Examining a Three-Dimensional Model of Competitive State Anxiety in Sport

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Dedication

Mum and Dad, this thesis is dedicated to you.

R11

Certificate of Research

This is to certify that, except where specific reference is made, the work described in this thesis is the result of the candidate's research. Neither this thesis, nor any part of it, has been presented, or is currently submitted, in candidature for any degree at any other University.

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Abstract

Within the sport psychology literature, it has been widely documented that experiencing competitive state anxiety does not always lead to performance impairments. Taking this into consideration, a three-dimensional model explaining the potential adaptive nature of anxiety was proposed by Cheng et al. (2009); however, little research has tested this model since its development. Subsequently, this thesis reassessed the measurement model because of limitations found in previous measurement model specifications (Cheng et al., 2009; Jones et al., 2019) and examined the model in relation to sport performance. Specifically, Study 1 addressed the limitations of formative measurement used in previous studies and developed the Three Factor Anxiety Inventory-2 (TFAI-2) by examining the factor structure of possible bifactor models using Bayesian structural equation modelling (BSEM). Two different participant samples provided support for a bifactor model with five specific factors (worry, private self-focus, public self-focus, physiological anxiety and perceived control) and one general factor, cognitive anxiety, that encompassed the items reflecting worry, private and public self-focus. Study 2 provided further support for this bifactor model and explored the predictive validity of the three main dimensions within the context of invasion game team sports and Finnish baseball. The findings revealed extreme evidence for perceived control predicting athletes' self-rated performance within the team sport participant sample and batting performance within the Finnish baseball participant sample over and above cognitive and physiological anxiety; however, the hypothesised impact of interaction effects was not supported. Study 3 examined the impact of high and low levels of perceived control on cognitive anxiety, physiological anxiety, effort, and netball shooting performance in simulated high and low anxiety conditions. Analyses revealed no differences between participants in the low anxiety condition. In the high anxiety condition, both high and low perceived control groups reported significant increases in heart rate and cognitive anxiety. However, participants in the high perceived control group maintained their perceptions of control, netball shooting performance and significantly increased their effort, while those in the low perceived control group maintained their effort but experienced significant decreases in their perceptions of control and performance. In light of the findings herein, this thesis provides a unique and significant contribution to the research area in four main ways: (1) it developed the TFAI-2 and supported the factor structure with three different participant samples; (2) the findings suggest that perceived control is as important to understanding the anxiety-performance relationship as cognitive and physiological anxiety; (3) the first experimental study grounded in Cheng et al.'s three dimensional model of competitive anxiety was developed; and (4) many methodological recommendations, such as implementing Bayesian statistics were adopted throughout. The thesis concludes with a discussion of the methodological, theoretical, and practical implications, strengths and limitations, and directions for future research.

Chapter 1

Introduction

The difference between success and failure in sport, put simply, depends on an athlete's ability to effectively execute motor skills and perform optimally under heightened levels of pressure. However, the formula for thriving and performing optimally under pressure is complex and one that coaches, sport psychologists and researchers alike are still striving to understand. A key contributing factor is the anxiety-performance relationship and therefore, it is unsurprising that there is a plethora of research dedicated to examining competitive state anxiety and its impact on performance (e.g., Jones, 1995; Leibert & Morris, 1967; Martens et al., 1990a; Shah et al., 2020; Woodman & Hardy, 2003). Historically, much of the research has focused on the potential negative effects of competitive state anxiety (e.g., Burton, 1988; Raglin, 1992) and the occurrence of "choking" (e.g., Hill et al., 2010). For example, Greg Norman's performance at the 1996 US Masters, in which Norman had an almost unbeatable lead at the start of the last day; however, he dramatically ended the day 6 over par and lost the competition. Norman's response was, "never in my career have I experienced anything like what happened…I was totally out of control and I couldn't understand it" (Jackson & Beilock, 2008).

Despite this well documented negative impact, a theme emerged from two reviews (Jones, 1995; Woodman & Hardy, 2001) suggesting that competitive anxiety does not always lead to performance impairments. With this in mind, Cheng et al. (2009) re-conceptualised competitive state anxiety with a model that attempted to explain the adaptive nature of the anxiety response. However, Cheng et al.'s re-conceptualisation has received little research attention, with only a few researchers endeavouring to examine the model (Cheng et al., 2011; Cheng et al., 2016; Jones et al., 2019).

Purpose of this thesis

In order to explore the potential adaptive nature of anxiety, the purpose of this thesis was to contribute to the development of the anxiety literature by examining Cheng et al.'s (2009) three-dimensional model of competitive state anxiety and the developments proposed by Jones et al. (2019). More specifically, the overall aim was to further explore the inclusion of the regulatory dimension; a construct that has not been integrated in previous competitive state anxiety theories. Associated with this aim were the following objectives:

- Reassess the reflective-formative measurement model proposed by Jones et al. (2019);
- Examine Cheng et al.'s (2009) proposed relationships between the three main dimensions (cognitive anxiety, physiological anxiety, and the regulatory dimension) and sporting performance;
- Investigate the impact of the regulatory dimension on athletes' performance during competition.

Structure of this thesis

This thesis comprises six main chapters and consists of four empirical studies. Following this introduction, Chapter 2 provides a critical review of the competitive state anxiety research in sport. The first section of the review outlines the definitions of stress, anxiety and arousal adopted for this programme of research. Second, the origins of anxiety are introduced, while the third section focuses on several influential competitive state anxiety theories, including the Multidimensional Anxiety Theory (MAT; Martens et al., 1990a) and the Cusp Catastrophe Model (Hardy & Fazey, 1987). The fourth section explores the concept of control within the anxiety-performance relationship and concludes with an in-depth review of the three-dimensional model of competitive anxiety (Cheng et al., 2009) and more recent developments proposed by Jones et al. (2019). Finally, the fifth section of the review discusses problems faced with the measurement of competitive state anxiety and how imprecise methods may be hindering the development of the literature.

The purpose of Chapter 3 (Study 1) was three-fold. First, the reflective-formative measurement model of the three-dimensional model of competitive anxiety proposed by

Jones et al. (2019) was re-considered and bifactor models were specified. Second, two different bifactor models were tested (*N* = 516), and third, Bayesian Structural Equation Modelling (BSEM) was adopted in order to address recommendations from previous researchers (e.g., Gucciardi & Zyphur, 2016; Niven & Markland, 2016). Findings provided empirical support for a bifactor model that consisted of six latent variables: five specific factors (worry, private self-focus, public self-focus, physiological anxiety, and perceived control) and one general factor (cognitive anxiety). Support for this bifactor model was replicated in a second participant sample (*N* = 174) and the revised measure was renamed the Three Factor Anxiety Inventory-2 (TFAI-2).

Chapter 4 (Study 2a and 2b) aimed to provide further support for the new bifactor model whilst also examining the predictive validity of the model on competitive sporting performance. To achieve this aim two participant samples were recruited. The first sample (Study 2a) consisted of athletes (*N* = 159) competing in invasion game sports (e.g., rugby, basketball, and football), whilst the second sample (study 2b) comprised Finnish baseball players (*N* = 117). Participants' responses to the TFAI-2 were grouped (*N* = 276) and subject to BSEM which validated the bifactor model for a third time.

In order to examine the predictive validity, Bayesian hierarchical regression was conducted. Findings revealed extreme evidence for perceived control predicting athletes' self-rated performance (Study 2a) and Finnish baseball players' batting performance (Study 2b) over and above cognitive and physiological anxiety and the interaction effects. Collectively, these findings support the inclusion of the regulatory dimension, reflected by perceived control, in Cheng et al.'s reconceptualisation of competitive state anxiety.

Chapter 5 (Study 3) presents an examination of the impact of the regulatory dimension in a situation of heightened pressure. Netball players experienced low or high perceived control instructions before completing a netball shooting task in low and high anxiety conditions. The main aim of this study was to examine the experimental effects of perceived control on netball shooting performance, cognitive anxiety, physiological anxiety, heart rate and effort, as previous studies have only reported its predictive validity. Findings revealed no differences between groups (high vs. low perceived control) in the low anxiety condition. In contrast, participants in the low perceived control condition maintained their effort but suffered significant decreases in both their perceptions of control and netball shooting performance, whereas those in the high perceived control group significantly increased their effort and maintained their perceptions of control and netball shooting performance in the high anxiety condition. Study 3 fully supported the assumptions of Cheng et al.'s competitive state anxiety model.

The final chapter of this thesis (Chapter 6) presents the overall findings from the four empirical studies and discusses the theoretical and methodological implications. Practical implications for sport psychologists, coaches and parents are also considered, and future theoretical and applied research directions presented.

Considerations in the presentation of this thesis

This thesis is presented in the following format in order to ensure consistency throughout: (1) American Psychological Association (APA) 7th Edition, (2) the table and figure numbers do not re-start for each chapter, and (3) there is one references list for all chapters at the end of the general discussion (Chapter 7). In addition, appendices are provided following the reference list which include copies of the measures used in all studies. APA formatting was used because author's training is within the discipline of sport psychology. Therefore, the supervisory team recommended the continued use of APA to ensure that the research training developed the appropriate skills to publish in sport psychology journals.

Chapter 2

Literature Review

Introduction

The aim of this chapter is to provide a review of the competitive state anxiety literature and offer the theoretical underpinnings for the research aims and questions examined within this thesis. To provide some structure to this review, the chapter is presented in five sections, beginning with definitions of key constructs. Second, the origins of anxiety are outlined, then section three provides a review of competitive state anxiety theories, from early unidimensional arousal-based theories to multidimensional theories. The fourth section explores the adaptive nature of anxiety that evolved within the literature, including reference to processing efficiency theory (PET; Eysenck & Calvo, 1992) and Carver and Scheier's (1988) control perspective, and concluding with a detailed review of the three-dimensional model of competitive state anxiety (Cheng et al., 2009). Finally, the fifth and concluding section explores the measurement of competitive state anxiety and the problems faced with the use of confirmatory factor analysis (CFA), which has also led researchers to pay less attention to measurement model specification. Within this section, the key points emanating from the review are summarised and avenues for future research are discussed.

Stress, Anxiety and Arousal Defined

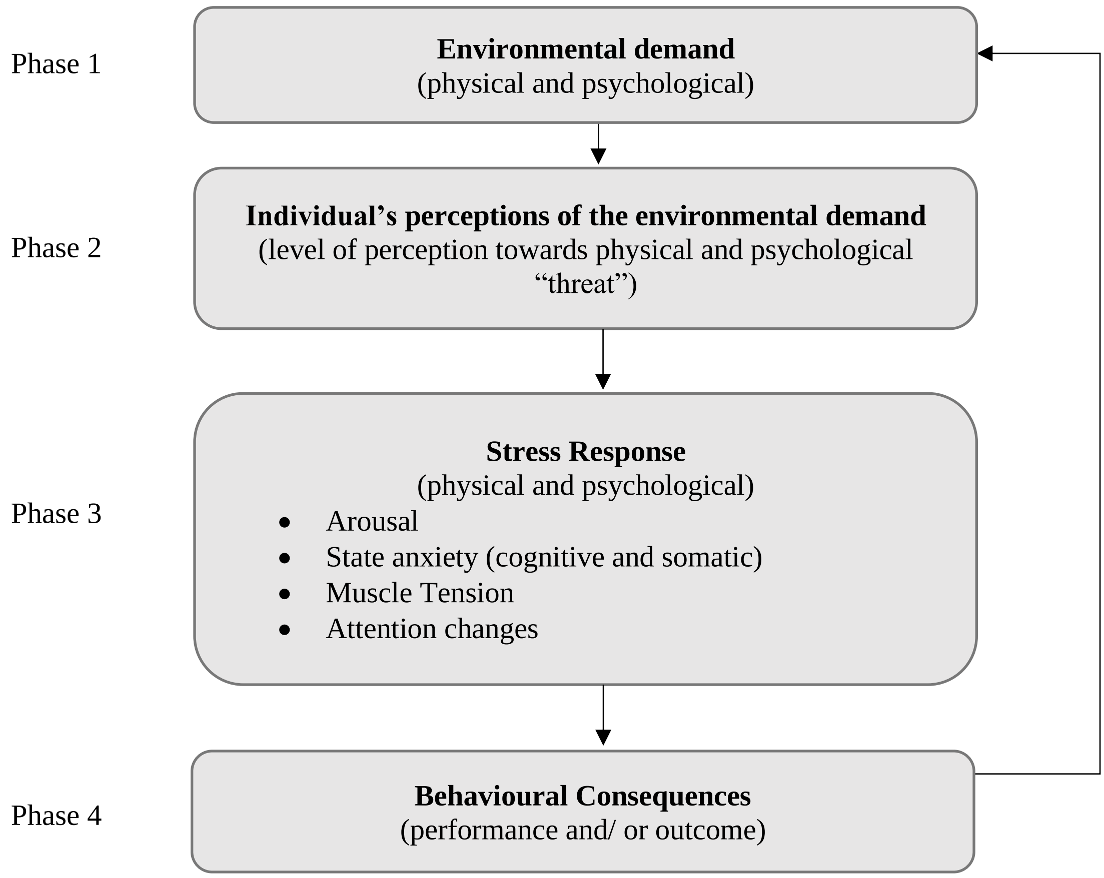
A lasting problem in sport psychology research has been the inconsistent and inaccurate use of the terms, "stress", "anxiety", and "arousal" (Woodman & Hardy, 2001). This has led to and will continue to lead to contradictory conclusions; thus, it is important to be transparent about the terminology used.

As sport psychology was becoming a speciality area in the late 1970s, stress was one of the initial focal points. During this time Seyle's (1956) work had infiltrated psychology research and the term "stress" in sport psychology was used in much the same way. Seyle's (1956) earliest work defined the concept as, "the non-specific response of the body to any demand placed on it" (p. 14). The phenomenon of "eustress" was then introduced in his formulation of general adaptation syndrome. Emphasis was placed on the adaptive nature of stress reactions and subsequently the terms “distress” and “eustress” were used to distinguish the non-adaptive and adaptive effects to stress reactions, respectively (Seyle, 1976).

Adopting a similar line of thinking, McGrath (1970) developed a process model that encapsulated the definition of stress and its outcomes. He defined stress as a “substantial imbalance between demand (physical and/ or psychological) and response capability, under conditions where failure to meet that demand has important consequences” (p. 20); this was the definition adopted in the present thesis. McGrath’s process model of stress, depicted in Figure 1, suggests that the effects of a stressor are dependent on the extent to which it is perceived as being disruptive to psychological and/ or physiological homeostasis (preventing a need/outcome to be fulfilled or offering the potential for fulfilling an important need/outcome). Thus, the relationship between the stressor and the individual’s perceptions of the situation can vary, portraying the potential for many different outcomes. For instance, a tennis player may perceive competing on Centre Court at Wimbledon threatening, whereas another tennis player may thrive at the thought of showcasing their ability to a large audience. The negative response experienced by the first tennis player may result in worrying thought patterns and in turn disrupted performance. The second tennis player is faced with the same demanding situation; however, they have perceived it as a challenge, which may lead to a superior performance outcome. As such, McGrath’s stress process explains that it is the individual’s perception of whether they can cope with the demand placed on them that predicts this relationship with performance. This stress process has also been highlighted by Fletcher et al. (2006), who distinguished between the terms “stressor” and “strain”. Stressors are characterised as the environmental demands that are associated with competitive performance, and strain is a negative psychological, physical, and/or behavioural response to the stressor. A stressor may not always impose a strain on the athlete, as long as the athlete perceives they have the ability to cope with the demand of the stressor.

Figure 1

McGrath's (1970) Four-Stage Process Model of Stress



Note. This figure was produced by McGrath in 1970, summarising the four stages to a stress response (as reprinted in Pa et al., 2020). From "Sports massage therapy towards pre-competition anxiety among Malaysian high-performance tennis players", by W. A. N. W. Pa et al., 2020, *1st Progress in Social Science, Humanities, and Education Research Symposium (PSSHERS 2019)*, p.1074 (https://doi.org/10.2991/assehr.k.200824.235). Copyright 2006-2020 by Atlantis Press.

As shown in Figure 1, the occurrence of a stressor may also lead to arousal, which has been used interchangeably with the terms activation, and anxiety causing confusion in the literature (Barry et al., 2005). Consequently, there is a need to distinguish between the terms “arousal”, “activation” and “anxiety”. In order to differentiate between arousal and activation Barry et al. (2005) among others, drew upon the separation proposed by Pribram and McGuiness’ (1975) in their model of attention. Pribram and McGuiness distinguished between arousal and activation through identifying three energetical components; arousal, activation and effort. Arousal was defined as the organism’s immediate response to some new input, whilst activation was described as the organism’s readiness to respond. In this context effort was then viewed as being responsible for the co-ordination of the arousal and activation resource pools. Hardy et al., (1996) adopted this distinction and defined arousal as the psychological and physical activity that occurs in response to a new input, varying on a continuum of deep sleep to intense excitement, whereas activation was defined as the psychological and physiological activity resulting from the preparation of a planned response to an expected situation. For example, it may be assumed that a professional footballer would be in an appropriate activation state when stepping up to take a penalty kick. However, if during this motion the goalkeeper unexpectedly jumps (new input) just before the footballer kicks the ball, the activation state may be interrupted by an arousal response, which may result in a missed penalty kick. Therefore, activation refers to the body’s activity during a planned response, whereas arousal refers to the body’s activity in response to a new input (Hardy et al., 1996) and this is the distinction the present thesis will adopt.

Anxiety is also a separate construct to arousal and activation and should be defined. Specifically, anxiety has been characterised as prevalent thoughts and feelings of worry, concern and uncertainty (Martens et al., 1990a; Woodman & Hardy, 2001), and can be divided into state (context-specific or situational) and trait (dispositional) dimensions (Spielberger, 1966). Furthermore, many theories of anxiety suggest that it is multidimensional in nature and comprises cognitive (negative thoughts and worries) and physiological (perceptions of somatic and autonomic physiological symptoms) constructs (e.g., Cheng et al., 2009; Liebert & Morris, 1967; Martens et al., 1990a). In relation to a sporting context, Cheng et al., (2009) defined the construct of competitive state anxiety as, "an unpleasant psychological state in reaction to perceived threat concerning the performance of a task under pressure" (p. 271). This definition will be adopted for the present research and an in-depth discussion of Cheng et al.'s model can be found in section three of the current chapter (p. 28), whilst the following paragraph explores the origins of anxiety in more detail.

Origins of Anxiety

Öhman (2000) explored the phenomenon of anxiety from an evolutionary perspective and argued that anxiety responses originate from an alarm system intended to protect individuals from impending danger. This alarm system is protective as it acts as a defence mechanism that is meant to be adaptive; it sends out warning signals alerting the individual to prepare and respond effectively to perceived threat (Öhman, 2000). In evolutionarily terms, it was more hazardous and costly to experience false negatives (i.e., failing to defend against potentially threatening stimuli) than false positives (i.e., effectively engaging a defence mechanism to a stimulus that was actually harmless), providing an explanation for why there are anxiety disorders (Öhman, 2008). Individuals are programmed to "play it safe", thus sometimes activating a defence response that on closer examination turned out to be unnecessary because the situation was non-dangerous. Such responses have been termed "irrational anxiety" (Öhman, 2008); however, the emphasis should be placed on the root of anxiety stemming from a protective function, which is activated through correctly anticipating threat (Eysenck, 1992) and mobilizing resources to provide energy and prepare for action (Calvo & Cano-Vindel, 1997; Calvo et al., 2003). Many other theorists have also highlighted a regulatory process, or an adaptive capacity involved within the anxiety response (Eysenck & Calvo, 1992; Mathews, 1992; Öhman, 2000), owing to the notion that anxiety can be adaptive and facilitative in nature.

Further arguments for the adaptive capacity of anxiety can be found in the clinical domain. In particular, the main characteristic that differentiates anxiety from depression is the ability to utilise a regulatory process or control system (Eysenck, 1992; Mathews, 1992). Specifically, individuals diagnosed with depression show passive disengagement with the environment and thus exhibit little use of such a control system to cope adaptively with perceived stress, whereas anxious individuals in response to threat actively engage with the environment (Eysenck, 1992) and simultaneously evaluate their capacity to be able to cope with the situation (Cheng et al., 2009). In addition, the diagnosis of generalised anxiety disorder was traditionally concerned with excessive levels of anxiety, however in 1994, more contemporary guidelines were administered that emphasised uncontrollability in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; APA, 1994). In other words, the criteria for diagnosing maladaptive anxiety included not only the amount of anxiety experienced but also examined differing levels of an individual's regulatory capacity.

