For example, individuals perceive pressure in different ways and this is likely to vary throughout an event (Eysenck & Wilson, 2016). Therefore, pressure was introduced in chapter 5 to examine cognitive biases and the perception of failure and explore the differences in performance across putting trials. Furthermore, perceived costs are likely to be higher for individuals when performing in the competitive environment. In sporting contexts, such as the competitive golf putting task in chapter 5, losing is an undesirable outcome, and the costs of losing are greater in high-pressure situations than low-pressure ones because more is at stake (Eysenck & Wilson, 2016). In contrast, in neutral situations, such as the laboratory conditions in chapter 4 when participants were asked to think back to undesirable outcomes they often think of when competing, participants may under report the strength of their feelings (Ericsson, 2006) because they are removed from the stressful environment, which may also account for the discrepant findings related to perceived threat.

However, it is important to recognise that these situations described by participants *were* meaningful to the individual and were common thoughts participants experience when competing. Whilst laboratory induced stress manipulations have some strength (see chapter 2, section 2.5.1), the levels of anxiety are likely to be lower than when an individual is experiencing pressure when placed in their most stressful 'real' situation. Thinking back to this stressful situation was part of the task in chapter 4, and although in that moment they were not directly experiencing pressure, they were thinking back to a time when they were experiencing a 'real' stressful and pressurised experience. Therefore, it could be argued that pressurised conditions were present more so in chapter 4 than chapter 5, although not directly induced.

In sum, the findings in the thesis have provided some of the first support for ACTS and add to research attempting to understand how competitive anxiety emerges under pressure. In particular, the findings here provide support for one of the main tenets of ACTS; perceived probability and cost of failure predict state anxiety. Additionally, it is likely that trait characteristics play a role in influencing attention to and interpretation of potentially threatening circumstances. All of these findings contribute to our understanding of the theoretical predictions postulated by ACTS (see Figure 6.1.). Using the methodology employed in the thesis is a first step to establishing determinants of anxiety, prior to more complex testing of ACTS. Indeed, by examining the hypotheses of ACTS in stages, it has been possible to establish how each concept may develop, specifically how thoughts about performance failure or errors influence perceived probability and cost, and subsequently influence state anxiety, in order to then build on these findings by investigating ACTS as a whole framework.

## 6.3. Applied implications

ACTS (Eysenck & Wilson, 2016) provides a theoretical framework in which psychologists and coaches are able to follow to attempt to determine why and how individuals become anxious when performing under pressure. As such, they are able to prescribe interventions best suited to the performer. The findings relating to perception of failure and the influence on state anxiety have important implications in regards to reducing anxiety under pressure. In particular, ACTS suggests individuals can intervene in at least two places (Eysenck & Wilson, 2016): either reducing the likelihood that pressure leads to state anxiety, or by reducing the effect of anxiety on performance (via attention control). Moreover, if someone does not become anxious, they should not experience the impaired attentional control and degraded performance associated with this emotion.

In the first instance, anxiety will not necessarily be greater under high-pressure than low-pressure conditions provided the individual sportsperson does not interpret the high-pressure condition as threatening. This can be achieved by considering Berenbaum's model: (1) specific failures during a competitive event are not interpreted as increasing the probability of losing; (2) high-pressure conditions are not interpreted as meaning that losing would have high costs. Both of these strategies reflect the importance of maintaining a rational interpretation of the competitive environment, and interventions designed to improve this process have been shown to aid sporting performance (e.g. Wood et al., 2018).

Findings from chapters 4 and 5 suggest main variables that could be targeted in interventions to reduce the likelihood of anxiety emerging. Perceived probability and perceived cost of failure were predicted to influence state anxiety and performance error, therefore coaches can focus on targeting irrational interpretations of failure to reduce negative perception of probability and cost when performing under pressure. Rational Emotive Behaviour Therapy (REBT) can aid individuals to distinguish between rational and irrational beliefs, and further assist them in responding to failure with healthy emotional and behavioural responses (Turner, 2016). Turner and colleagues have found that REBT sessions were able to significantly reduce irrational beliefs in athletes (mixed martial arts, Cunningham & Turner, 2016; cricket, Turner & Barker, 2013; football, Turner et al., 2014). However, research concerning REBT in sport is scant, and there is little evidence to support the use of behavior therapy in the interpretation of errors. Given that sport is a performance-driven industry, REBT and the influence on irrational and rational beliefs during performance should be empirically tested (Turner, 2016).