Representations of regulatory processes can also be found in social perspectives of stress, emotion, and coping theories (Gross, 1998; Gross et al., 2011; Lazarus & Folkman; 1987). For example, Lazarus and Folkman (1987) proposed a transactional stress model that emphasised the person-environment transaction and suggested that a stress response is highly influenced by individual appraisal processes. Once an individual is subjected to stress, they evaluate the relevance of the stressor (primary appraisal) and their resources to overcome the stressor (secondary appraisal). Primary and secondary appraisals were purported to have an impact on the coping strategies chosen, which in turn affects the individual's immediate stress response, as well as long-term health, psychological well-being, and social functioning. Emotion-regulatory processes have also been explored as moderators of the relationship between stressors and well-being (Gross et al., 2011). This perspective suggests that emotion reactivity is the result of two interactive processes: emotion generation and emotion regulation. Emotion generation refers to the initial emotional response that arises when an individual experiences a situation that challenges their personal goals, whilst emotion regulation refers to an individual's attempt to modify and control the emotion-generative process (e.g., controlling their reaction and regulating their emotional response in relation to their goals, rather than reacting to the challenging situation which may impede their goal). Subsequently, it has been suggested that emotions can be regulated in numerous ways (Gross, 1998).

Within the anxiety response specifically, regulatory processes have been highlighted in integrated models. For example, Rost and Schermer (1992) developed a model of test anxiety that included dimensions of initiation, manifestation, coping and stabilisation. Another example is Carver and Scheier's (1988) control-process perspective on anxiety, which suggested an individual's expectancies concerning their ability to be able to cope was a fundamental factor in determining their responses to anxiety. In addition, Eysenck and Calvo (1992) proposed that a control system is activated whilst anxious, which monitors and evaluates performance in response to perceived threat whilst also planning and regulating the use of processing resources.

In relation to sporting theories of competitive anxiety, Cheng and colleagues (2009) were the first to address the apparent adaptive nature of anxiety by including a regulatory dimension within their conceptualisation. The present thesis advocates this stance and integrated models of anxiety that involve an adaptive capacity are discussed in section three of this Chapter. However, before exploring these theories, the next section provides a review of the earlier competitive state anxiety theories in sport in order to give the reader an understanding of how this literature has developed.

Performance Anxiety Theories

Exploration into the nature of the anxiety-performance relationship within sport psychology has generated a large number of theoretical stances. Early theories such as drive theory (Hull, 1943) and the inverted-U theory (Yerkes & Dodson, 1908) were unidimensional and arousal-based explanations. Hanin (1978) developed the Individual Zones of Optimal Functioning (IZOF), which tapped into multidimensionality. Other multidimensional theories including the Multidimensional Anxiety Theory (MAT; Martens et al., 1990a) and the Cusp Catastrophe Model (Hardy & Fazey, 1987), were grounded in Liebert and Morris's (1967) Worry-Emotionality theory from the test anxiety literature. The Cusp Catastrophe Model also concentrated on an interactive approach that was later extended to the Butterfly Model (Hardy, 1996a). In the following section, each of these theories will be discussed, and several conceptual and empirical issues considered.

Unidimensional Theories

The first theories that attempted to explain the anxiety-performance relationship were dominated by general arousal-based explanations in the form of Drive theory (Hull, 1943), later modified by Spence and Spence (1966) and the Inverted-U hypothesis (Yerkes & Dodson, 1908). Drive theory proposed that the relationship between sporting performance and drive (used synonymously with arousal, anxiety and stress) was linear and the direction in which performance would decrease or increase was dependent on an athlete's dominant response. For example, Hull explained that in the earlier stages of learning an individual's dominant response is frequently incorrect, as the skill has not been well learned; therefore, increases in arousal/drive were hypothesised to be detrimental to performance. On the other hand, when the skill has been well learned and the dominant response is correct, then an increase in arousal would enhance performance. In a similar vein, the inverted-U theory (Yerkes & Dodson, 1908) explained that heightened arousal would enhance performance to a certain point, but if arousal increased beyond this point then performance would decline.

Both theories have been criticised for three notable reasons. First, there is a clear lack of empirical support (e.g., Martens, 1974; Neiss, 1988). Second, a central criticism is the simplicity in the suggestion that arousal is a unitary construct that has a linear or curvilinear relationship with performance (Hanin 1978). Third, and due to the simple nature of the theories, the effects of complex tasks were not addressed (e.g., Fisher, 1976) and consequently could only relate to general effects on global performance outcomes. That is, specific effects of arousal on different performance variables (e.g., information processing efficiency) were ignored (Eysenck, 1984). Therefore, the Drive theory and the inverted-U theory were too simplistic and incapable of explaining the relationships between arousal and the subcomponents of performance (Hockey & Hamilton, 1983).

Hanin (1978) attempted to address the above limitations by proposing an alternative theory formulated from an individualised perspective; Individual Zones of Optimal Functioning (IZOF). IZOF suggests that each athlete has an individual optimal level (high, moderate, or low) of intensity or zone of anxiety associated with peak performance. This zone focuses on intra-individual dynamics and inter-individual differences in the intensities of subjective emotional experiences related to performances and suggests that there is unlikely to be a single, specific optimal intensity zone of anxiety that results in best or poor performance for all athletes (Hanin, 1995). Additionally, if an athlete's pre-competition anxiety falls outside of their optimal zone, IZOF suggests that they are likely to experience performance decrements. Further developments were made to the IZOF model that included five basic dimensions; form, content, intensity, time, and context, which described different aspects of anxiety (Hanin, 2003). Despite this development and the inclusion of multiple dimensions, IZOF still fails to acknowledge the different aspects of the anxiety response, such as an athlete's cognitive appraisals (Gill, 1994). Therefore, the theories outlined thus far underrepresent the complexity of both arousal and anxiety responses (Burton, 1988). Hence there was a need for researchers to adopt a multidimensional approach that specifically described the anxiety response in relation to sporting performance.

Multidimensional Theories

Anxiety was first represented as a multidimensional construct in the 1960s and 1970s within the clinical, psychophysiological and test anxiety literature (Davison & Schwartz, 1976; Lacey, 1967; Leibert & Morris, 1967). These multidimensional properties emerged in the development of the Worry-Emotionality Inventory established by Liebert and Morris (1967), who proposed that feelings of worry represented the cognitive aspect of the anxiety response, whilst an emotionality dimension represented the physiological response to anxiety. Martens et al. (1990a) were the first to adopt this approach within a sport context and in so doing, developed the Multidimensional Anxiety Theory (MAT). The MAT uses a series of two-dimensional relationships, proposing that cognitive anxiety would have a negative linear relationship with performance and somatic anxiety would have a quadratic relationship with performance. In order to test such relationships, Martens et al. (1990b) developed a measurement tool called the Competitive State Anxiety Inventory-2 (CSAI-2). However, a third dimension identified as self-confidence emerged during the validation. Martens et al. (1990b) argued that self-confidence could be placed at the end of a continuum, with worry occupying the opposite end. In so doing, it was hypothesised that self-confidence and performance would be related in a positive linear manner. The CSAI-2 became the gold standard measure in the competitive anxiety literature (Jones, 1995); however, the underpinning argument for including self-confidence is theoretically flawed (for a comprehensive discussion on competitive state anxiety measurement see p. 35). For instance, prior to the development of MAT many researchers explained that self-confidence and cognitive anxiety responses to pressurised situations are orthogonal (e.g., Carver & Scheier, 1988; Hardy & Whitehead, 1984; Thayer, 1978). Therefore, athletes can experience both anxiety and self-confidence. On the other hand, the inclusion of self-confidence, although flawed, may signify the first attempt to tap into the adaptive nature of anxiety. The construct that emerged when developing the CSAI-2 may have been the adaptive nature of anxiety misinterpreted as self-confidence.

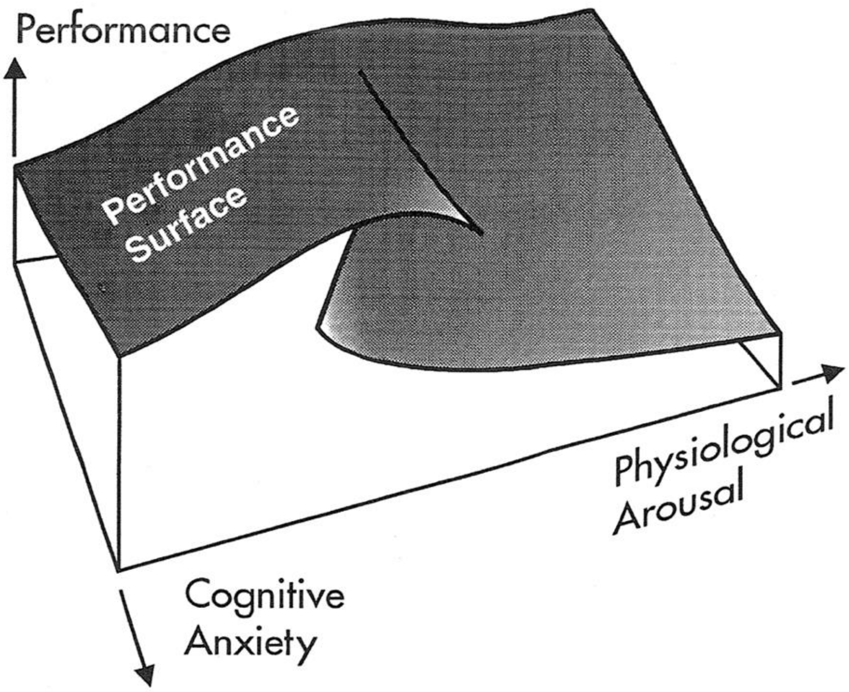
Nevertheless, the MAT was scrutinised in Burton's (1988) review and Woodman and Hardy's (2003) meta-analysis. Burton (1988) only found strong support for the predictions of MAT in two out of 16 papers testing the theory, while Woodman and Hardy (2003) revealed a weak to moderate relationship between MAT's subcomponents and performance. One explanation for this lack of support may be due to the fact that MAT only considers the additive effects of cognitive and somatic anxiety on performance and not the interactive effects between these dimensions (Hardy et al., 1996). The anxiety-performance relationship was still not fully captured using MAT, which led sport psychologists to apply more complex models in order to explain interactive effects which had previously been missed.

The cusp catastrophe model initially developed by Hardy and Fazey (1987) and further explored by Hardy and colleagues (e.g., Hardy 1996b; Hardy & Parfitt, 1991), represented an alternative multidimensional approach. Hardy and Fazey (1987) proposed that a serious weakness in previous research was examining the separate effects of cognitive and somatic anxiety on performance, arguing that future research should concentrate on their interactive effects. Adopting an interactive approach, the predictions of the cusp catastrophe model suggested that, when cognitive anxiety was low, there would be an inverted–U relationship between physiological arousal and performance; when cognitive anxiety was very high, performance would improve as physiological arousal increased to a certain point. If physiological arousal continued to increase beyond this point, then a catastrophic drop from an upper performance curve to a lower performance curve would occur. These are opposing curves, whereby the upper represents performance when physiological arousal is increasing and the lower represents performance when physiological arousal is decreasing. Therefore, the same level of physiological arousal could be associated with different levels of performance, dependent on whether arousal was increasing or decreasing. This phenomenon was known as the ‘hysteresis hypothesis’. The model also hypothesised that when physiological arousal was high, then a negative correlation was predicted between cognitive anxiety and performance. In contrast, a positive correlation between cognitive anxiety and performance was predicted when physiological arousal was low (see Figure 2).

While the initial tests of the cusp catastrophe model on basketball (Hardy & Parfitt, 1991), bowls (Hardy et al., 1994) and softball players (Krane et al., 1994) provided some support for the aforementioned predictions, the model is not without its critics. One pertinent criticism of these tests regards the way in which Hardy and colleagues manipulated physiological arousal. Physiological arousal was increased via physical exercise and measured by a heart rate monitor. Therefore, the physiological arousal recorded in these studies actually reflected the physical effort to complete the tasks and not anxiety induced physiological arousal (Hardy, 1999). Therefore, it may be argued that there is some ambiguity about the nature of physiological arousal within the model, as it could also be exercise-induced physiological arousal, exercise-induced effort, or anxiety-induced effort (Hardy, 1999). Further critics suggested the need for more sophisticated models that include constructs that may mediate the anxiety-performance relationship, such as self-confidence and task difficulty (Cohen et al., 2003).

Figure 2

The Upper and Lower Performance Surfaces of the Cusp Catastrophe Model of Anxiety and Performance



Note. This figure was produced by Hardy in 1996, adapted from Fazey and Hardy (1987) with permission from the authors. It displays the interactive effects of cognitive anxiety and physiological arousal on sporting performance (as reprinted in Hardy, 1996b). From "Testing the predictions of the Cusp Catastrophe model of anxiety and performance", by L. Hardy, 1996b, *The Sport Psychologist, 10,* pg.143 (https://doi.org/10.1123/tsp.10.2.140). Copyright 2020 by Human Kinetics.

Integration of Self-Confidence and Self-Efficacy

Self-confidence was integrated into the anxiety-performance relationship a second time as part of Hardy's (1996a) butterfly catastrophe model. Hardy (1990) accepted that self-confidence and anxiety were orthogonal and suggested that those who perform well when experiencing high levels of anxiety (high cognitive anxiety and physiological arousal) may also be experiencing high levels of self-confidence. Therefore, self-confidence was included as a mediating factor in the butterfly model, which is an extension of the catastrophe model outlined above and includes two additional factors; a bias factor and a butterfly factor. Hardy (1996a; 1996b) suggested that the bias factor represented self-confidence, meaning that self-confidence could moderate the interaction between cognitive anxiety and physiological arousal. It was proposed that high levels of self-confidence would allow performers to endure high levels of physiological arousal whilst also experiencing cognitive anxiety before suffering the catastrophic drop in performance. Hardy et al. (2004) employed a segmental quadrant analysis to test this proposal. Results showed that when athletes had low self-confidence and somatic anxiety was low, then cognitive anxiety was positively related to performance; exactly as predicted by the butterfly catastrophe model. However, when self-confidence was high, cognitive anxiety was more positively related to performance under high somatic anxiety rather than low, contradicting the model. Hardy and colleagues suggested that this occurred because the “high” somatic anxiety experienced was near the cusp (just before the catastrophic drop). Therefore, it was concluded that these findings fully supported the proposed model. On this note, others have argued that the catastrophe models are “plastic” and empirical findings can be stretched to meet the hypotheses of the model, thus being difficult to disprove and having limited practical value for sport psychologists (Gill, 1994).

Bandura (1977) also proposed a relationship between self-efficacy and anxiety in the development of self-efficacy theory. Bandura (1986) defined self-efficacy as “people’s judgements of their capabilities to organise and execute courses of action required to attain designated types of performances” (p. 391). That is, self-efficacy is a situation specific form of self-confidence (self-confidence being a global trait or state), whereby individuals believe they can achieve what is needed in a given situation. Bandura suggested that an individual’s levels of self-efficacy would be determined by four main sources of information: performance accomplishments, verbal persuasion, emotional arousal and vicarious experiences. In turn, an individual's self-efficacy would then determine their activity choice, energy expenditure, persistence at the particular task, thought patterns and emotional reactions (Bandura, 1986). Therefore, it was suggested that behaviour change, and the occurrence of anxious feelings were a direct outcome of efficacy expectations. However, anxiety reduction theorists (e.g., Eysenck, 1978; Wolpe, 1978) proposed that the anxiety response caused behavioural change and efficacy expectations, opposing Bandura's beliefs. Eysenck (1978) further argued that self-efficacy is merely an epiphenomenon of anxiety. More recently, researchers have agreed that anxiety and self-efficacy are two separate constructs and have moved towards exploring the moderating effects of self-efficacy on the relationship between competitive anxiety and sport performance (e.g., Besharat & Pourbohlool, 2011). For example, athletes who reported higher levels of self-efficacy also interpreted their anxiety symptoms as facilitative for performance (Hanton & Connaughton, 2002; Hanton et al., 2004). Therefore, self-efficacy may be a psychological construct that could aid athletes in coping with anxiety responses to competition; however, it is not directly related to the anxiety response.

While significant advances have been made in our understanding and portrayal of the anxiety-performance relationship, the potential adaptive nature of anxiety still warranted exploration as research using self-confidence and self-efficacy has, to date, been equivocal.

Protective and Potential Facilitative Effects of Anxiety

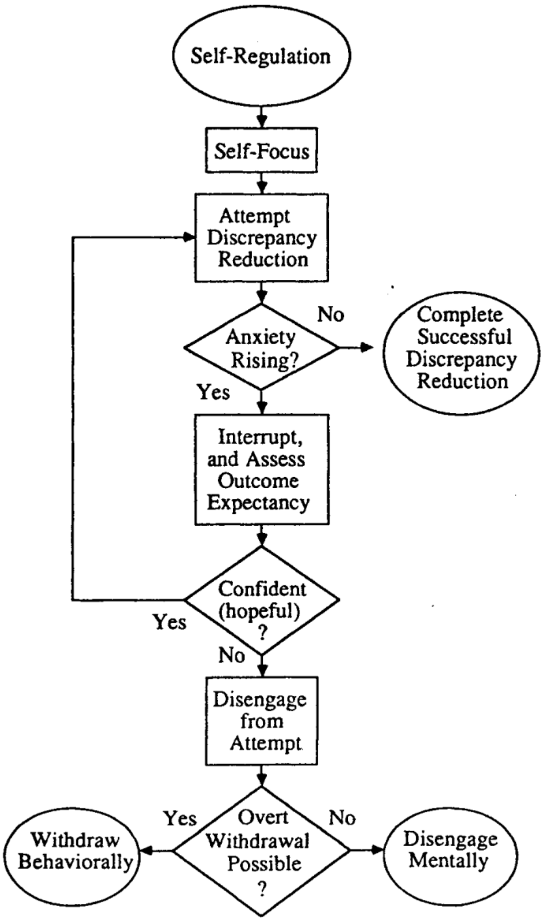
Thus far the theoretical focus of this review has outlined the progression of researchers' attempts to explain the anxiety-performance relationship. Although researchers have been eager to understand how some athletes maintain or improve their performance whilst anxious, the aforementioned theories did not directly address the potential adaptive nature and facilitative effects of anxiety. Therefore, the next section will highlight theories of direct relevance to the notion that anxiety can be protective or adaptive in nature. This review will include Carver and Scheier's (1988) control-process perspective on anxiety, processing efficiency theory (Eysenck and Calvo, 1992) and the inclusion of *control* within the anxiety-performance relationship (e.g., Jones, 1995), ending with a comprehensive review of the three-dimensional model of competitive anxiety developed by Cheng et al. (2009).

Control-Process Perspective

A control-process perspective for anxiety was first proposed by Carver and Scheier (1988), who suggested that human behaviour is regulated in a system of feedback control. In this view, individuals continually establish goals, expectations and intentions for themselves that are used as reference points. Individuals then monitor their actions with regards to these reference points; however, there will sometimes be conflict between competing reference values; and anxiety reflects such a conflict. For example, anxiety arises in situations where an individual attempts to behave in line with one reference value, but this may cause a discrepancy with regards to another reference value, such as physical safety, personal comfort, and/or acceptance from significant others. Carver and Scheier explain that the behavioural response to anxiety is a consequence of one critical variable; the individual's expectancy of being able to cope (see Figure 3). The individual with beliefs of being able to cope and complete the action required responds to the situation with renewed effort. Whereas, the individual who experiences self-doubt about being able to cope and expects a bad outcome is more likely to disengage with the anxious situation, resulting in impaired performance. Therefore, Carver and Scheier concluded that the anxiety-performance relationship is determined by control in the form of favourable versus unfavourable expectancies (there are many definitions and terms used for control, expectancies being one of them. For a review see Skinner, 1996) of being able to cope. Carver and Scheier's control perspective is important to highlight at this stage as aspects of the concept (i.e., control) are adopted by sport psychology researchers (e.g., Cheng et al., 2009) attempting to directly explain the adaptive nature of competitive anxiety.

Figure 3

Carver and Scheier's (1988) Control Process Perspective for Anxiety



Note. A flow-chart diagram portraying the consequences of attempting to match behaviour to a reference value in an anxious situation. When anxiety noticeably rises, the consequence of this is determined by the individuals' expectations of whether they can cope. Reprinted from "A control-process perspective on anxiety", by C. S. Carver and M. F. Scheier, 1988, *Anxiety Research, 1,* p.19 (https://doi.org/10.1080/10615808808248217). Copyright 2020 by Informa UK Limited.

Processing Efficiency Theory and Attentional Control Theory

Sport psychologists have also adopted the processing efficiency theory (PET; Eysenck & Calvo, 1992) in order to explain the adaptive nature of anxiety; that is, how anxious individuals may perform better than low anxious individuals (Hardy & Jackson, 1996; Wilson et al., 2006). The predictions of PET are based on the role of state anxiety and the assumption that the human attentional system has limited capacity, with cognitive anxiety serving two purposes. Increases in cognitive anxiety will reduce processing efficiency of a task as it consumes the attentional capacity normally used for the execution of said task, which is likely to lead to performance impairments (Baddeley, 2001). However, PET suggests that these potential performance impairments can be minimised by a control system (self-regulatory or executive) that is involved in the anxiety-performance dynamics. More specifically, cognitive anxiety highlights the importance of the task and the control system responds to information regarding task performance that is below anxious individuals' performance expectations. This response involves allocating additional effort to the task or initiating new strategies. Hockey (1986) also speculated about a similar control system which initiates two types of reactions. First, it was hypothesised that an individual may be able to cope with the threat and/or worry directly by reducing worrying thoughts and thus increasing available resources for the task at hand (Baddeley, 1993). The second reaction suggested that individuals may eliminate the potential negative effects of worry on task performance by deploying additional resources, such as effort, to the task.

In addition to the above theoretical position, it is argued within PET that the effects of anxiety on processing efficiency (the relationship between the effectiveness of performance and the effort or amount of processing resources invested) and on performance effectiveness (the quality of task performance) frequently differ. PET suggests that anxious individuals may make more use of the control system (i.e., exerting more effort), thus impairing anxious individuals' processing efficiency more than their performance effectiveness (i.e., maintaining performance quality). In other words, anxious individuals attempt to gain control over perceived threat and improve performance until their processing resource is depleted, or the extra effort appears to have no impact (Schwarzer et al., 1984).

Moreover, PET provided the foundations for the development of attentional control theory (ACT; Eysenck et al., 2007), which explains the functions of the central executive that are affected by anxiety. The main assumption is that anxiety impairs efficient functioning via two attentional systems; the stimulus driven and goal-directed attentional systems (Corbetta & Shulman, 2002). To elaborate, the goal-directed system is governed by expectations, knowledge, and current goals and has two functions; inhibition and shifting. Inhibition is a function that uses attentional control to suppress distractions from task irrelevant stimuli, which was portrayed as negative control, while the shifting function uses attentional control to move attention back and forth onto task relevant stimuli, depending on the task demands, which has been depicted as positive control (Eysenck et al., 2007). Increases in anxiety reduce attentional control and thus the ability to use such functions effectively and causes an imbalance between the stimulus driven and goal-directed systems resulting in impaired processing efficiency (Eysenck et al., 2007).

Both PET and ACT have been drawn upon in the sport psychology literature in order to explain the anxiety-performance relationship. For example, Murray and Janelle (2003) explored low and high trait-anxious participants during a driving task under baseline and competition conditions. They measured driving performance, response time and eye movements. Findings revealed that during the competition session both groups increased their search rate and maintained their performance, whilst response time reduced for the low-anxious group but increased for the high-anxious group. Considering, the high-anxious group increased their search rate and response time, yet maintained performance, indicates a reduction in processing efficiency with little change in performance effectiveness.

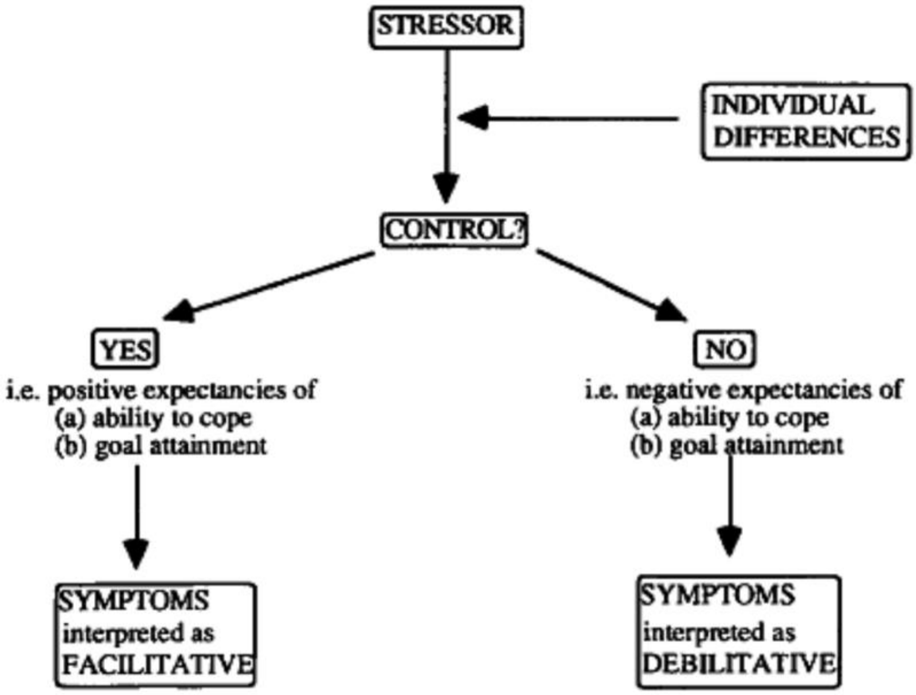
The use of a control system, or self-regulatory stance within PET and its extensions in ACT, provides an explanation for when performance is not significantly impaired despite increased levels of anxiety. This was an important step toward understanding the potential adaptive effects of anxiety. In particular, PET provided a platform for *control* to be explored as part of the anxiety-performance relationship within sport psychology.

Jones' (1995) Control Model

Among the theories of performance anxiety being produced in the 1990s, Jones (1995) developed a control model of debilitative and facilitative competitive anxiety (see Figure 4) adapted from Carver and Scheier's (1986, 1988) theory of self-regulation and control. When developing this model, Jones suggested that researchers should pursue the avenue of exploring which factors predict facilitative and debilitative anxiety states in athletes. More specifically, it was suggested that variables such as confidence and perceptions of control are likely to be important sources of variance in directional interpretations of anxiety. Jones hypothesised that athletes who have confidence in their ability to control both themselves and the environment will experience facilitative anxiety symptoms, whereas athletes who do not have confidence in their ability to control themselves and their surroundings will experience debilitative symptoms. Therefore, control was conceptualised as a cognitive appraisal about the degree of control to which an athlete perceives they have over themselves and their environment. Preliminary findings testing the model with swimmers revealed that anxiety intensity levels before competition did not differ; however, athletes who reported positive expectations also reported their anxiety to be more facilitative than those who reported negative expectations about the competition (Jones & Hanton, 1996).

Figure 4

Jones' (1995) Control Model of Debilitative and Facilitative Competitive State Anxiety



Note. This figure was produced by Jones in 1995, and it summarises the impact of control on whether competitive anxiety symptoms are interpreted as facilitative or debilitative for performance. Reprinted from "More than just a game: Research developments and issues in competitive anxiety in sport", by G. Jones, 1995, *British Journal of Psychology*, *86*, p.446 (https://doi.org/10.1111/j.2044-8295.1995.tb02565.x). Copyright 1999-2020 by John Wiley & Sons, Inc.

Despite these findings, Cheng et al. (2009) argued that the conceptualisation of control was misidentified. Jones used the construct of control as an additional factor when exploring the anxiety-performance relationship; however, Cheng and colleagues suggested that the notion of control should be fully integrated as part of the anxiety response, as proposed by Matthews (1992) and Öhman (2000). In Jones' model the influence of control was also characterised by the interpretation of anxiety symptoms. Cheng et al. argued that symptom interpretation may be irrelevant under particular circumstances, as athletes may not always be aware of their anxiety symptoms. For example, athletes may neglect or repress their anxiety in order to cope (Hippel et al., 2005). Therefore, athletes may not be aware or have an insight into whether the anxiety symptoms experienced are facilitative or debilitative for them. Cheng et al. argued that it would be more appropriate to reflect this adaptive potential of anxiety directly by perceived control, rather than indirectly through symptom interpretation.

For several years it has been proposed that individuals' perceptions of control are triggered directly within the anxiety-performance response (e.g., Carver & Scheier, 1988). As previously stated, Öhman (2000) suggested that the roots of anxiety stem from a defence mechanism that is meant to be functional, as it sends out warning signals that protect and prepare an individual to respond effectively to a perceived threat. Experiencing anxiety may also result in increased motivation (Eysenck, 1992), energy and focus (Carver & Scheier, 1988), positively impacting performance. Cheng et al. (2009) argue that this adaptive nature of anxiety has been underrepresented in earlier theories, as they are based on the conventional components of worry and emotionality. Similarly, interpreting anxiety symptoms as "facilitative" does not fully represent the adaptive nature of anxiety. Therefore, Cheng et al. presented a different viewpoint reflecting the maladaptive and adaptive aspects of anxiety in their three-dimensional model of competitive anxiety.

The Three-Dimensional Model of Competitive Anxiety

Cheng et al.'s (2009) re-conceptualisation of competitive anxiety is the most recent model developed to test the anxiety-performance relationship and has also recently been extended by Jones et al. (2019). Their model includes three higher order dimensions and six first order constructs; a cognitive dimension reflected by worry, private self-focus and public self-focus; a physiological dimension reflected by somatic tension and autonomic hyperactivity; and a regulatory dimension, reflected by perceived control.

The cognitive dimension differs from previous conceptualisations of the construct as it incorporates worry and self-focused attention. Cheng et al. (2009) defined worry as “a cognitive form of apprehension associated with possible unfavourable outcomes” (p. 272), in accordance with Eysenck (1992) and Liebert & Morris (1967) who regarded worry as a major anxiety symptom. In addition, Cheng et al. (2009) argued that there is a link between self-focus and anxiety through the concept of self-evaluation. To elaborate, self-focus is assumed to lead to a self-evaluative state, which is claimed to be a critical process involved in anxiety (Gibbons, 1990; Izard 1972), because increased emotional awareness heightens self-evaluation (Gibbons, 1990). Anxious individuals have also been characterised as self-preoccupied, in that they focus internally on their personal limitations (Schwarzer & Jerusalem, 1992). Therefore, the construct of self-focus was included in Cheng et al.’s cognitive anxiety dimension.

Jones et al. (2019) extended Cheng et al.’s cognitive anxiety dimension using common differentiations between two forms of self-focused attention; private and public (Fenigstein et al., 1975). Private self-focus occurs when an individual is concerned about their inner thoughts and feelings. In a sporting context, an athlete may become increasingly aware of their movements, thus in an attempt to control successful execution of that movement they may lapse into conscious processing, resulting in performance disruption (Masters, 1992). In contrast, public self-focus is an awareness of the self as a social object that has an effect on others, generally producing feelings of discomfort and evaluation apprehension. Behaviourally, an individual may broaden their focus allowing them to concentrate on those who are watching them and in turn change their behaviour in an attempt to meet their perceived expectations of others. However, such a distraction can also result in performance disruption as the athlete is not fully focused on their competition and thus may miss vital cues from their teammates or opponents (e.g., Geukes et al., 2012).

Differentiating between worry, private self-focus and public self-focus provides a more comprehensive overview of the cognitive dimension of competitive state anxiety.

In developing the physiological dimension, Cheng et al. (2009) applied the criteria used for generalised anxiety disorders in the DSM-III-R (APA, 1987), which uses anatomical structure and distinguishes between involuntary and voluntary muscle groups, referred to as autonomic hyperactivity and somatic tension, respectively. Subsequently, autonomic hyperactivity and somatic tension were included as separate factors within Cheng et al.'s physiological dimension. Autonomic hyperactivity was defined as "physiological reactions involved with the involuntary muscle groups that are associated with the body's inner organs" (p. 273), manifested, for example, as cold sweat, a dry mouth, and increased heart rate. Somatic tension was defined as "physiological reactions involved with the voluntary muscle groups that are motor orientated" (p. 273), examples of which include trembling, muscle tension, and fatigue. Unlike previous theories that have only included unidimensional physiological factors (e.g., catastrophe models and MAT), employing a multidimensional physiological anxiety factor that represents the anatomical structure lends itself to a more inclusive approach that fully captures athletes' physiological anxiety symptoms.

As well as cognitive anxiety and physiological anxiety, the most significant difference between the three-dimensional model of competitive anxiety and previous competitive anxiety theories is the inclusion of the regulatory dimension. This dimension was included to reflect the potentially adaptive capacity of anxiety and was grounded in the argument that anxiety is a defence mechanism which is meant to be functional, as anxious feelings trigger warning signals (Öhman, 2000). Subsequently, an individual can prepare and respond more effectively to the perceived threat. More specifically, this adaptive capacity was reflected in the model by perceived control. Cheng et al. (2009) defined perceived control as "the perception of one's capacities to be able to cope and attain goals under stress" (p. 273). In relation to this definition and as explained above, Carver and Sheier (1988) suggested that expectancies concerning coping and the ability to complete a task are critical components within the anxiety-performance relationship, as varying levels of expectancies (i.e., favourable versus unfavourable) would result in different responses to anxiety. Therefore, it was suggested that those experiencing anxiety would evaluate both environmental and internal threats (cognitive/physiological anxiety) and also evaluate their capabilities of coping with those threats while attempting to meet the demands of the perceived stressful situation (i.e., perceiving differing levels of control or even no control). Subsequently, and echoing the definition, the adaptive capacity of anxiety is a consequence of how well an individual perceives they are capable of coping and attaining task goals under pressure (Cheng et al., 2011).

It is important to note that Cheng et al.'s inclusion of perceived control is conceptually distinct to the notion of "self-confidence" included in both the Competitive State Anxiety Inventory-2 (CSAI-2; Martens et al., 1990b) and Jones' (1995) directional component. For example, in MAT it was proposed erroneously that self-confidence was at the opposite end of a continuum to worry; therefore, suggesting that those who reported feelings of worry would have low feelings of self-confidence and vice versa. In contrast, Cheng et al.'s regulatory dimension posits that an individual may report feelings of high anxiety (high levels of cognitive and/or physiological anxiety) but may also report high levels of perceived control over the stressful situation, thus capturing the adaptive capacity of anxiety. Moreover, Jones' (1995) directional dimension was not fully integrated as part of anxiety as it was only characterised by the interpretation of anxiety symptoms, whereas the regulatory dimension presented by Cheng et al. is represented by perceived control; a construct believed to be inherent to the anxiety-performance response. The difference between Cheng and colleagues' conceptualisation of perceived control and the model of self-control developed by Baumeister et al. (1994) should also be highlighted, as the notion of self-regulation has taken the interest of sport psychologists in recent years (e.g., Balk & Englert, 2020; Nicholls et al., 2016). The regulatory dimension is theoretically different as it is not a distinct coping effort or strategy; instead it is a reflection of the potential coping capacity directly involved in the anxiety dynamics (Cheng & Hardy, 2016).

Moreover, the construct of perceived control has been comprehensively explored outside of the anxiety-performance relationship (e.g., Skinner et al., 1988; Weisz & Stipek, 1982) with a large number of terms being used that fall under the rubric of “control” including, self-directedness, choice, decision freedom, agency, mastery, autonomy, self-efficacy, expectancies, and self-determination (Rodin, 1990, p. 1). Thompson and Spacapan (1991) also listed terms such as locus of control, helplessness, powerlessness, judgements of contingency, and control ideology. Within this pool of literature there are many similar theoretical stances and a distinction between the more common conceptualisations of perceived control and that offered by Cheng and colleagues should be made. These theoretical stances suggest that judgements of perceived control are the product of two independent control beliefs (Wallston et al., 1987; Weisz, 1986). The first has been termed “contingency beliefs” (Weisz & Stipek, 1982), “locus of control” (Rotter, 1966), means-ends beliefs (Skinner et al., 1988), and “control ideology” (Gurin et al., 1978). Taken from Skinner et al.’s (1988) interpretation, these terms all refer to means-ends beliefs, which are general beliefs about what is needed, or what is effective in producing the desired outcome. The second type of belief has been termed “agency beliefs” (Skinner et al., 1988), and “competence beliefs” (Wiesz & Stipek, 1982). This is the perception of one’s own ability to enact the necessary actions to obtain the desired outcome. In addition to means-ends and agency beliefs, Skinner et al. (1988) also incorporated “control beliefs” as a third independent belief even though some argued (e.g., Wallston et al., 1987; Weisz, 1986) that control beliefs are completely predictable from combinations of means-ends and agency beliefs. For example, “I can obtain outcome Y” (control belief), is equivalent to combining the following two statements "There exists means X which produces Y" (means-ends belief), and "I have or can obtain means X". But Skinner et al. (1988) argued that this is not plausible, as beliefs may not be organised according to their semantic relations. A general belief about control is subjective and there is no *a priori* guarantee that it is rational (Skinner et al., 1988). Individuals may report their beliefs about control without necessarily reflecting on the specific means required to reach the desired outcome. For example, control beliefs may act as an ego protection mechanism (Abramson & Alloy, 1980).

Considering this body of research, critics may question why Cheng et al.'s (2009) incorporation of perceived control within their performance anxiety theory is not multidimensional in nature. However, the component of perceived control as a regulatory element in the three-dimensional performance anxiety framework refers to one's capacities (involving ability and resource) to be able to cope and attain goals under stress. This definition is consistent with Carver and Scheier's (1988) control-process perspective on anxiety and several theorists posit that negative effects of high anxiety on performance can be countered by increased application of available resources or enhanced effort (Eysenck, 1992; Carver & Scheier, 1986). The key to Cheng et al.'s conceptualisation is that the adaptive nature of anxiety only taps into agency beliefs of perceived control. Athletes experiencing anxiety may be able to maintain or enhance performance if they perceive that they have the ability and/or capacity to be able to cope and attain their goals in the stressful situation. Therefore, it is an athletes' agency beliefs that directly impact the potentially adaptive nature of anxiety in sporting situations. In other words, anxious athletes' general beliefs about the means needed for their desired outcome is not going to impact the anxiety-performance relationship unless they possess the means required. Consequently, and by using Skinner et al.'s (1988) terms, the regulatory dimension is reflected by agency beliefs, rather than perceived control as a whole.

Using the three-dimensional model of competitive anxiety, Cheng et al. (2009) assumed that the regulatory dimension and the interactions between the regulatory dimension, cognitive dimension and physiological dimension would prove to be strong predictors of anxiety effects on sports performance. They also assumed that the regulatory dimension would attenuate the maladaptive effects of cognitive and/or physiological anxiety on performance. Cheng et al., (2011) tested these assumptions with 99 tae-kwon-do athletes by administering the Three Factor Anxiety Inventory 30 minutes before a competitive bout. Findings revealed that perceived control was the highest correlate with performance, and it accounted for a significant additional 20% of performance variance compared to cognitive and physiological anxiety alone. A significant interaction effect was also found, which showed that perceived control enhanced performance when somatic anxiety was low; however, perceived control did not improve performance when physiological anxiety was high. Cheng et al. suggested that further research was needed to explore the interaction effects and the adaptive potential of the regulatory dimension.

In a second test of the three-dimensional model of performance anxiety, Cheng and Hardy (2016) conducted three criterion-related validation studies. They investigated relationships between the performance-related variables of perfectionism, self-talk, and coping strategies with the three dimensions of anxiety, with a specific focus on the regulatory dimension. Findings showed that adaptive dimensions of perfectionism, self-talk (motivational and instructional) and approach coping, positively predicted the regulatory dimension, conversely maladaptive perfectionism and negative self-talk positively predicted cognitive and physiological anxiety. Cheng and Hardy argued that these findings provided further support for the adaptive nature of the regulatory dimension.

The most recent study that tested the three-dimensional model of performance anxiety was conducted by Jones et al. (2019), who explored the impact of all six factors of their revised model (worry, private self-focus, public self-focus, autonomic hyperactivity, somatic tension, and perceived control) on the performance of runners and triathletes. The only significant predictor of performance was perceived control, as those who performed well reported significantly higher levels of perceived control.

The conceptualisation of competitive state anxiety within sport psychology has clearly evolved. In particular, the model proposed by Cheng and colleagues and its recent development by Jones and associates provides a sound theoretical base for exploring the anxiety performance relationship as a whole. The studies that have tested the model suggest that the inclusion of the regulatory dimension predicts more performance variance than cognitive and physiological anxiety and may be the underlying construct that enables athletes to perform well when anxious. However, the measurement of the anxiety response has continued to be problematic throughout Cheng et al.'s research programme, including the initial attempt at developing a measurement tool for the three-dimensional model of competitive anxiety (Cheng et al., 2009). Therefore, the last section of this literature review will provide a comprehensive discussion of the measurement tools developed thus far and the problems that have occurred.

Measurement

The majority of the anxiety-performance literature to date has relied heavily on the CSAI-2 (Martens et al., 1990b) and the revised version, CSAI-2R (Cox et al., 2003). The CSAI-2 has been described as the "gold-standard" measurement tool for competitive state anxiety. Researchers have validated the scale in eight or more different languages and versions of the measure are still being used for research (e.g., Dunn et al., 2020; Mehrsafar et al., 2019; Wetherell & MacDonald, 2019). However, as briefly mentioned in the previous section of this chapter, several researchers have questioned the validity of both the CSAI-2 and CSAI-2R. Therefore, the last section of this literature review will explore the developments of the CSAI-2 and CSAI-2R, Jones and Swain's (1992) directional scale, Cheng et al.'s (2009) Three Factor Anxiety Inventory (TFAI) and issues associated with the analyses employed during the validation of these measures, with a specific focus on the widespread use of confirmatory factor analysis (CFA) and model specification.