Furthermore, studies investigating training under anxiety demonstrate that individuals are able to perform successfully when under pressure. For example, Oudejans and colleagues have demonstrated that training with anxiety can help to improve subsequent performance under pressure in both expert and novice athletes (Oudejans & Pijpers, 2010, 2009) and in police officers (Oudejans, 2008). Importantly, there is early indication that these positive training effects are durable over time (Nieuwenhuys & Oudejans, 2011). Furthermore, these findings from intervention studies can be applied to findings from the studies in the thesis examining ACTS and interventions can be tailored to re-framing perceptions of failure when training under pressure. Therefore, training under pressure will help individuals perform during important tasks, including acclimatising to the specific processes accompanying anxiety (Oudejans & Pijpers, 2009) and reappraising the perception of pressure during competitions, limiting the influences of cognitive biases and perceptions of failure.

Furthermore, interventions have been developed to attempt to reduce the effect of state anxiety on performance via improved attentional control. These interventions either train individuals to maintain focus on key sources of information while they perform, for example, through quiet eye training (Vine et al., 2011) or by training general functions of working memory (Ducrocq et al., 2018, 2016). However, training working memory can also be used as an intervention to reduce the likelihood that pressure leads to anxiety. Impairments in working memory can lead to excessive worrying (anxiety; Bredemeier &

Berenbaum, 2013). Indeed, a bi-directional relationship is suggested between working memory and worry. Deficits in working memory may make individuals prone to worry and conversely, working memory capacity is further compromised when individuals engage in worry and occupy working memory resources. Furthermore, recent evidence suggests that it may be possible to improve working memory in individuals with elevated levels of worry (trait) by teaching them to access more benign interpretations of ambiguous events (Hirsch, Hayes, & Mathews, 2009). Therefore, interventions targeted at training working memory have merit at both stages proposed by ACTS.

In summary, findings from this thesis can be used to inform interventions targeted at reducing anxiety symptoms for individuals performing under pressure. As mentioned, it is likely interventions can be targeted to intervene either by reducing the likelihood pressure leads to anxiety or by reducing the effect of anxiety on performance (Eysenck & Wilson, 2016). Furthermore, these findings can also be used to inform training studies already conducted (e.g. Nieuwenhuys & Oudejans, 2011; Oudejans, 2008; Oudejans & Pijpers, 2009) as well as to inform REBT to address rational thinking when faced with errors and failure (e.g. Cunningham & Turner, 2016; Turner & Barker, 2013, 2014; Turner et al., 2014a; Turner, Slater, & Barker, 2014b)

### 6.4. Limitations and directions for future research

The process of measuring attentional and interpretive biases for the studies was the biggest challenge of the thesis, particularly measuring attentional biases. The aim of chapter 3 was to solely measure attentional and interpretive bias following collection of sport trait anxiety scores and attentional control scores. Therefore, the tasks were developed based on cognitive bias literature (e.g.

Derakshan & Koster, 2010; Huppert et al., 2003; MacLeod, Mathews, & Tata, 1986; Miers et al., 2008; Mogg & Bradley, 1999; Stopa & Clark, 2000; Voncken et al., 2003) and measured reaction times to threat and interpretations of ambiguous scenarios. However, the aim of chapter 5 was to measure these biases specifically during a sporting task. There is limited research measuring biases in actual sporting tasks, where reaction times measured using dot probe tasks and interpretations of specific ambiguous scenarios measured through vignettes and questionnaires are a less relevant measure of threat, although some research makes reference to attentional biases in the anxiety-performance literature (see Eysenck et al., 2007). Therefore, experimental methods were explored to examine the hypotheses of ACTS in relation to cognitive biases, i.e. eye tracking and target perception, which were less commonly used within the research area but are often used in sport research. Eye-tracking technology has provided a new way to examine attentional biases to threat that measures viewing behaviour rather than response times, such as the location, number, and duration of overt eye movements to threatening relative to neutral stimuli (Armstrong & Olatunji, 2012; Yiend & Mathews, 2005). Examining gaze behaviour to assess attentional bias to emotional stimuli is a direct and continuous measurement of attention (see Armstrong & Olatunji, 2012, for a review). However, an issue with assessing eye movements with an eye tracking system is that the system cannot account for peripheral or covert vision.

Furthermore, challenges were encountered with the actual measurement of attentional biases when using eye tracking. Indeed, the eye tracker was calibrated for each participant to carry out the golf putting task. However, should an individual look up and attend to a threatening image, placed by the researchers, it was difficult to be certain that where the eye tracker located the participants gaze was an accurate representation of where the individual was looking. Therefore, attentional bias measures were taken prior to the putting task and prior to the pressure manipulation as the manipulation was counterbalanced and not all participants began putting in the high-pressure condition. However, this led to collecting attention bias data out of the high-pressure manipulation and therefore, could not demonstrate vigilance to threat through eye movements when under competitive pressure.

Furthermore, the sampling rate of the eye tracker posed an issue, particularly when it came to measuring saccades (i.e. the timing and direction of the first eye movement to the target) during the dot probe task. Capturing data at 30 Hz as opposed to the 200 Hz-1000 Hz eye trackers that are typically used in cognitive psychology laboratories meant the data was not as sensitive and the timing of the first fixation on the target was used instead. A low sampling frequency of 30 Hz can result in noisier parameter estimates in the instance of small saccades (van der Geest & Frens, 2002). Additionally, issues arose with calibration of the eye tracker to participants' eyes, as well as relying on the eye tracker to continuously work. In some instances of data collection, the footage was fragmented due to technical issues and possibly due to the changing positions of participants' heads influencing the quality of data. Whilst the same eye tracking device was used across all the relevant studies, there were still issues with the specific device which influenced the collection and quality of data. However, whilst these issues are common throughout the thesis, there is little in the literature with regards to the development of methods to evaluate the data quality of the respective eye trackers (see Reingold, 2014). Indeed, there is no gold standard eye tracking system.

This limitation leaves scope for future research to determine the best way to measure attentional biases when trying to explore whether a causal link exists between biases and the perception of failure in individuals when performing under pressure. Whether this is through cognitive bias modification training, or eye tracking during a task under pressure following identification of threat during performance. Furthermore, it is important for researchers to continue to address the novel research designs attempting to measure cognitive biases and the influence of perceived probability and cost of failure and state anxiety during sporting tasks. In particular, the free viewing eye-tracking method as a measure of attentional biases is a relatively new way to measure attentional biases. Difficulties arise with identifying the potential threats during the sporting task and continuously measuring gaze behaviour during performance, particularly when identifying potential threats in a controlled laboratory environment.

A limitation to the experimental research in the thesis is also the inconsistency in measurement of anxiety. Chapter 3 examines sport-specific trait anxiety, chapter 4 examines general state anxiety and chapter 5 examines competitive state anxiety. Whilst the SAS-2 (Smith et al., 1990) is a multidimensional measure of sport trait anxiety, the STAI state scale is relatively one dimensional, as is the anxiety thermometer used in chapter 5, which encompasses somatic and cognitive anxiety under the term anxiety with no differentiation between the two. The thesis measures anxiety specific to context and general anxiety, therefore, making it difficult to compare the anxiety findings across studies. Furthermore, it is also difficult to suggest that the measures of perceived probability and cost are influenced by the same anxiety components. Furthermore, the measures of state and trait anxiety do not account for the interpretation of anxiety symptoms by the participants and whether they view them as harmful in relation to the upcoming events (Jones and Swain, 1992; Hanton et al., 2003). Future research could consider using the Immediate Anxiety Measurement Scale (IAMS; Thomas, Hanton and Jones, 2002) to measure the cognitive and somatic components of competitive anxiety, including the anxiety interpretations and how anxiety may influence subsequent performance.

Finally, the breadth of the samples used across the studies also limits the findings, specifically in relation to the skill level of participants. This limitation may also account for the lack of findings across the thesis. The samples vary from recreational to elite level participants, with chapter 3 and chapter 5 recruiting golfers with a skill level of recreational or above and chapter 4 recruiting participants from any sport at any level. Research has suggested that skill level can play a key factor in how individuals interpret their anxiety symptoms. For example, Hanton and Connaughton (2002) interviewed elite and non-elite swimmers and recorded their retrospective interpretations of cognitive and somatic anxiety symptoms, as well as self-confidence and performance. Findings suggested that those with a higher skill level were able to cope with the competitive situation better and this then determined the interpretation of the cognitive and somatic anxiety symptoms experienced. Additionally, research examining rugby players has also demonstrated that skill level across groups influenced the interpretation of competitive anxiety and elite athletes experienced the same levels of anxiety as non-elite, but perceived them as less debilitating (Neil, Mellalieu and Hanton, 2006). Therefore, skill level may be a moderating factor which influences how anxiety is perceived under pressure, and may influence perceived probability and perceived cost of failure. Those that are less elite performers may perceive threat as more probable and costly than those who are more elite, and potentially are equipped with more skills to interpret symptoms in a more positive fashion (Neil et al., 2006). In particular, this limitation highlights an avenue for future research to examine the influence of skill level in relation to ACTS. In the first instance, it is important to distinguish findings between elite and non-elite participants to determine any potential differences in the perception of threat and the influence on state anxiety.