The CSAI-2 (Martens et al., 1990b) was derived from the Multidimensional Anxiety Theory (MAT; Martens et al., 1990a), as described earlier in section two of this chapter (p. 15). The CSAI-2 has three subscales; cognitive anxiety, somatic anxiety and self-confidence and comprises 27 items. Examples of the items within each dimension include, “I am concerned about this competition” and “I am concerned about choking under pressure”, reflecting cognitive anxiety; “I feel tense in my stomach” and “My heart is racing”, reflecting somatic anxiety; and “I am confident about performing well” and “I am confident because I mentally picture myself reaching my goal” reflecting self-confidence. Typically, the measure is administered to athletes one hour before their competition and athletes are asked to indicate “how you feel right now” for each item on a 4-point Likert scale ranging from “not at all” to “very much so”. One criticism of the CSAI-2 was put forward by Jones (1991) who noted, ‘...it is important to recognise that the CSAI-2, like many other state anxiety measures, is based on a somewhat limited dimension of the anxiety response’ (p. 153). The limited dimension that Jones is referring to is ‘intensity’, meaning that the inventory only measures the ‘intensity’ of athletes’ anxious symptoms, overlooking an individual’s directional interpretation. More specifically, it has been argued that the items are neutrally worded and thus could be representative of positive affective states. Therefore, one athlete may interpret the items “I am concerned about this competition” or “My heart is racing” as negative and detrimental to their performance, whereas another athlete may interpret the same symptoms as positive and facilitative for performance (Jones et al., 1993). This criticism highlights the ambiguity in athletes’ interpretations of their responses. Athletes’ reporting high ratings for the items are supposed to reflect high cognitive or somatic anxiety, which in turn is assumed to reflect a negative response, even though it may have reflected a positive emotional state for the athlete in question. This led Jones and Swain (1992) to include a directional scale that was grounded in Jones' (1995) control model. However, this directional scale faced many criticisms, both theoretically and in application. As explained in section 3 of this chapter, symptom interpretation can be considered as an indirect measure of the potential adaptive nature of anxiety and irrelevant under certain circumstances (Hippel et al., 2005). This is highlighted in many research studies where the directional scale was employed but did not account for much of the performance variance (e.g., Chamberlain & Hale, 2007; Jerome & Williams, 2000; Jones et al., 1993; Kais & Raudsepp, 2005).

During this time, the factor structure of the CSAI-2 was also questioned and examined by many researchers (e.g., Hardy 1996a; Lane et al., 1999; Lundqvist & Hassmen, 2005; Woodman & Hardy, 2003). For example, Lane et al. (1999) did not find acceptable fit indices for the original CSAI-2 model when performing a Confirmatory Factor Analysis (CFA) on a sample of 1,213 athletes. Lundqvist and Hassmen (2005) found similar results when attempting to validate a Swedish version. In addition, and as noted earlier, the inclusion of self-confidence has also been criticised as it is an independent construct (Woodman & Hardy, 2003). Woodman and Hardy also suggested that the terminology used in the cognitive anxiety subscale was ambiguous. More specifically, eight of the nine items start with the phrase "I am concerned", which could reflect the importance of the upcoming competition rather than cognitive anxiety symptoms. Cheng et al., (2009) took this limitation on board when developing the Three Factor Anxiety Inventory (TFAI) and prefaced the items reflecting the worry construct with "I am worried".

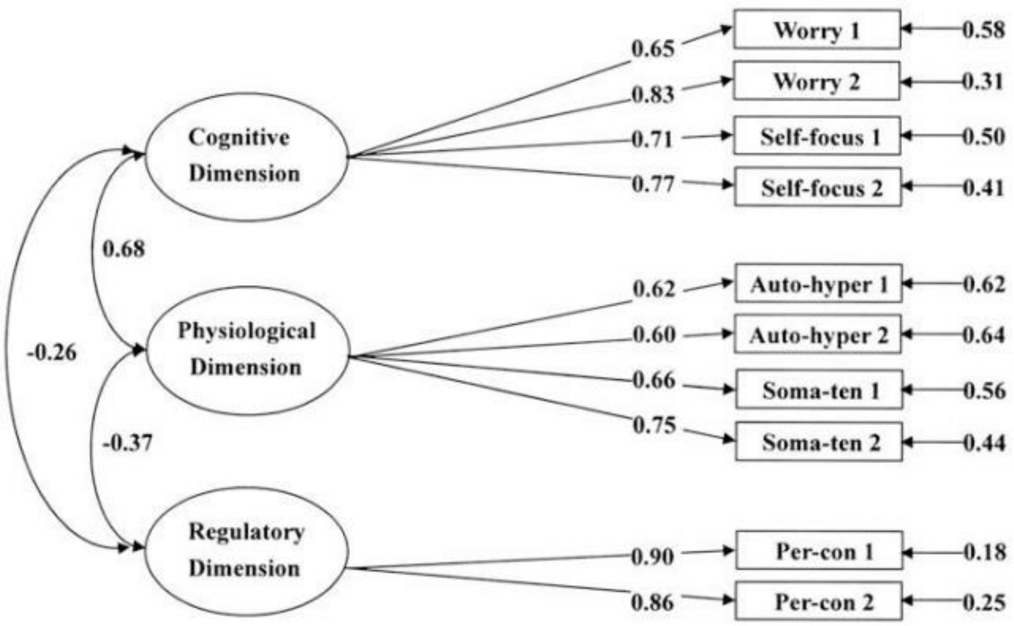
Due to the limitations detailed above, Cox et al. (2003) attempted to improve the factor structure of the CSAI-2 and produced a revised version; the CSAI-2R. They completed a three-part study whereby the first analysis on 503 participants revealed a poor fit; however, 10 items were subsequently removed and further analysis revealed a greatly improved fit. A final validation analysis was conducted using 331 participants and the revised measure produced a good fit for a second time. It was concluded that the CSAI-2R had a more robust factor structure than the CSAI-2 and should be employed in future sport psychology research.

Although attempts to improve the CSAI-2 were met with some success, a fundamental problem still stands. These scales are grounded on the traditional conceptualisation of anxiety based upon worry and emotionality (Liebert & Morris, 1967). The understanding of the anxiety-performance relationship has developed beyond this conceptualisation and researchers have provided evidence to suggest that this approach is too simplistic (Cheng et al., 2009). For these reasons Cheng et al. (2009) developed the Three Factor Anxiety Inventory (TFAI) in an attempt to present a more complex conceptualisation of anxiety as portrayed in their three-dimensional model of competitive anxiety.

Cheng et al. (2009) used their newly developed measure with two independent samples to examine their hierarchical model. To recap briefly, this hierarchical model contained three major dimensions, with cognitive anxiety reflected by worry and self-focus, physiological anxiety reflected by somatic tension and autonomous hyperactivity and the regulatory dimension reflected by perceived control. The initial measure consisted of 29-items, where five reflected worry, four reflected self-focus, six reflected autonomous hyperactivity, five reflected somatic tension, and nine reflected perceived control. In the first study 286 participants completed the inventory and CFA was employed to assess the validity of the measure. The CFA did not support the hierarchical model and acceptable fit was only found for a parcelled three-dimensional first-order model (see Figure 5). The measure was refined to 28-items for Study 2, and a total of 327 inventories were collected. During the analysis three items were removed; however, as with the first study, no support was found for the hierarchical model. Consequently, they merged worry and self-focus, and autonomous hyperactivity and somatic tension into single factors resulting in a parcelled three-dimensional first-order model, which produced a better fit. These findings show support for the major components (i.e., cognitive anxiety, physiological anxiety, and the regulatory dimension) activated during the anxiety response. However, Cheng et al. (2009) stated that the subcomponents should be retained at a descriptive level and that further research should aim to support the hierarchical model originally proposed.

Figure 5

Results of Cheng et al.'s (2009) CFA for Their Final Parcelled Model



Note. From "Toward a three-dimensional conceptualisation of performance anxiety: Rationale and initial measurement development", by K. Cheng, L. Hardy and D. Markland, 2009, *Psychology of Sport and Exercise, 10*, p. 276 (https://doi.org/10.1016/j.psychsport.2015.07.006). Copyright 2008 by Elsevier Ltd.

More recently the use of CFA for validating measurement tools has also been questioned. The key criticism is its highly restrictive nature (Marsh et al., 2009), which typically leads to mis-specified models (Browne, 2001). Therefore, the use of CFA may explain why Cheng and colleagues could only validate a parcelled three-dimensional first-order model. Consequently, the next section of this review will provide a detailed discussion of the use of CFA, and the specification of psychological models within the sport psychology measurement literature.

Statistical Analyses for Measurement Tools

In the field of sport psychology, the standard approach for assessing the factor validity of theoretically grounded multidimensional measures is to employ CFA using the Maximum Likelihood (ML) approach and imposing an independent clusters model or simple factor structure (ML-CFA; Niven & Markland, 2016). This approach was used in the development of the CSAI-2 (Martens et al., 1990b), CSAI-2R (Martens et al., 2003), TFAI (Cheng et al., 2009) and many other sport psychology questionnaires outside of the performance anxiety domain, for example, the Test of Performance Strategies (TOPS; Hardy et al., 2010) and the Sports Mental Toughness Questionnaire (SMTQ; Sheard et al., 2009). The main characteristic of ML-CFA is that indicators are free to load on their intended factors, whilst cross-loadings and residual correlations are fixed to zero. However, much of the sport psychology measurement research (e.g., Cheng et al., 2009; Gucciardi et al., 2009; Mallet et al., 2007) shows that this approach consistently leads to a non-significant likelihood ratio χ^2 test and rejection of the model (Marsh et al., 2009). This results in researchers arguing that the likelihood ratio χ^2 test is too sensitive to small differences between the computed model and observed data, thus the model can only be accepted on the grounds of approximate fit indices (Fong & Ho, 2013). Furthermore, Marsh et al. (2004) also suggested that it can be difficult to judge whether a model is well-fitting by using approximate indices, especially when there are a large number of indicators. Thus, researchers are likely to employ a series of post hoc model modifications and/or item deletion in order to improve the fit, which may capitalise on chance (MacCallum et al., 1992; Niven & Markland, 2016).

More recently it has become apparent that the reason for the poor fitting models is because the use of ML-CFA typically mis-specifies the model from the outset by imposing the highly restrictive rules of fixing cross-loadings and constraining residual correlations to zero, whereas realistically, the model is more complex with many small cross-loadings (Asparouhov & Muthén, 2009; Browne, 2001; Marsh et al., 2009). Marsh et al. (2009) even argued that non-zero cross-loadings are inherent in psychological measurements and can be anticipated from the items themselves. A second problem is that these restrictions will result in inflated factor correlations and can bias the factor loadings, thus changing the meaning of the latent variable (Cole et al., 2007; Kolenikov, 2011).

Exploratory structural equation modelling (ESEM; Asparouhov & Muthén, 2009) has attempted to provide a solution for this problem by integrating aspects of Exploratory Factor Analysis (EFA) and CFA. Taken from EFA, the approach allows for non-zero cross loadings and a rotation of the factor matrices (i.e., target rotation). It also provides standard errors and conventional fit indices, similar to CFA, however, the problems with this approach are two-fold. First, there are no guidelines for choosing the best rotation. Marsh et al. (2013) would suggest employing target rotation; however, this method was validated on a model where some of the items representing each factor had zero-cross loadings. Although it does not require the items to be set at zero, an approximation of a simple structure has been found to produce a stronger model (Marsh et al., 2014). Indeed, as stated above, simple structures are not always the case for psychological measures, and target rotation may not perform as well in regard to accurately estimating the true population correlation for such cases. Second, applications of ESEM have not explored the adequacy of the fit indices and cut off scores for the assessment of fit for the models (Marsh et al., 2010). Applications of ESEM (e.g., Morin & Maïano, 2011) have used ML-CFA guidelines for goodness of fit, however their relevance to ESEM is not clear.

Problems with validation in sport psychology do not end with the type of analysis adopted, but also with the measurement model specified (Jones et al., 2019; MacKenzie et al., 2005). The reliance on using CFA has led researchers to pay less attention to the nature and direction of the relationships between the constructs in their measures (Roberts & Thatcher, 2009). More specifically, classic test theory assumes that the variance in scores measuring a construct, such as anxiety, is a function of the true score plus error. Therefore, meaning flows from the latent construct to the items reflecting the latent construct. In other words, each item is viewed as an imperfect reflection of the underlying latent construct (Bollen, 1989; Nunnally & Bernstein, 1994). Such models are known as a reflective measurement models as they represent reflections and manifestations of a construct. They are grounded by the notion that all indicator items are caused by the same latent construct and so all items should be highly correlated and interchangeable. This conceptual model is theoretically correct for many measurement models; however, it has been argued that it does not make sense in all instances (Bollen & Lennox, 1991). For example, it may make more sense for some constructs to be defined by their indicators, thus the meaning is viewed in the opposite direction from the indicators to the construct. This type of construct is labelled as formative (Mackenzie et al., 2005).

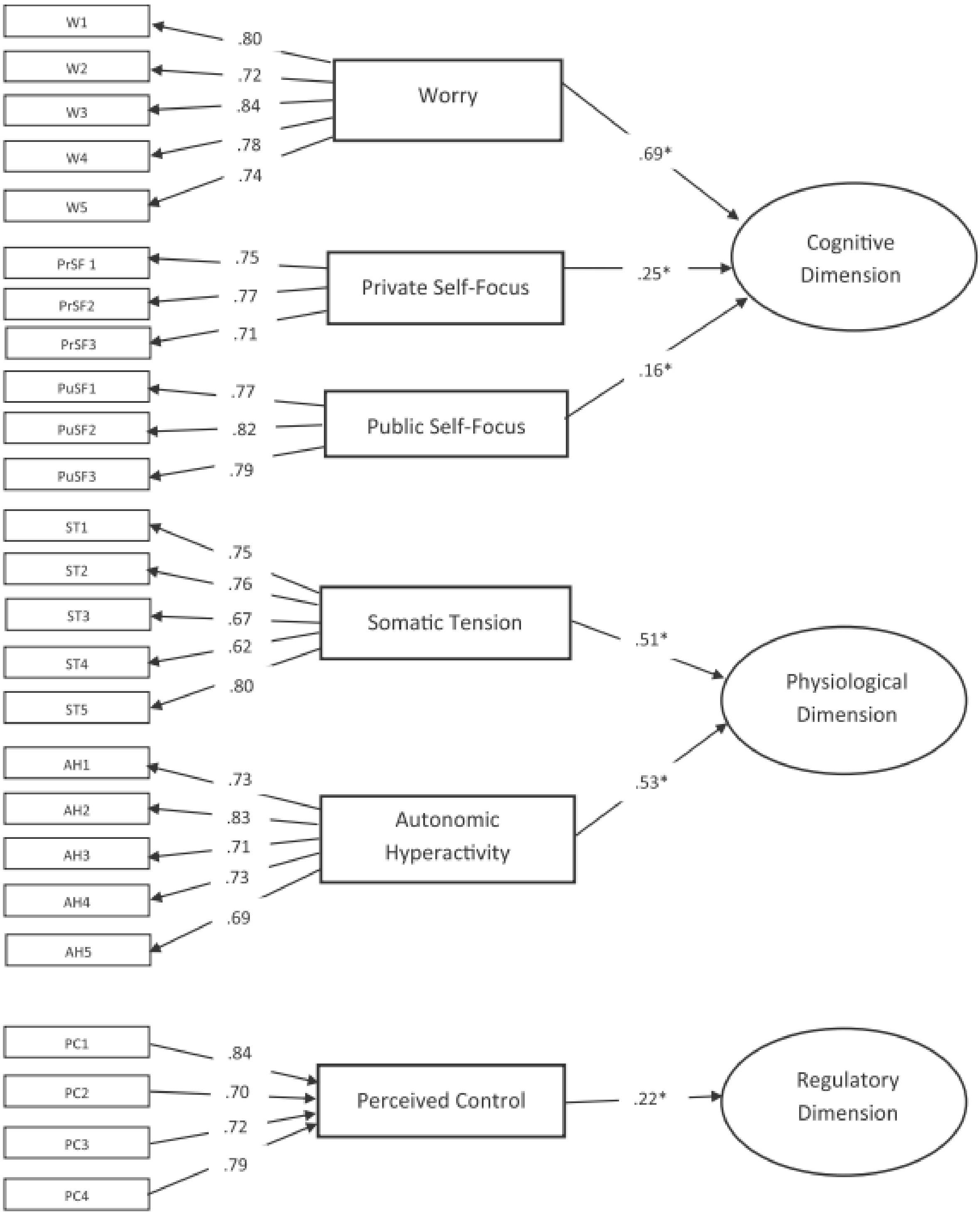
MacKenzie et al. (2005) provided the example of a mis-specified model in the form of transformational leadership, which is traditionally modelled reflectively; however, MacKenzie and colleagues argued it would be better modelled formatively. To elaborate, transformational leadership was measured reflectively by charisma, idealised influence, inspirational leadership, intellectual stimulation, and individualised consideration (Bass, 1998). Conversely, Mackenzie et al. suggested that these factors are not reflective indicators, as they are conceptually distinct and thus not interchangeable, because omitting one factor, such as charisma, would change the conceptual structure of transformational leadership. Such characteristics also suggest that each construct is likely to have different antecedents and consequences, providing evidence to suggest that transformational leadership should be portrayed as a formative construct. Because the occurrence of model mis-specification can result in inaccurate conclusions about the structural relationships between constructs and measurement error (Jarvis et al., 2003; MacKenzie et al., 2005), it is crucial researchers consider the relationships between constructs within measurement models before conducting validation analyses.

Jones et al. (2019) used the aforementioned recommendations to re-examine the relationships between the constructs within the three-dimensional model of performance anxiety and proposed a reflective-formative model. They suggested that the first order latent constructs (worry, private self-focus, public self-focus, somatic tension, autonomic hyperactivity and perceived control) should be measured by reflective indicators owing to the preposition that each of these constructs has one unique theme that every item measuring the subsequent construct will reflect. Therefore, the items are similar in nature, interchangeable and likely to covary (Jarvis et al., 2003). Jones et al. then proposed that these first order constructs would serve as formative indicators for the second order latent variables, cognitive and physiological anxiety and the regulatory dimension. They specified these constructs as formative, because the direction of causality emanates from the first to second order constructs. Using Jarvis et al.’s (2003) guidelines, the first order constructs relate to conceptually unique facets of their second order constructs. Therefore, they are not interchangeable, for example omitting the construct worry would conceptually change the second order construct of cognitive anxiety. The first order constructs are also not expected to covary, as they are likely to differ between athletes. For example, Jones and colleagues suggested that not all athletes who score highly on private self-focus will score highly on public self-focus, as it is possible for some athletes to have elevated levels of private self-focus and lower levels of public self-focus and vice-versa. In addition, the associated behavioural consequences may differ for each construct. For example, athletes who experience increases in worrying thoughts may experience performance impairment on tasks that heavily rely on the working memory (Eysenck et al., 2007). Alternatively, high levels of public self-focus may increase an athlete's awareness of important others, becoming distracted by irrelevant cues in the crowd and subsequently broadening their focus towards the crowd's direction (Schwarzer & Jerusalem, 1992). Whilst, high levels of private self-focus may increase an athlete's awareness of skill execution in order to maintain performance, inducing conscious processing (Masters, 1992). Similar formative arguments can be put forward for somatic tension and autonomous hyperactivity, as Jones and colleagues suggested that they are also likely to have differing consequences. They hypothesised that somatic tension may directly impact an athlete's movements through increased muscle tension, whereas autonomic hyperactivity may impact performance through physiological reactions involved with the body's inner organs, such as increased breathing and heart rate, consequently altering an athlete's preferred activation state (Hardy et al., 1996; Hockey & Hamilton, 1983).

From this perspective, Jones et al. (2019) tested the structural model of the three-dimensional model of performance anxiety in three parts. They started with Cheng et al.'s original parcelled model and using CFA they confirmed the poor fit reported by Cheng et al. Second, they increased and enhanced the original item pool to 85 items in order to fully assess each factor. In creating the item-pool, the items from Cheng et al. that produced a significant factor loading were retained. Then, new items were generated based on Cheng et al.'s original definitions of worry, somatic tension, autonomic hyperactivity and perceived control. Additionally, items were also created to include the distinction between public and private self-focus based on Fenigstein et al.'s (1975) definitions. The 85 items were subject to extensive critique, which included evaluation of face validity, clarity of wording, reverse worded items, sentence structure and quantity of the items. Consequently, a final item pool of 55 items was agreed and subject to Partial Least Squares (PLS) analysis in order to specify their hypothesised reflective-formative model. PLS was chosen as it is a preferred method when exploring constructs measured primarily by formative indicators (Haenlein & Kaplan, 2004). However, this analysis revealed a poor fitting model. The first order factors violated discriminant validity and the structural path coefficient from private self-focus to cognitive anxiety was not significant. Following a process of item deletion, a final 25-item model produced a significantly better fit; however, the first order factors violated discriminant validity. More specifically, between worry and private and public self-focus and between autonomous hyperactivity and somatic tension. Although there was violation, the final 25-tems were retained for one final analysis on a larger sample consisting of 516 athletes. The PLS analysis revealed a good fitting model and the path coefficients from the first order factors to their second order formative factors were all positive and significant (see Figure 6). However, autonomous hyperactivity and somatic tension violated discriminant validity for a second time.

Figure 6

The Results of a Fully Differentiated Hierarchical Model of Competitive State Anxiety



Note. From "Measurement and validation of a three-factor hierarchical model of competitive anxiety", by E. S. Jones, R. Mullen and L. Hardy, 2019, *Psychology of Sport and Exercise*, *43*, p.41 (https://doi.org/10.1016/j.psychsport.2018.12.011). Copyright 2018 by Elsevier Ltd.

Formative measurement models have become increasingly popular in psychology (e.g., Jones et al., 2019; MacCallum & Browne, 1993), sociology (e.g., Bollen, 1984) and marketing (Diamantopoulos & Winklhofer, 2001; Jarvis et al., 2003); however, more recently they have come under scrutiny (e.g., Edwards, 2011; Howell et al., 2007; Lee & Cadogan, 2013). It has been suggested that problems arise in six key areas; dimensionality, internal consistency, identification, measurement error, construct validity, and causality (see Edwards, 2011). For example, the meaning of a formative latent variable (e.g., cognitive anxiety) is defined by conceptually distinct formative indicators (e.g., worry, private self-focus and public self-focus), and by the variances and covariances of these indicators. Therefore, as the variance of one indicator increases relative to the others, the meaning of the formative latent variable will become dominated by that indicator. Combining this with the effects of the indicators' covariance further complicates the definition of the formative latent variable (Edwards, 2011). Second, by definition, formative indicators represent different facets of a construct, thus they are not expected to correlate with one another (Mackenzie et al., 2005; Podsakoff et al., 2006). It can become problematic when correlations among formative indicators are large, as the loadings relating the indicators to the formative construct become unstable, resulting in large standard errors and difficulties in model estimation (Edwards, 2011). In relation to the competitive state anxiety theory, Jones et al. reported that all of the formative indicators violated discriminant validity in their first PLS analysis, and autonomous hyperactivity and somatic tension violated discriminant validity again in their second analysis, highlighting the construct validity criticism of formative modelling.

In summary, there are three apparent problems within sport psychology measurement research. The first is the heavy reliance on CFA and the second is the specification of measurement models. These problems are interlinked as the use of CFA assumes that the model is reflective in nature, leading researchers to pay less attention to the description and direction of the relationships between the constructs in their measures (Roberts & Thatcher, 2009). The third problem arises when a model appears to be formative in nature, as formative measurement has also been heavily scrutinised (e.g., Edwards, 2011; Howell et al., 2007; Lee & Cadogan, 2013). Such complications are inherent in Jones et al.’s (2019) reflective-formative model of competitive state anxiety. Therefore, further testing utilising alternative statistical analyses is warranted.

Summary and Research Aims

In summary, this review chapter clarified issues surrounding some of the key definitions used synonymously in previous competitive anxiety literature and outlined the conceptual origins of the anxiety construct. Third, this chapter reviewed some of the early performance anxiety theories, while the fourth section examined models and theories of direct relevance to the notion that anxiety can be protective or adaptive in nature. This section concluded with an in-depth critique of the three-dimensional model of competitive anxiety (Cheng et al., 2009; Jones et al., 2019) and subsequent studies that have tested the model’s assumptions. The fifth and final section provided a comprehensive review of the key issues inherent in contemporary measures of competitive state anxiety.

There are three key points emanating from this review which the present thesis will address. First, researchers should acknowledge the limitations that arise with the continued use of CFA and how this has led researchers to pay less attention to model specification (Jarvis et al., 2003). Jones et al. (2019) recognised these limitations within Cheng et al.’s TFAI, and in order to address this, they proposed a reflective-formative hierarchical model; however, this newly established reflective-formative model is in its infancy and the debate surrounding the effectiveness of formative measurement is evolving and remains contentious (Edwards, 2011). Therefore, further research examining the measurement model of the TFAI is warranted and will be explored in Study 1 of this thesis.

Second, Cheng et al.'s reconceptualisation of competitive state anxiety has received little research attention; only four empirical studies to date. This is surprising as theoretically it is more comprehensive at explaining the competitive state anxiety response compared to previous theories. Nevertheless, researchers cannot be certain of the assumptions put forward by Cheng et al. until further research has been conducted. In particular, direct replication studies would serve to validate the results reported by Cheng et al. (2011) and increase researchers' confidence in the model (e.g., Schmidt, 2009; Simons, 2014). Although advantageous, direct replication studies have been lacking in the sport psychology domain (Halperin et al., 2018). Therefore, Study 2a and 2b of this thesis aims to test the ability of Cheng et al.'s model to predict sporting performance and the interactive relationships between the three main dimensions.

Third, Cheng et al. included a regulatory dimension of competitive state anxiety reflected by perceived control (agency beliefs). This is an important step in the development of competitive state anxiety as it is the first to fully differentiate between the adaptive nature of anxiety and anxiety symptoms. Thus far, the regulatory dimension has significantly predicted sporting performance (Cheng et al., 2011; Jones et al., 2019) and consequently, Cheng et al. have suggested that it is the main feature of their model. However, few studies have tested the model, and no studies have employed an experimental design with the aim of examining the impact of differing levels of perceived control on competitive state anxiety responses and sporting performance; highlighting the final aim this programme of research will address.

Chapter 3

Testing Bayesian Bifactor Models to Examine and Validate a Three-Factor Multidimensional Model of Competitive State Anxiety

(Study 1)

Abstract

Jones et al. (2019) developed a novel reflective-formative framework for the hierarchical model of competitive state anxiety. The present study aimed to combat measurement limitations inherent in Jones et al.'s study by implementing two different bifactor models and incorporating Bayesian structural equation modelling (BSEM) to re-examine Jones et al.'s measure. The models were tested by re-examining data collected by Jones et al. (2019), where 516 participants (M_{age}= 20.86, *SD* = 3.83) completed the competitive state anxiety measure one hour before a competitive game. Findings revealed that one model had a much better statistical fit compared to the other. To explore the validity of this finding, the better fitting model was tested again using a different sample consisting of 174 participants collected by Jones et al. (M_{age}= 37.50, *SD* = 11.59). For a second time the results revealed an excellent statistical fit for the model given the data, providing support for a Bayesian bifactor approach. The present study demonstrates the effectiveness of utilising a bifactor framework for multidimensional constructs. Furthermore, the advantages of adopting bifactor models and BSEM, along with their applied benefits for psychological measurement tools are discussed.

Keywords: anxiety, reflective-formative, bifactor, Bayesian, measurement

Introduction

The psychological processes underlying athletes' competitive state anxiety are highly complex, involving numerous unobservable latent variables (e.g., worry, self-focus, psychophysiological factors, and perceptions of control) and their interconnecting causal pathways. Therefore, quantitative inquiry in the field of sport psychology requires the use of sophisticated and adaptable statistical modelling techniques that effectively capture such complexity (McIntosh, 2020).

The use of maximum-likelihood confirmatory factor analysis (ML-CFA) has become a methodological mainstay for evaluating theoretical models; however, adoption of this technique results in most models being rejected owing to its highly restrictive nature (Marsh et al., 2009). Consequently, researchers rely on approximate fit indices to justify the acceptance of a model (Fong & Ho, 2013). This issue is inherent in the competitive state anxiety literature (and many others) and has been noted in the validation of the Competitive State Anxiety Inventory-2 (CSAI-2; Martens et al., 1990b), its revised version (CSAI-2R; Cox et al., 2003), and the Three Factor Anxiety Inventory (TFAI; Cheng et al., 2009). To this end, there is a need for theoretical and technical innovations in order to increase the rigour and flexibility of theoretical model evaluation. In recent years, the sport psychology domain has seen significant advances in this respect (e.g., Gunnell & Gaudreau, 2014; Jones et al., 2019; Niven & Markland, 2016) with work of this nature continuing to proliferate (McIntosh, 2020).

A notable measurement study by Jones et al. (2019) applied a novel reflective-formative analytical framework to re-examine and extend Cheng and colleagues' (2009) hierarchical model of anxiety (see pp. 42-45 for a detailed rationale of Jones et al.'s reflective-formative model). Although this model accurately represents the relationships between the constructs within Cheng et al.'s (2009) model, formative measurement has come under critical scrutiny (e.g., Edwards, 2011; Howell et al., 2007; Lee & Cadogan, 2013). As discussed in Chapter 2 of this thesis (p. 47), there are six key areas where problems may arise: dimensionality, internal consistency, identification, measurement error, construct validity, and causality. Because of these limitations Edwards (2011) proposed a potential solution. More specifically, it was suggested that the rationale for formative measurement models could be fulfilled by specifying reflective measurement models in different ways, enabling reflective measurement models to serve the purpose of formative constructs without their inherent limitations.

Implementing Edward's (2011) recommendations, a possible alternative reflective measurement model that could be used is the bifactor model (DeMars, 2013, Rockstuhl & Van Dyne, 2018). In a bifactor model the covariances among item responses can be explained by one or more general factor(s) (Hyland, 2015) that account for the common variance among specific factors that are similar in content (Gunnell & Gaudreau, 2014; Reise, 2012). The general factor(s) represents a conceptually broad factor (e.g., cognitive anxiety) and the specific factors portray detailed subcomponents (e.g., worry). Bifactor models are especially useful for portraying multidimensional constructs (see Chen et al., 2006). This is because, both the specific factors and general factors can simultaneously be examined as antecedents or consequences of external variables. The effects of specific factors could also be explored whilst the effects of the general factors are controlled for and vice versa (Hyland, 2015). In this way, the multidimensionality of the responses can be more clearly clarified (Reise et al., 2013), which allows for all the benefits of reflective measurement, whilst also being able to examine the impact of the different sub-components of the proposed model of competitive state anxiety.

For these reasons, the present study set out to reframe Jones et al.'s reflective-formative model as a bifactor model. In addition to utilising the most appropriate model specification, consideration of analytical strategies was also required in order to fully examine the psychological processes underpinning competitive state anxiety.

Consequently, Bayesian Structural Equation Modelling (BSEM; Muthén & Asparouhov, 2012) was chosen due to its advantages for assessing factorial validity over ML-CFA (Niven & Markland, 2016). For example, the biggest difference between the Bayesian approach and ML-CFA is that ML-CFA views parameters as constants, whereas the Bayesian approach views parameters as variables with a mean and distribution of values. This allows specification of informative priors on cross-loadings and residual correlations using approximate zero means and small variances (Niven & Markland, 2016), meaning that researchers can allow for items to load onto unintended factors. The variances are specified *a priori* so the user can set limits on the amount of deviation from zero they would be prepared to tolerate. Specifying small variances suggests that the estimates are near zero, but not exactly zero. For example, specifying a mean of 0 and a variance of ± .01 corresponds to a 95% factor loading limit of ± .20 (Muthén & Asparouhov, 2012). These small cross-loadings should be factored into a psychological model, as theoretically they can be complex, with many of the items relating to other factors within the model (Marsh et al., 2009). Allowing an item to cross-load by such a small factor loading will not change the meaning of the factor in question and can combat the problem of inflated factor correlations when utilising ML-CFA. In addition, informative priors for cross-loadings and residual correlations may be combined with informative priors for the major factor loadings, through using substantive theory or previous empirical findings (Niven & Markland, 2016).

Bayesian analysis also provides useful diagnostic information on the behaviour of the indicators. A 95% credibility interval is given for each parameter and the estimates that do not encompass zero indicate that the parameter is statistically significant. This information is also provided for cross-loading parameters; therefore, researchers can decide what values they are prepared to tolerate. For example, a cross-loading parameter that has a 95% credibility interval that does not encompass zero may not be tolerated, as being close to zero is preferred (Niven & Markland, 2016). Subsequently, this information can aid a researcher in making judgements on whether to eliminate problematic indicators, which is an advantage over ML-CFA. When employing ML-CFA, modification indices are used which provides information on improving model fit by freeing one parameter at a time. MacCallum et al. (1992) suggested that such a technique capitalises on chance. In contrast, BSEM provides information about potential modifications with all the parameters estimated simultaneously (Muthén & Asparouhov, 2012). Muthén and Asparouhov (2012) suggested that a further advantage for using BSEM over ML-CFA is that is does not rely on normal distribution, as Bayesian credibility intervals are not assumed to be symmetric and so parameters with highly skewed distributions can be incorporated in the model. A final advantage is that BSEM has been shown to perform better than ML-CFA when using small sample sizes, thus it is not reliant on large sample sizes (Lee & Song, 2004). For these reasons BSEM was chosen as the most appropriate statistical analysis for the present study.

In summary, and in order to validate the theoretical stance of the competitive state anxiety theory proposed by Cheng et al. (2009) and its recent developments by Jones et al. (2019), there is a need to fully understand the appropriate model specification and implement flexible analytical strategy. The efforts to date have been hindered by the use of ML-CFA (Cheng et al., 2009) and the ever-changing debate and apparent disadvantages of using formative measurement (Jones et al., 2019). Therefore, the aim of the present study was to reframe Jones et al.'s reflective-formative model as a reflective bifactor model using BSEM.

Bayesian Structural Equation Model 1

Method

Participants

As reported by Jones et al., 516 athletes participated in their study including both males (*N* = 174) and females (*N* = 342) with ages ranging between 17 and 41 years (M_{age} 20.86, *SD* = 3.83) who were competing in a variety of sports (Archery = 40, Badminton = 22, Basketball = 42, Cheerleading = 6, Football = 40, Field Hockey = 31, Karate = 8, Netball = 240, Rugby = 57, Touch Rugby = 14, Volleyball = 16) and at differing performance levels (international = 73, national = 83, regional = 118, county = 166, and club = 76). They had an average of 9.35 years (*SD* = 4.64) competitive experience. Ethical approval to re-examine these data was obtained from the ethics committee of the authors' institution.

Measure

Competitive State Anxiety Measure

The questionnaire developed by Jones et al. (2019) comprises 25-items. Participants were asked to complete the measure regarding how they felt 'at that moment in time' responding to each item on a 5-point Likert scale, from *completely disagree* (1) to *completely agree* (5). Of the 25-items, five assess worry (e.g., "I am worried that I may make mistakes"), three items assess private self-focus (e.g., "I am aware that I will be conscious of every movement I make"), whilst three statements measure public self-focus (e.g., "I am conscious that others will be judging my performance"). In addition, five statements assess autonomic hyperactivity (e.g., "My heart is racing") and five assess somatic tension (e.g., "I find myself trembling"). Lastly, four statements assess perceived control (e.g., "I feel I have the capacity to cope with this performance"). For the complete set of questions see Appendix A.

Procedure

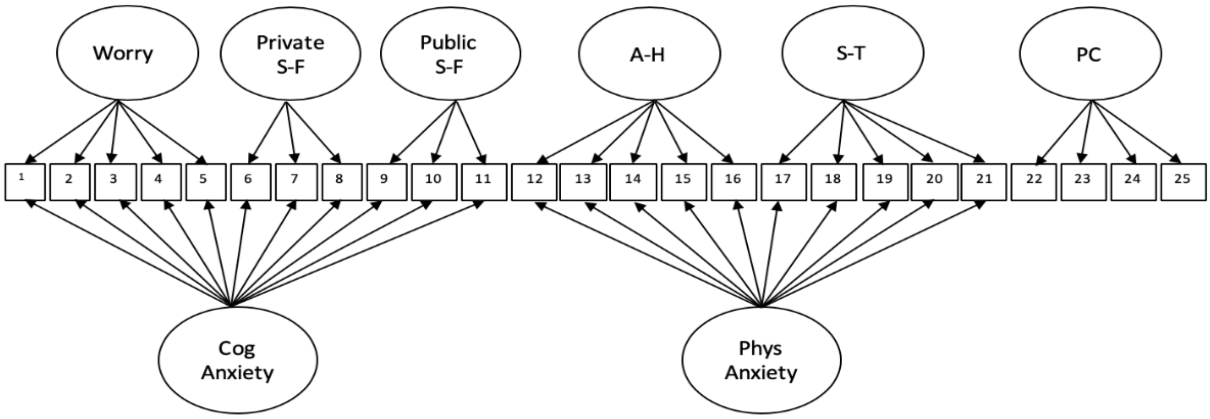
The researcher met participants one hour before their competitive event to collect prospective data. Participants completed a questionnaire pack that included informed consent, demographic information, and the competitive state anxiety measure. On completion, the researcher collected the questionnaire pack, and thanked and debriefed the participants.

Model Specification

Two different bifactor models were specified and tested because somatic tension and autonomous hyperactivity have consistently been problematic during attempts to validate the model when they were specified as two separate constructs (Cheng et al., 2009; Jones et al., 2019). For example, during Cheng et al.'s initial testing, the two physiological factors were highly correlated, revealing a poor fit. Jones et al. (2019) reported similar problems in both their analyses. Specifically, the reported factor correlations were strong (>.80) and greater than the square root of the AVE of the latent variable. To resolve this issue, the present study compared two bifactor models; one that distinguishes between autonomous hyperactivity and somatic tension, and another that combines the same items reflecting autonomous hyperactivity and somatic tension onto a single factor of physiological anxiety. All the items were retained so that the single physiological factor still reflects the full anatomical structure and symptoms. More specifically, Model 1 (see Figure 7) used the same items and factors as Jones et al., consisting of eight latent variables; six specific factors (worry, private self-focus, public self-focus, autonomic hyperactivity, somatic tension, and perceived control) and two general factors (cognitive anxiety and physiological anxiety). In comparison, Model 2 (see Figure 8) consists of six latent variables: five specific factors (worry, private self-focus, public self-focus, physiological anxiety, and perceived control) and one general factor (cognitive anxiety).

Figure 7

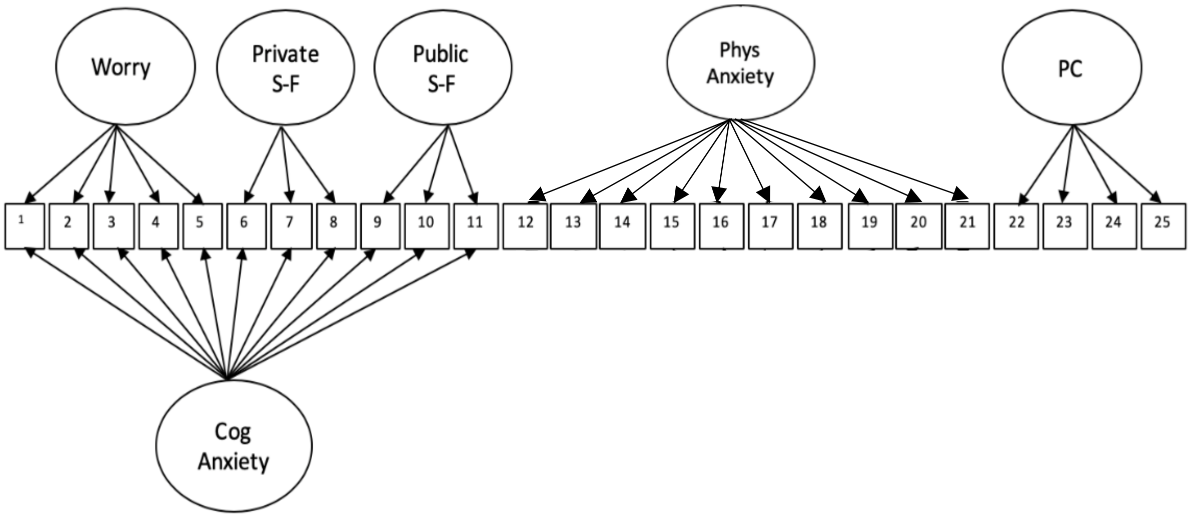
Model 1 – A Bifactor Model of Competitive State Anxiety with two General Factors and six Specific Factors



Note. Cog = Cognitive; S-F = Self-Focus; A-H = Autonomous Hyperactivity; S-T = Somatic Tension; Phys = Physiological; PC = Perceived Control

Figure 8

Model 2 – A Bifactor Model of Competitive State Anxiety with one General Factor and Five Specific Factors



Note. Cog = Cognitive; S-F = Self-Focus; Phys = Physiological; PC = Perceived Control

Data Analysis

In line with Niven and Markland's (2016) model testing strategy, a series of four BSEM models were estimated for both bifactor Model 1 (see Figure 7) and Model 2 (see Figure 8) using Mplus version 8.0 (Muthén & Muthén, 1998-2017). For the first model (1.1), non-informative priors were specified for the major loadings, exact zero cross-loadings, and exact zero residual correlations (i.e., ICM). The second model (1.2) estimated non-informative priors for the major loadings, informative approximate zero cross loadings, and exact zero residual correlations. For the third (Model 1.3), non-informative priors for the major loadings, informative approximate zero cross loadings, and residual correlations were estimated. Finally, for the fourth model (1.4), informative priors for the major factor loadings, informative approximate zero cross loadings, and residual correlations were estimated. The prior variances for cross loadings and residual correlations were specified at ± .01 with the indicators and factors standardised. This corresponds to relatively small factor loadings and residual correlations with a 95% limit of ± .20 (Muthén & Asparouhov, 2012). A sensitivity analysis was also performed to assess the stability of the estimates (Gucciardi & Zyphur 2016; Niven & Markland, 2016; van de Schoot & Depaoli, 2014). The models were re-run with smaller (.005) and larger (.015) prior variances for the cross-loadings to examine any discrepancies with the parameter estimates compared to those obtained with a prior variance of .01. Informative priors for the major loadings were specified in the final model using prior knowledge from factor analyses conducted in earlier research by Cheng et al. (2009) and Jones et al. (2019). Their major factor loadings had an average of .6, consequently the present study set a prior mean for the major factor loadings at .6 with a variance of .04, allowing the factor loadings to vary ± .39 (Gucciardi & Zyphur, 2016).