The thesis supports some of the key assumptions of ACTS (Eysenck & Wilson, 2016), specifically those in relation to the perception of failure and the role of probabilities and costs in the initiation of state anxiety. Therefore, it is important that future research continues to examine these variables and considers not only the limitations to the current studies in this thesis but also to replicate the findings. Indeed, it is also important to consider the limitations in the present study when conducting future research.

Whilst it is likely cognitive biases also play a role in the initiation of state anxiety, it is possible from some of the current findings that the role is less influential than the perception of failure. However, the current research has highlighted that there is a need for future research to examine potential moderating factors, for example skill level, which may play a role in individuals' experience of perceived probabilities and costs. Furthermore, it is vital that the measurement of state anxiety is considered as the varied measurements in the current studies in this thesis result in mixed conclusions when it comes to explaining how anxiety is initiated by cognitive biases and the perception of failure.

Furthermore, it is equally as important to consider practical conceptualisations of ACTS and how it links with current research that is applied to sport. For example, the catastrophe theory (Hardy, 1990) proposes that cognitive anxiety and physiological arousal (somatic anxiety) interact with each other and when both are high, performance catastrophically drops. In relation to ACTS, individuals would perform until perceived probability and costs increase and initiate or increase state anxiety, which in turn would disrupt attention and performance, and the catastrophic drop occurs (see also, Hardy, 1999, for a link to processing efficiency theory). Additionally, once performance is lost, it is difficult to reinstate, demonstrating the feedback loop proposed in ACTS between the perception of failure and errors, and the continuation of poor performance (see Figure 6.1.). However, as previously mentioned, more experimental research is necessary. In particular, to examine the relationships proposed in Figure 6.1 before bringing them into an applied setting, with the intention to understand and attempt to help athletes manage anxiety and their performance.