The model was estimated with the Markov chain Monte Carlo algorithm using two processors and 100,000 iterations to allow convergence and stability of the estimates.

Convergence was examined by the potential scale reduction factor (PSR), where convergence is obtained when the PSR value lies between 1.0 and 1.1 (Gelman et al., 2004). Model fit was examined through posterior predictive checks, which portray the amount of discrepancy between the model produced and original data using the likelihood ratio χ^2 test and its associated posterior predictive p value (PPP). A model with good fit should have a PPP value around or above .50 (<.50 suggests a poor fitting model) and a symmetric 95% confidence interval centred around zero (Muthén & Asparouhov, 2012). Model fit comparisons were also guided by the deviance information criteria (DIC) and Bayesian information criteria (BIC). Smaller values for the information criterion indicate better fit, because less information has been lost from the observed data to the estimated model (Gucciardi & Zyphur, 2016).

Results

Model 1. Table 1 displays the fit statistics. Model fit was poor for all analyses. Models 1.1 and 1.2 converged on a solution; however, the PPP for both models indicated poor fit and Model 1.3 did not converge on a solution. The model fit for Model 1.4 where informative priors were specified for major factor loadings, cross-loadings and residual correlations was adequate; however, the DIC and BIC values were high, indicating that the observed data was not replicated in this estimated model. In addition, many of the factor loadings failed to reach the cut off level of .40 (Ford et al., 1986). In fact, for the general factor of cognitive anxiety, 10 item loadings out of 11 were smaller than 0.40. For the general factor of physiological anxiety, 8 item loadings out of 10 were smaller than 0.40 and for the specific factor loadings, 21 item loadings out of 25 were smaller than 0.40 (see Table 2). With these limitations in mind, a sensitivity analysis was not conducted.

Table 1

Model 1 Statistical Fit and Convergence

					Difference between observed and replicated χ2 95% CI		
Model 1- Bifactor model with two general factors	No. free parameters	PPP	BIC	DIC	Lower 2.5%	Upper 2.5%	PSR
Model 1.1: Non-informative	96	0.00	72947.21	72365.27	336.54	456.47	1.02
Model 1.2 Informative priors on cross-loadings (0,.01) only	221	0.00	73487.84	72249.01	150.73	291.15	1.01
Model 1.3: Informative priors on cross-loadings (0,.01) and residual correlations	521	0.76	75558.62	71456.10	-99.78	45.90	14.17
Model 1.4: Informative priors on main factor loadings (.6,.04), cross-loadings (0,.01) and residual correlations	521	0.42	74920.25	72288.88	-68.07	83.10	1.09

Note. PPP = posterior predictive p value; BIC = Bayesian Information Criteria; DIC = Deviance Information Criteria; PSR = potential scale reduction.

Table 2

Model 1.4 Standardised Parameter Estimates and 95% Confidence Intervals

	Specific Factors						General Factors	
	Worry	Private Self-focus	Public Self-focus	Somatic Tension	Autonomous Hyperactivity	Perceived Control	Cognitive Anxiety	Physiological Anxiety
W_1	**.14**[.05,.24]**	.00[-.03,.03]	.00[-.04,.04]	-.001[-.04,.04]	.00[-.04,.04]	.001[-.04,.04]	**.14***[.05,.24]**	-
W_2	**.08**[.03,.13]**	.00[-.17,.20]	.00[-.03,.03]	.00[-.03,.03]	.00[-.03,.03]	-.01[-.03,.02]	**.08**[.03,.13]**	-
W_3	**.72***[.41,.87]**	.01[-.03,.03]	.02[-.17,.19]	.13[-.02,.29]	**.19**[.04,.33]**	.05[-.14,.21]	**.50***[.16,.76]**	-
W_4	**.10**[.04,.17]**	.00[-.04,.04]	.00[-.03,.03]	.001[-.03,.03]	.001[-.03,.03]	.003[-.03,.03]	**.10***[.04,.16]**	-
W_5	**.15**[.06,.24]**	.00[-.03,03]	.00[-.04,.04]	.00[-.03,.03]	.001[-.04,.05]	-.002[-.05,.04]	**.15***[.06,.24]**	-
Priv_1	.00 [-.03,.03]	**.08***[.03,.13]**	.00[-.03,.03]	.00[-.03,.03]	.00[-.03,.03]	.00[-.03,.03]	**.08***[.03,.13]**	-
Priv_2	-.001[-.03,.02]	**.08***[.03,.13]**	-.001[-.03,.03]	-.001[-.03,.02]	.00[-.03,.03]	.00[-.03,.03]	**.08**[.03,.13]**	-
Priv_3	-.001[-.05,.04]	**.15**[.06,.25]**	.00[-.04,.04]	-.001[-.04,.04]	.00[-.04,.04]	-.001[-.05,.04]	**.15***[.06,.24]**	-
Pub_1	.001[-.02,.03]	.00[-.03,.03]	**.08***[.03,.13]**	.001[-.03,.03]	.00[-.03,.03]	.00[-.03,.03]	**.08***[.03,.13]**	-
Pub_2	.00[-.03,.02]	.00[-.03,.03]	**.08***[.03,.13]**	.00[-.03,.03]	.00[-.03,.03]	.00[-.03,.03]	**.08**[.03,.13]**	-
Pub_3	.00 [-.04,.04]	.00 [-.04,.04]	**.15***[.06,.24]**	.00[-.04,.04]	.00[-.04,.04]	.00[-.04,.05]	**.15***[.06,.25]**	-
Som_1	.00[-.03,.03]	.00[-.03,.03]	.00[-.03,.03]	**.10***[.04,.16]**	.00[-.03,.03]	.00[-.03,.03]	-	**.10***[.04,.16]**
Som_2	.001[-.03,.03]	.00[-.03,.03]	.00[-.03,.03]	**.10***[.04,.16]**	-.001[-.03,.03]	.00[-.03,.03]	-	**.10***[.04,.17]**
Som_3	.002 [-.04,.05]	.00[-.05,.04]	.00[-.04,.05]	**.15***[.06,.24]**	.001[-.04,.05]	.001[-.04,.05]	-	**.15***[.06,.25]**
Som_4	.001[-.03,.03]	-.001[-.03,.03]	.001[-.03,.03]	**.10***[.04,.17]**	.00[-.03,.03]	.00[-.03,.03]	-	**.10***[.04,.17]**
Som_5	.13 [-.05,.27]	.002[-.19,.21]	.02[-.18,.21]	**.71***[.58,.81]**	**.17*[.01,.33]**	.03[-.16,.21]	-	**.46***[.29,.62]**
Aut_1	.09[-.10,.25]	-.01[-.29,.24]	.02[-.25,.27]	.12[-.06,.30]	**.82***[.59,.91]**	-.19[-.42,.09]	-	**.28*[.01,.56]**
Aut_2	.06[-.13,.28]	.02[-.44,.51]	.03[-.30,.50]	.09[-.14,.29]	**.44**[.15,.71]**	**.44*[.08,.61]**	-	**.33**[.07,.59]**
Aut_3	.001[-.04,.05]	.00[-.05,.04]	.00[-.04,.04]	.001[-.04,.05]	**.15***[.06,.25]**	.00[-.04,.04]	-	**.15***[.06,.25]**

Table 2 Continued…

	Specific Factors						General Factors	
	Worry	Private Self-focus	Public Self-focus	Somatic Tension	Autonomous Hyperactivity	Perceived Control	Cognitive Anxiety	Physiological Anxiety
Aut_4	.001[-.03,.03]	.00[-.03,.03]	.00[-.03,.03]	.001[-.03,.03]	**.10***[.03,.17]**	.00[-.03,.03]	-	**.10***[.03,.16]**
Aut_5	.19**[.06,.31]	.03[-.28,.32]	.00[-.24,.26]	-.05[-.24,.14]	.10[-.21,.34]	-.04[-.34,.21]	-	**.85***[.73,.91]**
PC_1	.001[-.04,.04]	.00[-.04,.04]	.00[-.04,.04]	.002[-.04,.05]	.002[-.04,.05]	**.16***[.07,.27]**	-	-
PC_2	.003[-.04,.05]	.001[-.04,.05]	.00[-.04,.05]	.002[-.04,.05]	.00[-.04,.04]	**.21***[.10,.34]**	-	-
PC_3	.00[-.03,.03]	.00[-.03,.03]	.00[-.03,.03]	.00[-.03,.03]	.00[-.03,.03]	**.09***[.03,.14]**	-	-
PC_4	.003[-.04,.05]	.001[-.04,.05]	.00[-.04,.04]	.001[-.04,.05]	.00[-.04,.04]	**.18***[.08,.28]**	-	-

Note. *p<0.05, **p<0.01, ***p<0.001, bold script shows factor loadings which are significant using BSEM criteria. For the factor loading to be significant, the confidence interval should not encompass zero (Muthen & Asparouhov, 2012). The shaded cells are items intended to load onto their corresponding factor. Values that are not shaded but bolded are significant cross loadings.

Model 2. Table 3 displays the fit statistics for Model 2. Model 2.1 and 2.2 converged on a solution; however, the PPP for the models indicated poor fit. A good fitting model was found for Models 2.3 and 2.4. In comparison to Model 2.3, the specification of informative priors for the major factor loadings for Model 2.4 improved the goodness of fit. The PPP value was closer to .5 and the 95% posterior predictive confidence interval was symmetric and centred closer around 0. In addition, the BIC and DIC values decreased slightly and the factor loadings improved. For Model 2.3, the general factor of cognitive anxiety had 4 out of 11 item loadings smaller than 0.40 and the specific factors had 14 out of 25 item loadings smaller than 0.40. Whereas, for Model 2.4 the general factor of cognitive anxiety had 3 out of 11 item loadings smaller than 0.40 and the specific factors had 4 out of 25 item loadings smaller than 0.40 (see Table 4). Therefore, including prior knowledge for the major factor loadings greatly improved the model fit.

Sensitivity analyses indicated that the factor loadings and cross-loadings were relatively stable when specifying prior variances for the cross-loadings at smaller (.005) and larger (.015) values. For Model 2.4, 95.59% of the inconsistencies fell between ± .05 and the maximum difference was .063 with prior variances set at .015 and 96.32% of the inconsistencies fell between ± .05 and the maximum difference was -.10 with prior variances set at .005.

Model 1.4 compared with Model 2.4. The findings showed that the bifactor model with one general factor (Model 2.4) was a better fit for the data. Model 1.4 revealed poor fit statistics and most of the item factor loadings were below 0.40, even though priors from previous studies were incorporated (see Table 2). In addition, Model 1.4's BIC and DIC values were larger than Model 2.4, indicating that the observed data was not represented in Model 1.4. In comparison, for Model 2.4 the probability of the hypothesised model was excellent, the DIC and BIC values more than halved, and the factor loadings greatly improved (see Table 4).

Table 3

Model 2 Statistical Fit and Convergence

Model 2- Bifactor model with two general factors	No. free parameters	PPP	BIC	DIC	Difference between observed and replicated $\chi 2$ 95% CI Lower 2.5%	Upper 2.5%	PSR
Model 2.1: Non-informative	86	0.00	33241.72	32858.76	586.46	705.87	1.01
Model 2.2 Informative priors on cross-loadings (0,.01) only	186	0.00	33400.48	32237.03	61.46	201.33	1.00
Model 2.3: Informative priors on cross-loadings (0,.01) and residual correlations	486	0.59	34891.68	32347.01	-81.83	65.98	1.09
Model 2.4: Informative priors on main factor loadings (.6,.04), cross-loadings (0,.01) and residual correlations	486	0.52	34875.67	32323.53	-77.55	72.66	1.07

Note. PPP = posterior predictive p value; BIC = Bayesian Information Criteria; DIC = Deviance Information Criteria; PSR = potential scale reduction.

Table 4

Model 2.4 Standardised Parameter Estimates and 95% Confidence Intervals

	Specific Factors					General Factor
	Worry	Private Self-focus	Public Self-focus	Physiological Anxiety	Perceived Control	Cognitive Anxiety
W_1	**.33**[.05,.55]**	-.001[-.17,.17]	.01[-.16,.19]	.05[-.11,.20]	-.08[-.21,.06]	**.50***[.25,.70]**
W_2	**.51**[.16,.72]**	.04[-.13,.21]	.02[-.17,.20]	.11[-.06,.28]	.00[-.15,.15]	.18*[-.03,.43]
W_3	**.44**[.22,.63]**	.01[-.16,.16]	.01[-.15,.17]	.07[-.07,.21]	.02[-.11,.14]	**.46***[.28,.65]**
W_4	**.47**[.16,.66]**	.01[-.16,.16]	.03[-.15,.19]	.04[-.11,.20]	-.06[-.21,.08]	**.44***[.22,.65]**
W_5	.27[-.04,.60]	-.05[-.21,.14]	.02[-.16,.21]	.07[-.09,.24]	.003[-.14,.15]	**.55***[.26,.78]**
Priv_1	.02[-.18,.20]	**.46*[.00,.72]**	-.01[-.20,.17]	.02[-.15,.20]	-0.4[-.19,.12]	**.38**[.11,.74]**
Priv_2	-.01[.21,.17]	**.51**[.12,.75]**	.01[-.18,.18]	0.7[-.12,.23]	-.003[-.15,.15]	**.48**[.16,.76]**
Priv_3	-.003[-.20,.18]	**.45*[.06,.73]**	.04[-.16,.23]	.12[-.08,.30]	.03[-.14,.18]	**.38**[.10,.66]**
Pub_1	.02[-.15,.20]	-.002[-.18,.16]	**.47**[.15,.71]**	.04[-.11,.20]	.02[-.12,.17]	**.52***[.30,.75]**
Pub_2	.02[-.15,.18]	.07[-.10,.21]	**.60**[.24,.78]**	.06[-.09,.20]	-.03[-.17,.11]	**.41***[.19,.66]**
Pub_3	.05[-.11,.23]	-.04[-.20,.13]	.19[-.10,.49]	.05[-.10,.21]	-.01[-.14,.13]	**.56***[.31,.77]**
Som_1	.03[-.11,.18]	.01[-.13,.0.16]	.02[-.13,.18]	**.33***[.13,.55]**	.03[-.11,.16]	-
Som_2	.04[-.13,.21]	.03[-.13,.20]	.06[-.12,.23]	**.55***[.37,.70]**	-.02[-.16,.13]	-
Som_3	.08[-.11,.28]	.01[-.17,.20]	.05[-.14,.23]	**.47***[.22,.70]**	-.07[-.23,.11]	-
Som_4	-.02[-.20,.17]	.04[-.13,.21]	-.004[-.18,.17]	**.45***[.19,.69]**	-.05[-.21,.12]	-
Som_5	.01[-.15,.17]	.01[-.14,.16]	.01[-.15,.16]	**.62***[.44,.76]**	-.004[-.15,.13]	-
Aut_1	.02[-.16,.20]	-.002[-.17,.16]	-.01[-.18,.17]	**.45***[.19,.65]**	.02[-.14,.18]	-
Aut_2	.04[-.14,.22]	.03[-.16,.20]	-.02[-.20,.16]	**.53***[.32,.71]**	-.04[-.20,.13]	-
Aut_3	.05[-.90,.21]	.02[-.12,.17]	-.01[-.15,.14]	**.51***[.32,.68]**	.02[-.11,.15]	-

Table 4 Continued...

	Specific Factors					General Factor
	Worry	Private Self-focus	Public Self-focus	Physiological Anxiety	Perceived Control	Cognitive Anxiety
Aut_4	.02[-.14,.19]	.03[-.14,.19]	.04[-.12,.20]	**.59***[.40,.73]**	-.02[-.16,.12]	-
Aut_5	.02[-.17,.19]	.01[-.17,.184	.03[-.16,.21]	**.56***[.33,.75]**	-.002[0.16,.16]	-
PC_1	.01[-.16,.19]	.05[-.12,.21]	.01[-.17,.18]	-.09[-.24,.07]	**.61***[.43,.75]**	-
PC_2	-.04[-.21,.13]	-.05[-.22,.12]	-.02[-.19,.15]	-.03[-.18,.12]	**.62***[.44,.75]**	-
PC_3	-.05[-.23,.13]	-.01[-.18,.15]	.01[-.16,.17]	.03[-.11,.18]	**.66***[.49,.78]**	-
PC_4	-.05[-.21,.13]	.01[-.15,.18]	-.02[-.18,.14]	-.04[-.18,.12]	**.68***[.52,.81]**	-

Note. *p<0.05, **p<0.01, ***p<0.001, bold script shows factor loadings which are significant using BSEM criteria. For the factor loading to be significant, the confidence interval should not encompass zero (Muthen & Asparouhov, 2012). The shaded cells are items intended to load onto their corresponding factor. Values that are not shaded but bolded are significant cross loadings.

Discussion

The aim of the present study was to reframe Jones et al.'s reflective-formative model as a reflective bifactor model using BSEM, in an attempt to combat the disadvantages associated with ML-CFA (Cheng et al., 2009) and formative modelling (Jones et al., 2019). This study illustrates the value of adopting a bifactor model for multidimensional constructs (Chen et al., 2006) and highlights the effectiveness of applying the BSEM approach to the assessment of the factorial validity of measurement instruments.

A second aim was to attempt to resolve the problem that autonomous hyperactivity and somatic tension have continuously violated discriminant validity (Cheng et al., 2009; Jones et al., 2019). This was achieved by comparing two different bifactor models, Model 1 (see Figure 7) and Model 2 (see Figure 8). The results indicated that Model 1.4 was a poor fit with weak factor loadings. In comparison, Model 2.4 had an excellent fit, the DIC and BIC values more than halved, and the factor loadings were much stronger.

The present study was also the first to model competitive state anxiety using these models and methods. Consequently, Model 2 was re-tested with the aim of providing further support for the model

Bayesian Structural Equation Model 2

The first BSEM factor analysis compared two different bifactor models and revealed support for a single specific physiological anxiety factor (Model 2), compared to a general physiological factor that incorporated two specific factors; autonomous hyperactivity and somatic tension (Model 1). Theoretically, it can be argued that autonomous hyperactivity and somatic tension are distinct with unique definitions and physiological anxiety symptoms. Despite this clear theoretical differentiation, every factor analysis to date has violated discriminant validity, suggesting that they are not empirically distinct. Considering the strong theoretical arguments, all of the items reflecting autonomous hyperactivity and somatic tension were retained to reflect the single specific physiological factor in Model 2, so that the single physiological factor still reflected the anatomical structure and fully captured many physiological anxiety symptoms. Therefore, BSEM factor analysis 2 aims to provide further support for Model 2, by re-examining the model using a different participant sample from Jones et al.'s (2019) study.

Method

Participants

As Jones et al. reported, a total of 174 British participants consisting of 97 males and 77 females (M_{age} = 37.50 years, *SD* = 11.59) took part. The participants were either competing in running events (*N* = 121) or triathlons (*N* = 50) at a variety of skill levels (international and national = 19, regional = 22, county = 26, club = 54, or other = 51). The competitive events included half-marathons, 10-km races, full triathlons and sprint triathlons, where the average competitive years of experience was 13.74 (*SD* = 13.01). Ethical approval to re-analyse this data was obtained from the author's institutional ethics committee.

Measure and Procedure

Jones et al.'s 25-item competitive anxiety questionnaire and prospective data collection procedure as outlined previously in BSEM 1 were used (see p. 56).

Data Analysis

The same series of four BSEM models as outlined in BSEM 1 (see p. 59) were conducted to re-examine bifactor Model 2 (hereafter referred to as Model 3), using the second participant sample (*N* = 174).

Results

Table 5 displays the fit statistics for Model 3. Model 3.1 and Model 3.2 converged on a solution; however, the PPP values display two poor fitting models. In addition, the 95% posterior predictive confidence interval was not symmetric and centred around zero, suggesting that these models were not a good fit considering the data. In contrast, Model 3.3 and Model 3.4 converged on a solution, their PPP values were closer to .5, and their 95% posterior predictive confidence intervals were centred around zero. When comparing Model 3.3 and Model 3.4 against recommended fit statistics, the results show that Model 3.4 was the better fitting model given the data. Model 3.4 specified priors for the main factor loadings, cross loadings and residual correlations, showing that incorporating prior knowledge for the main factor loadings improved model fit, in line with BSEM 1. More specifically, Model 3.4's PPP value was slightly larger than .50 and the 95% confidence interval was centred around zero. Furthermore, the BIC and DIC values were small, indicating that the information from the observed data had not been lost in the hypothesised model. On inspection of the factor loadings, the general factor of cognitive anxiety had 3 factor loadings below .40 and the specific factors had 7 factor loadings below .40, however, only 3 were not significant (see Table 6).

Sensitivity analyses indicated that the factor loadings and cross-loadings were relatively stable when specifying prior variances for the cross-loadings at smaller (.005) and larger (.015) values. For Model 3.4, 98.53% of the inconsistencies fell between ± .05 and the maximum difference was .056 with prior variances set at .015 and 97.06% of the inconsistencies fell between ± .05 and the maximum difference was .069 with prior variances set at .005

Table 5

Model 3 Fit Statistics and Convergence

					Difference between observed and replicated χ2 95% CI		
Model 3- Bifactor model with two general factors	No. free parameters	PPP	BIC	DIC	Lower 2.5%	Upper 2.5%	PSR
Model 3.1: Non-informative	86	0.00	11542.44	11259.46	450.08	572.19	1.00
Model 3.2 Informative priors on cross-loadings (0,.01) only	186	0.00	11790.13	10826.17	113.85	256.37	1.00
Model 3.3: Informative priors on cross-loadings (0,.01) and residual correlations	486	0.71	12880.54	10886.10	-96.88	54.71	1.08
Model 3.4: Informative priors on main factor loadings (.6,.04), cross-loadings (0,.01) and residual correlations	486	0.61	12851.37	10974.07	-88.54	66.29	1.03

Note. PPP = posterior predictive p value; BIC = Bayesian Information Criteria; DIC = Deviance Information Criteria; PSR = potential scale reduction.

Table 6

Model 3.4 Standardised Parameter Estimates and 95% Confidence Intervals

	Specific Factors					General Factor
	Worry	Private Self-focus	Public Self-focus	Physiological Anxiety	Perceived Control	Cognitive Anxiety
W_1	**.42**[.15,.62]**	-.02[-.17,.14]	.05[-.11,.20]	.08[-.06,.23]	.02[-.12,.15]	**.41***[.20,.62]**
W_2	**.45**[.16,.67]**	.01[-.15,.19]	.02[-.14,.18]	.14[-.02,.30]	.03[-.11,.16]	**.29**[.07,.52]**
W_3	.23*[-.02,.49]	.03[-.12,.19]	.03[-.18,.13]	.02[-.12,.16]	-.06[-.19,.08]	**.49***[.27,.67]**
W_4	**.41**[.10,.63]**	.04[-.13,.20]	-.02[-.13,.17]	.04[-.11,.18]	-.07[-.21,.06]	**.43***[.21,.66]**
W_5	**.35*[.13,.56]**	.01[-.14,.15]	.02[-.23,.10]	-.01[-.14,.14]	-.05[-.17,.08]	**.52***[.32,.68]**
Priv_1	.03[-.14,.21]	**.29*[.00,.63]**	-.07[-.14,.15]	.001[-.15,.15]	-.02[-.15,.12]	**.56***[.21,.80]**
Priv_2	-.003[-.15,.14]	**.59**[.25,.80]**	.01[-.20,.16]	.05[-.10,.20]	0.2[-.11,.15]	**.50**[.23,.76]**
Priv_3	.04[-.17,.23]	.45[-.05,.72]	-.01[-.12,.17]	.06[-.11,.24]	.07[-.10,.22]	.24[-.04,.69]
Pub_1	.04[-.12,.18]	-.02[-.17,.12]	**.61***[.38,.75]**	-.01[-.14,.14]	-.003[-.13,.12]	**.38***[.17,.59]**
Pub_2	.02[-.15,.18]	.01[-.15,.17]	**.54**[.23,.72]**	.03[-.11,.18]	-.01[-.15,.13]	**.41***[.15,.64]**
Pub_3	.02[-.14,.19]	-.05[-.19,.10]	**.31**[.05,.54]**	.03[-.11,.18]	-.02[-.15,.12]	**.48***[.25,.69]**
Som_1	.02[-.13,.18]	.01[-.13,.16]	.02[-.12,.17]	**.35**[.10,.59]**	.02[-.12,.15]	-
Som_2	.03[-.13,.19]	.10[-.05,.25]	-.04[-.19,.12]	**.54***[.33,.72]**	.001[-.14,.14]	-
Som_3	.04[-.16,.24]	.01[-.17,.18]	.05[-.14,.22]	**.53***[.22,.76]**	-.07[-.24,.10]	-
Som_4	.04[-.14,.22]	-.01[-.18,.16]	-0.1[-.19,.16]	**.37**[.07,.64]**	-.02[-.17,.14]	-
Som_5	-.02[-.16,.12]	.04[-.09,.18]	-.001[-.14,.14]	**.40***[.21,.58]**	.02[-.10,.15]	-
Aut_1	.04[-.15,.22]	-.01[-.18,.17]	.02[-.16,.19]	**.57***[.28,.80]**	-.04[-.21,.12]	-
Aut_2	.05[-.15,.24]	-.01[-.18,.16]	-.03[-.20,.14]	**.58***[.36,.75]**	-.11[-.27,.05]	-
Aut_3	.02[-.12,.16]	-.01[-.15,.12]	.06[-.08,.19]	**.30**[.09,.50]**	.07[-.05,.19]	-

Table 6 Continued…

	Specific Factors					General Factor
	Worry	Private Self-focus	Public Self-focus	Physiological Anxiety	Perceived Control	Cognitive Anxiety
Aut_4	.06[-.10,.22]	.03[-.13,.18]	-.01[-.16,.14]	**.48***[.26,.67]**	-.04[-.18,.10]	-
Aut_5	-.01[-.16,.16]	.01[-.14,.15]	.001[-.14,.14]	**.55***[.33,.72]**	-.02[-.15,.12]	-
PC_1	-.01[-.19,.17]	.03[-.13,.20]	.10[-.07,.25]	-.13[-.30,.04]	**.50***[.30,.67]**	-
PC_2	-.02[-.19,.14]	.03[-.13,.18]	-.04[-.19,.12]	-.12[-.27,.04]	**.57***[.40,.71]**	-
PC_3	-.07[-.24,.11]	.03[-.13,.20]	-.01[-.17,.15]	.01[-.15,.16]	**.73***[.56,.85]**	-
PC_4	-.01[-.18,.15]	-.01[-.17,.16]	-.05[-.22,.11]	.03[-.13,.19]	**.68***[.50,.81]**	-

Note. *p<0.05, **p<0.01, ***p<0.001, bold script shows factor loadings which are significant using BSEM criteria. For the factor loading to be significant, the confidence interval should not encompass zero (Muthen & Asparouhov, 2012). The shaded cells are items intended to load onto their corresponding factor. Values that are not shaded but bolded are significant cross loadings.

General Discussion

The aim of the present study was to reframe Jones et al.'s reflective-formative model as a bifactor model using BSEM. A second aim was to compare two bifactor models in an attempt to resolve the fundamental issue where autonomous hyperactivity and somatic tension have continuously violated discriminant validity. Therefore, a bifactor model with a multidimensional physiological anxiety construct (Model 1) was tested and compared against a bifactor model with a unidimensional physiological anxiety specific factor (Model 2). Model 2 revealed a significantly better fit than Model 1 in BSEM 1. Additionally, a good statistical fit was found when Model 2 was tested for a second time on a different participant sample. Taken together, this study illustrates the value of adopting bifactor models for multidimensional constructs, promotes the benefits of adopting the BSEM approach for the assessment of the factorial validity, and provides initial support for physiological anxiety to be measured as a single specific factor.

For both BSEM 1 and BSEM 2 analyses, the restrictions imposed on Models 1.1, 2.1, and 3.1 produced poorly fitting models, as did models with small variance priors on the cross-loadings alone (Models 1.2, 2.2, and 3.2). Taking advantage of the flexibility of BSEM by allowing small variance priors on both cross-loadings and residual correlations, however, produced better fitting models although not brilliant (Models 1.3, 2.3, and 3.3). Excellent fitting models (e.g., Models 2.4 and 3.4) were found when the flexibility of BSEM was fully taken advantage of by specifying priors for the main factor loadings using previous research. This approach provides a more theoretically and empirically realistic yet parsimonious solution in comparison to ICMs. For example, the Models 1.1, 2.1 and 3.1 analysed in the present study are all representative of ICMs and revealed poor fitting models, illustrating that the problems inherent in ICMs and the use of ML-CFA are because of unjustified exact zero restrictions on cross-loadings and residual correlations. This is problematic, as given the current ICM findings (Model 1.1, 2.1 and 3.1), researchers would have concluded that the theoretical model did not fit resorting to collapsing subscales and/or item and subscale deletion. Following this process can lead researchers to move away from the theoretical basis for their instruments and consequently discard important information. By applying BSEM with small variance priors on main factor loadings, cross loadings and residual correlations (e.g., Model 2.4, and 3.4) this problem did not occur, and it can be argued that the resulting models provide a better representation of the underpinning competitive state anxiety theory than if the subscales were collapsed (e.g., Cheng et al., 2009).

A second aim for BSEM 1 was to explore the difference between stipulating a multidimensional physiological anxiety construct (Model 1) and a unidimensional physiological specific factor (Model 2). As indicated above, the fourth analysis (where small variance priors on main factor loadings, cross-loadings, and residual correlations were specified) for each Model provided the best result given the data and underpinning theory, therefore Model 1.4 and Model 2.4 were compared. Model 1.4 revealed an adequate fit, whereas Model 2.4 revealed excellent fit statistics. As such, this finding is consistent with Cheng et al.'s (2009) and Jones et al.'s (2019) previous research; therefore, the reality of validating a multidimensional physiological anxiety construct that distinguishes between autonomous hyperactivity and somatic tension still proves problematic.

Considering Model 2 was found to be superior to Model 1, it was tested for a second time, on a different participant sample (Model 3), and revealed an excellent statistical fit for a second time. However, the factor loadings of the items should be examined in more detail. For both models three out of 36 factor loadings were not significant, which may appear problematic; nevertheless, it is important to note that a pattern emerged. To elaborate, where an item did not load significantly onto a specific factor, it loaded significantly on to the general factor, and vice versa. For example, Model

2 revealed that the item, “I am worried about the consequence of failure” did not load onto its intended specific factor, worry, but it was significant when reflecting its general factor, cognitive anxiety. This can be common with bifactor models, as Hyland (2015) explains that there are situations where items will load higher onto their general factor than their respective specific factor and vice versa. Such cases are meaningful and relevant to the model, as they are of great importance to the factor they load highly on. In addition, such results indicate which items may predominantly explain any covariation between observable indicators and the different factors (Hyland, 2015); an insight which cannot be explored using hierarchical models. Therefore, the non-significant factor loadings may not be as problematic as first thought.

From a theoretical standpoint, the findings provide strong support for the inclusion of both public and private self-focus. This is in line with the initial work of Fenigstein et al. (1975) and Jones et al.’s (2019) hypothesis that public and private self-focus are separate factors that contribute differentially to athletes’ cognitive anxiety. The ability to examine the independence of worry, private self-focus and public self-focus also has significant applied implications. Sport psychologists will be able to establish a greater understanding of an athlete’s response to competitive state anxiety and in turn develop a more individualised intervention dependent upon the athlete’s needs. For example, an athlete who scores higher on public self-focus may benefit from an intervention that promotes a task focus such as a pre-performance routine (Cotterill, 2010; Mesagno, & Beckmann, 2017). In contrast, an athlete who scores highly on worry may benefit from an individualised intervention that challenges their worrying thoughts through a range of cognitive techniques (Hardy et al., 2001; Williams & Leffingwell, 2002; Wood et al., 2015).

Additionally, further support was found for the inclusion of the regulatory dimension, as all items indicative of perceived control loaded significantly onto their intended specific factor. Research beyond measurement models has also explored the impact of the regulatory dimension on sporting performance. For example, Cheng et al. (2011) found perceived control to be the single best predictor of performance in a competitive situation, whilst Jones et al. (2019) found that participants who performed well reported higher levels of perceived control. These findings coupled with those from the present study further highlight that the regulatory dimension is a fundamental component of the competitive state anxiety response. Given the nature of perceived control, future research might focus on how different levels of perceived control interact with the other components of competitive state anxiety and how these interactions impact performance.

Strengths, Limitations, and Future Research Directions

The present study has two key strengths. First, it provides support for the use of bifactor models for multidimensional constructs within sport psychology. To the author's knowledge, self-determination theory (Gunnell & Gaudreau, 2015) and the psychological needs thwarting scale (Myers et al., 2014) are the only other theories in this area that have been modelled as bifactor models, and both studies revealed positive results. For example, Gunnell & Gaudreau (2015) were able to highlight how the specific regulations proposed in self-determination theory and a general factor of motivation can be simultaneously studied, recommending that researchers continue to explore the efficacy of bifactor models.

The most dominant advantage of bifactor models is that they allow for the specific constructs of worry, private self-focus and public-self focus to be measured reflectively whilst the differential effects of these specific factors and the general factor, cognitive anxiety, can be examined simultaneously. Furthermore, the effects of specific factors could also be explored while the effects of the general factor are controlled for and vice versa (Hyland, 2015). Therefore, this model provides a new research avenue, as it allows for the cognitive dimension to be examined in greater detail. More research could be conducted to fully understand the specific factors of cognitive anxiety and under which circumstances they explain unique variance in sporting performance.

Second, the hypothesised bifactor model with a unidimensional physiological anxiety specific factor (Model 2 and Model 3) was supported on two separate occasions. Therefore, future researchers and applied sport psychologists can be more confident in administering the 25-item questionnaire for measuring competitive state anxiety. In addition, a decision was made to rename the measure as the Three Factor Anxiety Inventory-2 (TFAI-2), to reflect the considerable methodological differences between the modified measure presented here and those of Cheng et al. (2009) and Jones et al. (2019).

Despite these strengths and the stable nature of the newly developed TFAI-2, a problem remains unresolved, that is the ability to fully differentiate between somatic tension and autonomous hyperactivity within this measurement model. A body of research exploring individuals' interoceptive sensitivity may explain this fundamental problem when modelling the physiological dimension (e.g., Fairclough & Goodwin, 2007; Feldman-Barrett et al., 2004). Feldman-Barrett and colleagues suggested that individuals do not have immediate and explicit access to feelings of autonomic and somatic activity and that internal cues can only produce feelings of arousal when those cues are attended to and perceived. Such perceptions are impacted by several factors and some individuals are better at detecting their symptoms than others (Fairclough & Goodwin, 2007). Those that cannot detect their physiological anxiety symptoms may report low scores for every item measuring physiological anxiety, thus skewing the measurement model results, and causing a major issue for the current measure. Even though the present study could only find support for a unidimensional physiological anxiety factor, it is important to note that this factor was made up of all the items that originally reflected somatic tension and autonomous hyperactivity, thus all items were retained for future research. Consequently, further research should explore the physiological dimension, incorporating psychophysiological measurements alongside self-report measures to gain a greater understanding of individual's interoceptive capabilities. There is a final need for future research investigations to explore the predictive validity of the TFAI-2. Considering the measure is in its infancy, more research is required to examine the explanatory power for predicting sporting performance in relation to Cheng et al.'s (2009) original assumptions of the theory.

In conclusion, the present study supports the use of a unique measurement model for portraying the competitive state anxiety theory. In particular, support was found for the hierarchical nature of the cognitive anxiety dimension and the inclusion of factors representing physiological anxiety and the regulatory dimension.

Chapter 4

Predictive Validity of the Three-Dimensional Anxiety Inventory-2 in Team Sport Athletes

(Study 2a and 2b)

Abstract

The purpose of this study was to further examine the measurement model and explanatory power of the TFAI-2 for predicting sports performance. A field study design was adopted with 159 athletes (M_{age}= 20.16 years, *SD* = 1.78; Study 2a) competing in invasion game sports (rugby, football, netball and basketball) and 117 baseball players (M_{age}= 16.74 years, *SD* = .73; Study 2b). The TFAI-2 was administered approximately one hour before competition and a sport performance measure specifically developed for the current study (Study 2a) was administered approximately 30 minutes following the competition. In study 2b, the baseball players' performance was measured using their batting percentage. First, Bayesian structural equation modelling (BSEM) was used to provide further support for the bifactor structure of the TFAI-2 measure. Second, Bayesian hierarchical regression was used to examine the original assumptions of Cheng et al.'s (2009) competitive anxiety model. Specifically, that perceived control would account for significantly more performance variance over and above that explained by cognitive and physiological anxiety, and that the interactive effects of anxiety variables would make a significant contribution to performance variance once the main effects were controlled for. The three main components of competitive state anxiety did not interact to predict performance as hypothesised; however, the findings did demonstrate the positive impact of perceived control on sporting performance. The theoretical and practical implications of the importance of the regulatory dimension of anxiety are discussed.

Keywords: bifactor, measurement, competitive anxiety, predictive validity, perceived control

Introduction

Cheng et al.'s (2009) reconceptualisation of competitive state anxiety and its further development by Jones et al. (2019) incorporates three main dimensions; cognitive anxiety, physiological anxiety and a regulatory dimension. This framework is crucial to extending our understanding of the anxiety-performance relationship as each dimension builds upon previous theories by specifying further factors. The most pertinent difference between Cheng et al.'s model and previous incarnations of competitive state anxiety is the inclusion of the regulatory dimension, which is grounded in the idea that anxiety can be adaptive, sending warning signals that enable individuals to respond more effectively to perceived threat (Öhman, 2000). Accordingly, the regulatory dimension is indicated by perceived control that concerns the capability of coping and attaining goals under pressure. Such a construct has also been referred to as agent-means beliefs (Skinner, 1996) and its inclusion in Cheng et al.'s model of competitive state anxiety is consistent with a number of conceptual considerations (e.g., Carver & Scheier, 1988; Eysenck & Calvo, 1992; see p. 28 of this thesis for a detailed review of Cheng et al.'s model).

Theoretically, Cheng et al.'s reconceptualisation of competitive state anxiety captures the full complexity of the anxiety response, more so than previous theories. However, a robust and validated measure is also necessary to enable accurate model testing. The measurement model was considered and developed further in Study 1 of this thesis, where support was found for a bifactor model using two different participant samples and the measure used to capture the model was named the TFAI-2. However, considering this measurement model is in its infancy, the first aim of the present study was to provide additional validation of the TFAI-2 using two further participant samples.

The second aim of the present study was to examine the predictive validity of the model. This aim is important as little research has endeavoured to test the model. Prior to the emergence of Cheng et al.'s model, the importance of perceived control within the anxiety-performance relationship appeared in two studies. First, Hanton and Connaughton (2002) investigated elite and sub-elite swimmers' retrospective perceptions and causal beliefs about the link between anxiety symptoms and performance and found that higher levels of control were perceived to enhance performance. Second, Otten (2009) proposed a structural equation model to predict performance under pressure, where perceived control was the best predictor of basketball performance, more so than the factor "expertise" (expertise was operationalised as the number of years of basketball-playing experience). In addition, higher levels of sport confidence led to more feelings of perceived control; therefore, it was suggested that perceived control may be the mechanism by which sport confidence enhances performance under pressure. These studies were not grounded in Cheng et al.'s model, and since its publication there have been very few empirical tests of this reconceptualisation. The studies that have tested Cheng et al.'s theory are reviewed in Chapter 2 of this thesis (see p. 34). For the purpose of the present study, several aspects of those studies are noteworthy.