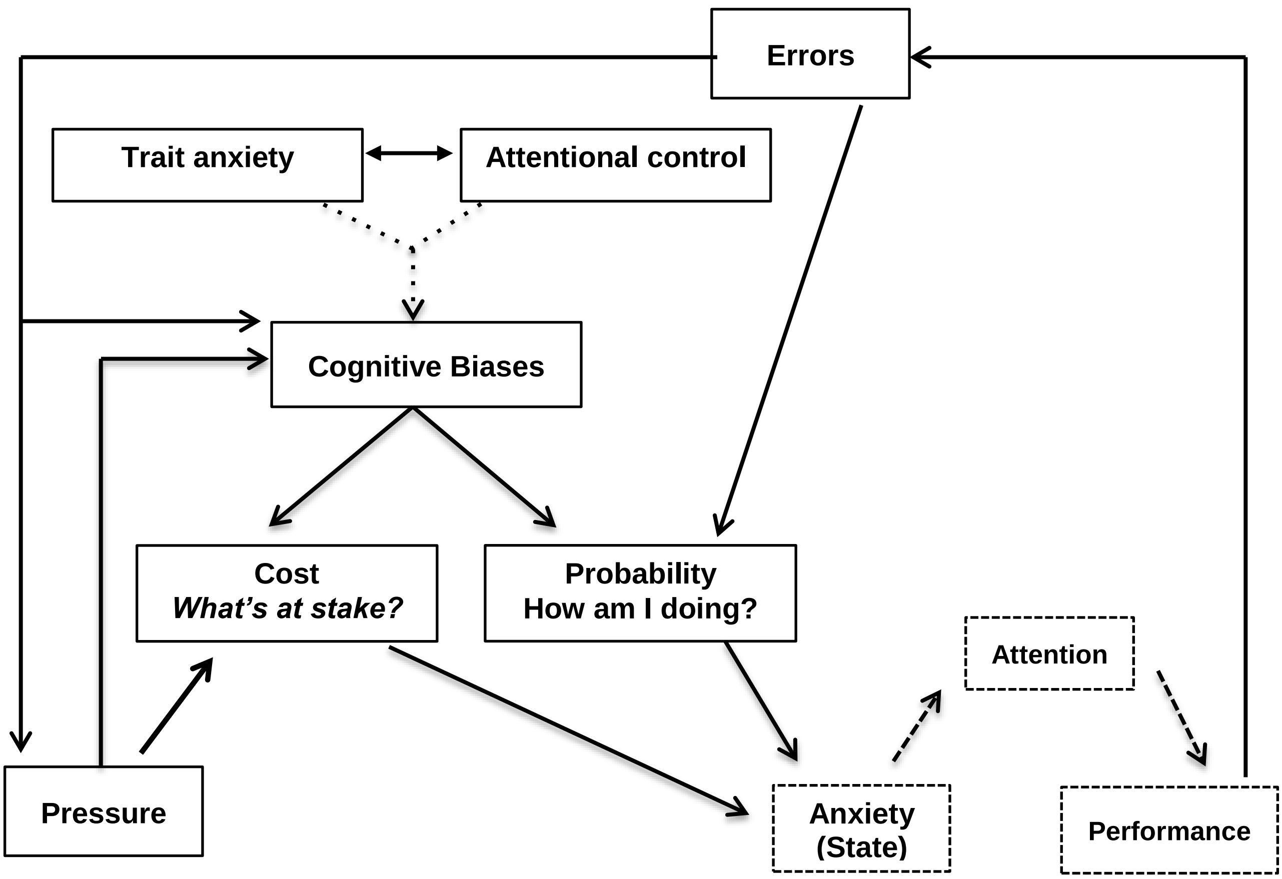

***Figure 6.1.*** *The schematic of ACTS, showing all the relationships examined within the thesis, including the influence of sport trait anxiety and attentional control on cognitive biases (Chapter 3); the influence of perceived cost and perceived probability on state anxiety (Chapter 4); and the influence of cognitive biases on perceived cost and probability and the subsequent influence on state anxiety, alongside the influence of errors on probability of failure and pressure (Chapter 5).*

Based on the findings of the thesis, it is important for future research to attempt to replicate the results presented here. The thesis is the first to examine the predictions of ACTS, and while supporting some predictions (perceived probability and cost predict state anxiety) it is extremely necessary for research to continue to expand the current findings as there were inconsistencies among the studies. Additionally, there are few findings regarding attentional and interpretive bias in sport, as well as perceived probability and perceived cost of failure in different sporting tasks and at different skill levels. Furthermore, while the current research focused on golf, it is also important to determine whether these findings transfer to other aiming tasks and team sports.

### 6.5. Conclusion

The thesis is the first body of work examining performance under pressure from the perspective of the moderating variables initiating the anxiety response and in particular from the perspective of the predictions of ACTS (Eysenck & Wilson, 2016). The findings demonstrate perception of failure influences state anxiety, a main tenet of ACTS (Eysenck & Wilson, 2016). Furthermore, it is likely cognitive biases are influenced by individual’s trait characteristics, however it is necessary for future research to examine the specific relationship between cognitive biases and the perception of failure. In sum, the results lead the way for future research to further explore the role of moderating variables in initiating state anxiety under competitive pressure. In particular, the influence of cognitive biases on the perception of failure to establish a link between these two variables and their influence on state anxiety. However, the practical significance of the findings can be targeted towards tailoring interventions to reappraise perceptions of failure (i.e. the likelihood and cost of undesirable outcomes) during performance under pressure. Overall, the thesis makes a novel contribution to the literature by supporting ACTS and extending knowledge on how anxiety emerges under pressure. As such the work has implications in practical settings relevant to interventions reducing anxiety responses in individuals performing under pressure in sport.

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## Appendix 1

**Name:** ______________________ **Email:** _____________________

**Sport Anxiety Scale-2**

Please read each question, and then circle the number that says how you USUALLY feel before or while you compete in sports. There are no right or wrong answers. Please be as truthful as you can.

**Before or while I compete in sports:**

| | | Not at all | A little bit | Pretty much | Very much |
|---|---|---|---|---|---|
| 1. | It is hard to concentrate on the game | 1 | 2 | 3 | 4 |
| 2. | My body feels tense | 1 | 2 | 3 | 4 |
| 3. | I worry that I will not play well | 1 | 2 | 3 | 4 |
| 4. | It is hard for me to focus on what I am supposed to do | 1 | 2 | 3 | 4 |
| 5. | I worry that I will let others down | 1 | 2 | 3 | 4 |

**Before or while I compete in sports:**

| | | Not at all | A little bit | Pretty much | Very much |
|---|---|---|---|---|---|
| 1. | I feel tense in my stomach | 1 | 2 | 3 | 4 |
| 2. | I lose focus on the game | 1 | 2 | 3 | 4 |
| 3. | I worry that I will not play my best | 1 | 2 | 3 | 4 |
| 4. | I worry that I will play badly | 1 | 2 | 3 | 4 |
| 5. | My muscles feel shaky | 1 | 2 | 3 | 4 |

**Before or while I compete in sports:**

| | | Not at all | A little bit | Pretty much | Very much |
|---|---|---|---|---|---|
| 1. | I worry that I will mess up during the game | 1 | 2 | 3 | 4 |
| 2. | My stomach feels upset | 1 | 2 | 3 | 4 |
| 3. | I cannot think clearly during the game | 1 | 2 | 3 | 4 |
| 4. | My muscles feel tight because I am nervous | 1 | 2 | 3 | 4 |
| 5. | I have a hard time focusing on what my coach tells me to do | 1 | 2 | 3 | 4 |

Scoring key: Somatic: 2, 6, 10, 12, 14; Worry: 3, 5, 8, 9, 11; Concentration disruption: 1, 4, 7, 13, 15

## Appendix 2

| | Almost never | Sometimes | Often | Always |
|---|---|---|---|---|
| When I need to concentrate and solve a problem, I have trouble focusing my attention | 1 | 2 | 3 | 4 |
| When I am working hard on something, I still get distracted by events around me | 1 | 2 | 3 | 4 |
| It's very hard for me to concentrate on a difficult task when there are noises around | 1 | 2 | 3 | 4 |
| When I am reading or studying, I am easily distracted if there are more people talking in the same room | 1 | 2 | 3 | 4 |
| When trying to focus my attention on something, I have difficulty blocking out distracting thoughts | 1 | 2 | 3 | 4 |
| I have a hard time concentrating when I'm excited about something | 1 | 2 | 3 | 4 |
| When concentrating I ignore feelings of hunger or thirst | 1 | 2 | 3 | 4 |
| After being interrupted or distracted, I can easily shift my attention back to what I was doing before | 1 | 2 | 3 | 4 |
| When a distracting thought comes to mind, it is easy for me to shift my attention away from it | 1 | 2 | 3 | 4 |
| I can quickly switch from one task to another | 1 | 2 | 3 | 4 |
| It takes me a while to get really involved in a new task | 1 | 2 | 3 | 4 |
| It is difficult for me to coordinate my attention between the listening and writing required when taking notes during lectures | 1 | 2 | 3 | 4 |
| I can become interested in a new topic very quickly when I need to | 1 | 2 | 3 | 4 |
| I have a hard time coming up with new ideas quickly | 1 | 2 | 3 | 4 |
| It is hard for me to break from one way of thinking about something and look at it from another point of view | 1 | 2 | 3 | 4 |
| My concentration is good even if there is music in the room around me | 1 | 2 | 3 | 4 |
| When concentrating I can focus my | 1 | 2 | 3 | 4 |

| | | | | |
|---|---|---|---|---|
| attention so that I become aware of what's going on in the room around me | | | | |
| It is easy for me to read or write while I'm also talking on the phone | 1 | 2 | 3 | 4 |
| I have trouble carrying on two conservations at once | 1 | 2 | 3 | 4 |
| It is easy for me to alternate between two different tasks | 1 | 2 | 3 | 4 |

## Appendix 3

*Sport Scenarios*

1) You have a ten-foot putt to win a tournament
What are you thinking?

I am one of the top putters in this tournament and have been putting well all day; I'm going to make this

| Doesn't pop up in my mind | | Might pop up in my mind | | Definitely pops up in my mind |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

This putt is too difficult for me; I'm definitely going to miss it

| Doesn't pop up in my mind | | Might pop up in my mind | | Definitely pops up in my mind |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

Whether I make this putt or miss it, I will be happy with my performance in this tournament

| Doesn't pop up in my mind | | Might pop up in my mind | | Definitely pops up in my mind |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

2) You are faced with a tough chip over a bunker to a tight pin
What are you thinking?

I have practiced this shot over and over, I can do this

| Doesn't pop up in my mind | | Might pop up in my mind | | Definitely pops up in my mind |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

I really don't want to chip this into the bunker

| Doesn't pop up in my mind | | Might pop up in my mind | | Definitely pops up in my mind |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

Just focus on your technique and trust yourself, it doesn't matter what the outcome is

| Doesn't pop up in my mind | | Might pop up in my mind | | Definitely pops up in my mind |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

3) You’ve got a tight tee shot with water on the right and out of bounds left
What are you thinking?

I barely ever miss fairways; I’m going to flush this straight down the middle

| Doesn’t pop up in my mind | | Might pop up in my mind | | Definitely pops up in my mind |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

I’ve been hitting it left and right all day, please just try and steer it between the two hazards

| Doesn’t pop up in my mind | | Might pop up in my mind | | Definitely pops up in my mind |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

Let’s just swing freely here and see what happens

| Doesn’t pop up in my mind | | Might pop up in my mind | | Definitely pops up in my mind |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

4) You’re going for a par 5 in two. You have to hit your best shot to get it there and there’s water short if you mishit it
What are you thinking?

I’m going to hit this on the green and make an eagle

| Doesn’t pop up in my mind | | Might pop up in my mind | | Definitely pops up in my mind |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

It would be horrible if I hit it in the water and made a bogey (or worse) on such an easy hole

| Doesn’t pop up in my mind | | Might pop up in my mind | | Definitely pops up in my mind |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

This is something that I’ve done many times before, let’s just do it again

| Doesn’t pop up in my mind | | Might pop up in my mind | | Definitely pops up in my mind |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

5) You have a three foot putt on the 18th to break par for the first time in your life. Your friends are all watching from the balcony
What are you thinking?

I have felt so good over my putts all day, there's no way I'm going to miss this

Doesn't pop up in my mind | Might pop up in my mind | Definitely pops up in my mind

1 2 3 4 5

This is so scary, everyone is going to laugh at me if I miss and I'll never have this chance again

Doesn't pop up in my mind | Might pop up in my mind | Definitely pops up in my mind

1 2 3 4 5

Miss or make, my friends will still think I'm great and I've had a great day on the course either way

Doesn't pop up in my mind | Might pop up in my mind | Definitely pops up in my mind

1 2 3 4 5

*Non-sport scenarios*

1) You bought some golf balls the other day, but never picked them up.
What are you thinking?

I'm looking in the wrong place but they're definitely around here somewhere

Doesn't pop up in my mind | Might pop up in my mind | Definitely pops up in my mind

1 2 3 4 5

They've been stolen

Doesn't pop up in my mind | Might pop up in my mind | Definitely pops up in my mind

1 2 3 4 5

There are just so many golf clubs here that mine is difficult to find

Doesn't pop up in my mind | Might pop up in my mind | Definitely pops up in my mind

1 2 3 4 5

2) You receive a telephone call from the bank
What are you thinking?

You have other more important things to do first

| Doesn't pop up in my mind | | Might pop up in my mind | | Definitely pops up in my mind |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

You completely forgot

| Doesn't pop up in my mind | | Might pop up in my mind | | Definitely pops up in my mind |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

It just didn't cross your mind

| Doesn't pop up in my mind | | Might pop up in my mind | | Definitely pops up in my mind |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

3) You receive your TV and broadband bill
What are you thinking?

They ring to tell you that you are approved for the loan

| Doesn't pop up in my mind | | Might pop up in my mind | | Definitely pops up in my mind |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

They ring to tell you that your credit rating is not good enough for the loan

| Doesn't pop up in my mind | | Might pop up in my mind | | Definitely pops up in my mind |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

They ring to tell you they need more information to complete the application

| Doesn't pop up in my mind | | Might pop up in my mind | | Definitely pops up in my mind |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

4) You've put your golf clubs somewhere and when you go back for them later on, you can't find them.
What are you thinking?

The company is giving you three free channels for three months

| Doesn't pop up in | | Might pop up in my | | Definitely pops up in |
|---|---|---|---|---|

| my mind | | mind | | my mind |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

The company is charging you for sport channels that you did not ask for

| Doesn't pop up in my mind | | Might pop up in my mind | | Definitely pops up in my mind |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

The company sent you your monthly bill

| Doesn't pop up in my mind | | Might pop up in my mind | | Definitely pops up in my mind |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

5) You receive a telephone call from your landlord
What are you thinking?

They are refunding some of your rent back to you

| Doesn't pop up in my mind | | Might pop up in my mind | | Definitely pops up in my mind |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

They are evicting you from the rented property

| Doesn't pop up in my mind | | Might pop up in my mind | | Definitely pops up in my mind |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

They are calling to acknowledge your rent payment

| Doesn't pop up in my mind | | Might pop up in my mind | | Definitely pops up in my mind |
|---|---|---|---|---|
| 1 | 2 | 3 | 4 | 5 |

**Appendix 4**

People often think about things they don't want to happen to them during competition. Some examples of these undesirable outcomes are "*this one is not going in either*" or "*I'm not going to be able to win this*".

Think about the things that generally ***worry*** you when competing in *your* sport.

In the five boxes below we would like you to list the ***five*** undesirable outcomes you think about most often.

| | |
|---|---|
| 1 | |
| 2 | |
| 3 | |
| 4 | |
| 5 | |

For *each* outcome, we would like you to indicate ho***w probable*** they are to actually happen

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Outcome 1** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | Extremely unlikely | | | | | | Extremely likely |
| **Outcome 2** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | Extremely unlikely | | | | | | Extremely likely |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Outcome 3** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | Extremely unlikely | | | | | | Extremely likely |
| **Outcome 4** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | Extremely unlikely | | | | | | Extremely likely |
| **Outcome 5** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | Extremely unlikely | | | | | | Extremely likely |

For *each* outcome, we would like you to indicate ***how upset*** you would feel if the outcome actually happened.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Outcome 1** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | Not at all upset | | | | | | Extremely upset |
| **Outcome 2** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | Not at all upset | | | | | | Extremely upset |
| **Outcome 3** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | Not at all upset | | | | | | Extremely upset |
| **Outcome 4** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | Not at all upset | | | | | | Extremely upset |
| **Outcome 5** | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| | Not at all upset | | | | | | Extremely upset |

**Appendix 5**

The state version of the State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch & Lushene, 1970).

A number of statements which people have used to describe themselves are given below. Read each statement and then circle the appropriate number to the right of the statement to indicate how you feel ***right now***, that is, ***at this moment***.

There are no right or wrong answers. Do not spend too much time on any one statement but give the answer which seems to describe your present feelings best.

| | **Not at all** | **Somewhat** | **Moderately so** | **Very much so** |
|---|---|---|---|---|
| I feel calm | 1 | 2 | 3 | 4 |
| I feel secure | 1 | 2 | 3 | 4 |
| I feel tense | 1 | 2 | 3 | 4 |
| I feel strained | 1 | 2 | 3 | 4 |
| I feel at ease | 1 | 2 | 3 | 4 |
| I feel upset | 1 | 2 | 3 | 4 |
| I am presently worrying over possible misfortunes | 1 | 2 | 3 | 4 |
| I feel satisfied | 1 | 2 | 3 | 4 |
| I feel frightened | 1 | 2 | 3 | 4 |
| I feel comfortable | 1 | 2 | 3 | 4 |
| I feel self-confident | 1 | 2 | 3 | 4 |
| I feel nervous | 1 | 2 | 3 | 4 |
| I am jittery | 1 | 2 | 3 | 4 |
| I feel indecisive | 1 | 2 | 3 | 4 |
| I am relaxed | 1 | 2 | 3 | 4 |
| I feel content | 1 | 2 | 3 | 4 |
| I am worried | 1 | 2 | 3 | 4 |
| I feel confused | 1 | 2 | 3 | 4 |
| I feel steady | 1 | 2 | 3 | 4 |
| I feel pleasant | 1 | 2 | 3 | 4 |

**Appendix 6**

**Appendix 7**

**Low Pressure instructions**

We will shortly ask you to perform a golf putting task consisting of nine putts. The aim of this task is to get the ball in the hole or finish the ball as close to the hole as you possibly can with each putt. We will instruct you when you may begin each putt, and then you can hit each putt in your own time. After each putt, we will record the distance the ball finishes from the hole. Please just try your best.

**High pressure instructions**

We will shortly ask you to perform a golf putting task consisting of nine putts. This is the most important part of the experiment and it is very important that you try to get the ball in the hole or finish the ball as close to the hole as you possibly can with each putt. We will instruct you when you may begin each putt, and then you can hit the putt in your own time. After each putt we will record the distance the ball finishes from the hole and ask you a few questions.

You are being paired with another participant for this part of the study and your previous performance was actually your first set of results. You are competing against other pairs and based on your partners' results you are top of the leader board. You need to maintain your partners lead in order to win. At the end of the study the leader board will be emailed to all participants. We will also be videoing your performance attempts and golf experts will be looking at them to evaluate your technique. You must improve your performance in order to bring yourself and your partner up the table.