First, Jones et al. (2019) explored the impact of competitive state anxiety on runners' and triathletes' performance. They examined differences in worry, private self-focus, public self-focus, autonomic hyperactivity, somatic tension, and perceived control between high and low performing athletes. High performers reported significantly higher levels of perceived control compared to low performers.

Second, Cheng et al. (2011) examined the explanatory power of their Three Factor Anxiety Inventory (TFAI; Cheng et al., 2009) for predicting sport performance. They set out to test the main assumption of their framework, which proposed that the regulatory dimension of competitive state anxiety, and the interaction effects between the three main dimensions would prove to be strong predictors of performance. The TFAI was administered 30 minutes before tae-kwon-do athletes took part in a competitive bout and a performance measure derived specifically for the study was administered approximately 30 minutes after the bout ended. Moderated hierarchical regression showed that cognitive and physiological anxiety only accounted for 2% of performance variance, whereas perceived control accounted for an additional 20%. Moreover, the interaction effects accounted for a further 15% of performance variance, once the variance explained by the three main factors of competitive anxiety were controlled for. The nature of this interactive effect was between perceived control and physiological anxiety. More specifically, it revealed that performance was enhanced by increased perceived control under low physiological anxiety. Moreover, performance was not significantly enhanced with increased perceived control and high physiological anxiety; however, it was maintained, suggesting that perceived control may have attenuated the potentially maladaptive effects of higher levels of physiological anxiety on performance. Taken together, these results are promising, supporting some of the key predictions of Cheng et al.'s (2009) model. However, more research is warranted to further investigate interactions among the anxiety subcomponents and the adaptive potential of the regulatory dimension.

Therefore, the second aim of the present two-part study was to re-examine the findings produced by Cheng et al. (2011). It was hypothesised that: (a) further support would be found for the bifactor model; (b) perceived control would account for significant additional performance variance over and above that contributed by cognitive and physiological anxiety; (c) the interaction effects would make a significant contribution to the performance variance; and (d) perceived control would attenuate the maladaptive effects of cognitive and/or physiological anxiety intensity upon performance.

Study 2a

Method

Participants

The sample comprised 159 participants (Male = 92, Female = 67) with ages ranging between 18 and 32 years (M_{age} = 20.16, *SD* = 1.78). Participants were competing in a variety of invasion games (rugby = 38, football = 45, netball = 51, basketball = 25), at different performance levels (international = 13, national = 22, regional = 33, county = 45, university = 43, and club = 3). The participants had an average of 10.74 (*SD* = 4.28) years of competitive experience with an average of 2.64 (*SD* = 1.48) of those years at their current skill level. Ethical approval was obtained from the University of South Wales ethics committee.

Measures

TFAI-2

This measure was validated in Study 1 of this thesis (see p. 56 and Appendix A for more detail).

Self-Rated Performance

In line with recommendations from previous research (Cheng et al., 2011; Hardy & Hutchinson, 2007; Jones et al., 2019), a self-report measure of performance was derived from the characteristics of good performances that are shared between invasion game sports. The research team developed seven items and contacted several University and regional level sport teams' coaches (*N* = 12) with questions about the performance measure. Five coaches replied (one hockey coach, two football coaches, one rugby coach and a netball coach) with their feedback, which was subsequently reviewed by the research team. Changes to the items were made accordingly. The coaches were contacted a second time with the reviewed items, and all agreed the final 7 items without further modification. The 7-item scale consisted of the following statements: (a) I was able to control my emotions when needed throughout my performance; (b) I communicated effectively with teammates; (c) My physical fitness and work rate allowed me to cope with the demands of the match; (d) I fulfilled my role in the team and was able to execute strategies well; (e) I made effective decisions; (f) I had the drive and personal effort for optimal performance; and (g) I executed the required technical skills to the best of my ability. These items were measured on a 5-point Likert scale ranging from *completely disagree* (1) to *completely agree* (5) and the scores were averaged. The factor validity of this single performance factor was examined, and a Bayesian structural equation model produced a perfec fit given the data, PPP = .50, Δobserved and replicated χ^2 95% CI [-24.39, 23.12], DIC = 2648.31, BIC = 2791.30.

Global Performance

The athletes were also asked to rate their performance on one global question "Overall, how well do you believe you performed" using a 10-point Likert scale ranging from *very poor* (1) to *excellent* (10). This was included so the global nature of performance was still captured, and the item is an exact comparison to the coaches' question outlined below.

Coach-Rated Performance

The athletes' coaches were asked to rate their athletes' performance in order to gain an objective performance measure. Gaining a coach's perspective of performance was included because researchers have argued that a single self-assessed measure is too subjective and may be affected by athletes' social desirability and mood (Totterdell, 2000). Therefore, utilising a composite measure of self-rated and coach rated performance creates a more reliable picture of "performance" (Jones et al., 2019). This measure was completed immediately after the athletes' match, using one question "How well do you believe this player performed?" It was marked on a 10-point Likert scale ranging from *very poor* (1) to *excellent* (10).

Procedure

Once individuals agreed to participate, the researcher arranged to meet them 60 to 90 minutes, depending on the team's pre-match routine, before a competitive match in order to collect prospective data. At this point informed consent was obtained after which they completed a demographic questionnaire. The demographic questionnaire asked questions about the athlete's age, gender, the sport they played, the competition they were participating in, their current skill level and their number of years of competitive experience. Following this, the TFAI-2 was administered before the warm-up for their competition. Within 30 minutes of completing their match, the researcher administered the self-rated performance measure and global performance question to the athletes and the coach-rated performance question to the respective coaches. Finally, the athletes and coaches were thanked and debriefed.

Data Analysis

Bifactor Model

The bifactor model validated in Study 1 of this thesis was tested for a third time by combining Study 2a and Study 2b participants (*N* = 276) responses to the TFAI-2. BSEM was conducted in Mplus version 8.0 (Muthén & Muthén, 1998-2017) and the same process outlined in Study 1 was implemented (see p. 59 for more detail).

Descriptive Statistics and Hierarchical Regression

Bayesian inference as opposed to more traditional null-hypothesis significance testing (NHST) was adopted. The almost exclusive use of *p* value NHST within psychology literature has been repeatedly criticised (e.g., Rouder & Morey, 2012; Wagenmakers, 2007; Wagenmakers et al., 2018). One main critique is that *p* values are often misinterpreted as Bayesian posterior probabilities. More specifically, the interpretation of $p < .05$ significantly supports the alternative hypothesis and therefore the null hypothesis can be rejected, is a leap that is logically incorrect (Gigerenzer et al., 2004). This is because the use of a *p* value does not indicate how much support there is for the alternative hypothesis, or whether the null hypothesis can truly be rejected. In fact, some researchers have adopted both frequentist statistics and Bayes factors in order to gain a *p* value but interpret the *p* value using Bayes factors (e.g., Gainforth et al., 2015; Loffing et al., 2017).

The Bayesian approach has many other pragmatic advantages over NHST, including the ability to quantify evidence in favour of the null or alternative hypothesis (e.g., Dienes, 2014), compare statistical models (e.g., Wagenmakers, 2007), and there are less restrictive normality assumptions depending less on asymptotic theory, thus researchers are more likely to produce more reliable results (Song & Lee, 2012). For these reasons, and following recommendations (e.g., Kruschke et al., 2012) the present study employed Bayesian statistics. The Bayes factors methodology is based on the quantification of the relative degree of evidence for supporting two opposing hypotheses, null hypothesis (H_0) vs. alternative hypothesis (H_1) by means of Bayes factors (BF_{01} or BF_{10}), weighing the support for one model against the other. BF_{10} indicates the Bayes factor in favour of H_1 over H_0, whilst BF_{01} indicates the Bayes factor in favour of H_0 over H_1, specifically $BF_{10} = 1/BF_{01}$ (van Doorn et al., 2020). The present study used evidence categories created by Lee and Wagenmakers (2013) to interpret the resulting Bayes factors, as shown in Table 7.

Descriptive statistics and hierarchical regression were conducted using JASP software (0.14.0; JASP Team, 2020). First, for the descriptive statistics, means and standard deviations were calculated for the anxiety dimensions and all performance measures. Second, Bayesian *t*-tests were conducted to examine any potential gender effects in both the independent variables, the three anxiety dimensions; cognitive anxiety, physiological anxiety, and perceived control, and dependent variables, self-rated performance and global performance and coach-rated performance scores.

To conduct the Bayesian hierarchical regression, the data was first standardised, and Bayesian correlational analysis was used to identify zero-order relationships among variables. In addition, visual checks of scatter plots of the criterion and predictor variables and Q-Q plots of the residuals were conducted to assess normality (van den Bergh et al., 2020a). Second, in order to replicate Cheng et al.'s (2011) analysis strategy, the predictors were entered in the regression in three steps: (1) cognitive anxiety and physiological anxiety; (2) perceived control; and (3) cognitive anxiety × physiological anxiety, perceived control × physiological anxiety, perceived control × cognitive anxiety, and the three way interaction term.

Table 7

The Descriptive Interpretation of Bayes Factors BF_{10}

Bayes factor	Evidence Category
>100	Extreme evidence for H_1
30 - 100	Very strong evidence for H_1
10 - 30	Strong evidence for H_1
3 - 10	Moderate evidence for H_1
1 - 3	Anecdotal evidence for H_1
1	No evidence
1/3 - 1	Anecdotal evidence for H_0
1/10 - 1/3	Moderate evidence for H_0
1/30 - 1/10	Strong evidence for H_0
1/100 - 1/30	Very strong evidence for H_0
<1/100	Extreme evidence for H_0

Note. A descriptive and approximate classification scheme for Bayes factor interpretations as produced by Jeffreys in 1961 and adjusted by Lee & Wagenmakers in 2013 (as reprinted in Wagenmakers et al., 2018). From "Bayesian inference for psychology. Part II: Example applications with JASP", by E-J. Wagenmakers and colleagues, 2018, *Psychonomic Bulletin & Review, 25*, p. 67 (https://doi.org/10.3758/s13423-017-1323-7).

Results

Bifactor Model

Table 8 shows the fit of the bifactor model. Adequate convergence was achieved for all models. The restrictive independent clusters BSEM model with zero cross-loadings and zero residual correlations converged on a solution; however, the PPP value indicated a poor fit to the data. The model fit was also unacceptable when informative small variance priors on the cross-loadings, and informative priors on the cross-loadings and residual correlations were specified. However, the last model specified with informative priors on the main factor loadings, cross-loadings and residual correlations had an excellent fit for the data, with PPP close to .5 and symmetric 95% posterior predictive confidence intervals centred around zero.

The items' standardised factor loadings and 95% credibility intervals are shown in Table 9. All major factor loadings, with the exception of one, were significant and of these only two did not meet conventional loading criteria (e.g., >.40; Ford et al., 1986). The item that was not significant was from the public self-focus subscale, "I am worried that I may not meet the expectations of important others." One item reflecting the specific worry factor, "I am worried that I may not perform to the best of my ability", had a relatively low loading of .38, and an item from the worry specific factor, "I am worried about the uncertainty of what may happen", had a low factor loading of .24 when reflecting the general factor cognitive anxiety. Additionally, the majority of cross-loadings shrunk toward their zero prior means and were within their a priori limits of ±.20, with the exception of one item from the physiological anxiety specific factor, "I feel physically nervous" that significantly cross-loaded onto the worry specific factor with a loading of .21.

When specifying prior variances for the cross-loadings at smaller (.005) and greater (.015) values, the factor loadings and cross-loadings remained constant. For example, with prior variances set at .005, 94.12% of the discrepancies fell between ±.05 and the maximum discrepancy was .14. Whilst 97.79% of the discrepancies fell between ±.05 and the maximum discrepancy was -.08 with prior variances set at .015.

Table 8

TFAI-2 BSEM fit and Convergence

					Difference between observed and replicated $\chi 2$ 95% CI		
Model – TFAI-2	No. free parameters	PPP	BIC	DIC	Lower 2.5%	Upper 2.5%	PSR
Non-informative	86	0.12	18969.62	16213.37	-26.81	105.35	1.02
Informative priors on cross-loadings (0,.01) only	186	0.00	18049.97	17269.44	24.76	159.15	1.00
Informative priors on cross-loadings (0,.01) and residual correlations	486	0.42	19488.78	17310.78	-87.03	62.89	1.06
Informative priors on main factor loadings (.6,.04), cross-loadings (0,.01) and residual correlations	486	0.47	19468.67	17369.84	-73.51	80.23	1.02

Note. PPP = posterior predictive p value; BIC = Bayesian Information Criteria; DIC = Deviance Information Criteria; PSR = potential scale reduction

Table 9

TFAI-2 Standardised Parameter Estimates and 95% Confidence Intervals

	Specific Factors					General Factor
	Worry	Private Self-focus	Public Self-focus	Physiological Anxiety	Perceived Control	Cognitive Anxiety
W_1	**.49** [.14,.71]**	-.01[-.18,.17]	.07[-.13,.25]	.01[-.13,.16]	-.04[-.18,.01]	**.48***[.28,.70]**
W_2	**.50***[.18,.72]**	.05[-14,.23]	.02[-.17,.21]	.11[-.06,.38]	-.20[-.17,.14]	**.24*[.03,.46]**
W_3	**.46**[.18,.68]**	.01[-.16,.19]	.08[-.10,.25]	.07[-.07,.21]	-.03[-.17,.11]	**.48***[.27,.67]**
W_4	**.38**[.09,.64]**	-.01[-.18,.15]	-.01[-.18,.17]	.05[-.08,.18]	-.04[-.19,.10]	**.66***[.44,.82]**
W_5	**.43***[.14,.68]**	.01[-.16,.17]	-.02[-.19,.17]	.07[-.07,.20]	-.04[-.17,.10]	**.55***[.34,.76]**
Priv_1	.06[-.12,.23]	**.44**[.11,.69]**	-.03[-.21,.16]	.11[-.05,.26]	-.01[-.16,.14]	**.44***[.19,.69]**
Priv_2	-.02[-.21,.17]	**.48**[.09,.74]**	.04[-.15,.24]	.07[-.08,.21]	.01[-.14,.17]	**.43***[.17,.69]**
Priv_3	.00[-.19,.17]	**.54**[.13,.79]**	.05[-.14,.23]	.09[-.06,.23]	.01[-.14,.16]	**.41***[.15,.66]**
Pub_1	.06[-.12,.22]	.01[-.16,.17]	**.56*[.00,.77]**	.04[-.09,.18]	-.004[-.14,.13]	**.50***[.28,.74]**
Pub_2	.03[-.15,.21]	.06[-.11,.23]	**.58*[.20,.77]**	.12[-.03,.26]	.04[-.10,.17]	**.45***[.23,.65]**
Pub_3	.07[-.11,.26]	-.05[-.23,.12]	.07[-.20,.44]	.04[-.10,.18]	-.04[-.18,.10]	**.68***[.45,.83]**
Som_1	**.21*[.01,.39]**	.11[-.08,.29]	.06[-.13,.25]	**.46***[.25,.63]**	.00[-.16,.16]	-
Som_2	.07[-.11,.26]	.06[-.13,.23]	-.06[-.25,.13]	**.63***[.45,.76]**	-.06[-.22,.09]	-
Som_3	.03[-.16,.21]	.00[-.19,.19]	.08[-.12,.27]	**.59***[.40,.74]**	-.01[-.17,.15]	-
Som_4	.03[-.16,.22]	.10[-.15,.23]	.02[-.18,.21]	**.50***[.25,.71]**	-.03[-.20,.14]	-
Som_5	-.02[-.19,.16]	.06[-.12,.23]	-.01[-.19,.18]	**.63***[.44,.77]**	.03[-.13,.19]	-
Aut_1	-.01[-.21,.19]	.03[-.16,.22]	.04[-.16,.24]	**.50***[.28,.67]**	.05[-.13,.21]	-
Aut_2	.06[-.13,.24]	-.04[-.21,.14]	.06[-.12,.24]	**.55***[.36,.70]**	-.04[-.19,.12]	-
Aut_3	.04[-.14,.22]	.01[-.17,.18]	.04[-.14,.22]	**.62***[.42,.77]**	-.01[-.17,.16]	-
Aut_4	.04[-.14,.23]	-.01[-.19,.18]	.03[-.16,.23]	**.53***[.35,.67]**	-.12[-.27,.04]	-

Table 9 Continued…

	Specific Factors					General Factor
	Worry	Private Self-focus	Public Self-focus	Physiological Anxiety	Perceived Control	Cognitive Anxiety
Aut_5	.03[-.15,.20]	.02[-.16,.19]	.03[-.16,.21]	**.49***[.24,.69]**	.004[-.16,.17]	-
PC_1	.04[-.14,.22]	-.02[-.20,.16]	0.12[-.06,.30]	-.12[-.27,.03]	**.65***[.48,.78]**	-
PC_2	-.10[-.27,.07]	-.01[-.18,.15]	-.002[-.17,.16]	-.04[-.19,.10]	**.68***[.53,.80]**	-
PC_3	-.01[-.19,.17]	.03[-.16,.20]	-.02[-.21,.16]	-.02[-.18,.13]	**.67***[.48,.82]**	-
PC_4	-.10[-.28,.08]	.02[-.16,.20]	-.06[-.24,.14]	.03[-.12,.18]	**.67***[.49,.80]**	-

Note. *p<0.05, **p<0.01, ***p<0.001, bold script shows factor loadings which are significant using BSEM criteria. For the factor loading to be significant, the confidence interval should not encompass zero (Muthen & Asparouhov, 2012). The shaded cells are items intended to load onto their corresponding factor. Values that are not shaded but bolded are significant cross loading.

Descriptive Statistics and Hierarchical Regression

Correlation analysis was initially used to identify zero-order relationships among variables. It revealed strong evidence (BF > 10) for positive relationships between cognitive and physiological anxiety, self-rated performance with perceived control, global performance and coach-rated performance, and global performance with coach-rated performance. The complete correlation matrix is displayed in Table 10 along with means and standard deviations.

Table 10

Mean, Standard Deviation and Correlations for the Three Main Competitive State Anxiety Dimensions and Performance Variables

Variable	Mean (SD)	1	2	3	4	5	6
1. Cognitive Anxiety	2.95(.75)	-	-	-	-	-	-
2. Physiological Anxiety	1.83(.50)	.56***	-	-	-	-	-
3. Perceived Control	3.80(.56)	-.20	-.17	-	-	-	-
4. Self-rated performance	3.68(.67)	.07	.15	.31***	-	-	-
5. Global Performance	6.34(1.66)	-.02	.16	.13	.69***	-	-
6. Coach-rated Performance	6.87(1.44)	.04	.10	.02	.35***	.48***	-

Note. *BF_{10} > 10, **BF_{10} > 30, ***BF_{10} > 100. Measures of anxiety and self-rated performance were scored on a 5-point Likert scale while measures of global performance and coach-rated performance were scored on 10-point Likert scales

There was no strong evidence found for gender differences in any of the independent and dependent variables. For performance ratings, even though coach-rated performance and global performance were strongly correlated, there was strong evidence for differences between the level of scoring. The posterior median was .33, the 95% credible interval ranged from -.48 to -.17, and the BF was 304 in favour of H_1 (alternative hypothesis), indicating that the coaches were 304 times more likely to score the athletes performance more highly than the athletes rated themselves.

As no significant gender differences were obtained, all data were standardised before normality tests were conducted. Problems were found with the global performance and coach-rated performance dependent variables, as they did not have a linear relationship with any of the predictor variables. In addition, on inspection of the Q-Q plots the residuals were not normally distributed (van den Bergh et al., 2020a). Consequently, these variables did not form part of the main analysis.

The total performance variance explained by the whole model was 15%. Cognitive and physiological anxiety (M_1) accounted for only 2% of performance variance and did not predict performance any better than a model with no predictors (BF_{10} = .17; strong evidence for H_0). Perceived control (M_2) accounted for a significant additional 12% variance and predicted the data 3342.86 times better than M_1, providing extreme evidence for M_2. The interaction effects (M_f) did not make a significant contribution to the model, only accounting for an extra 1% of the performance variance (BF_{10} = .02; extreme evidence for H_0), as shown in Table 11.

Table 11

Summary of Hierarchical Regression for Anxiety Variables Predicting Athletes' Self-Rated Performance

Variables Entered	P(M)	P(M|Data)	BF_M	BF_{10}	R^2
Step 1					
Null Model	.33	.004	.01	1.00	.00
Step 2					
M_1 - Cognitive Anxiety and Physiological Anxiety	.33	.10	.23	.17	.02
Step 3					
M_2 - Perceived Control	.50	1.00	3342.86	3342.86	.14
Step 4					
M_f - Interaction Effects	.29	.02	.04	.02	.15

Note. P(M) = prior model probability; P(M|data) = posterior model probability; BF_M = a Bayes factor which quantifies the change between prior probability to posterior probability; BF_{10} = Model's Bayes factor compared to the model previously; R^2 = the explained variance of each model. The individual interaction effects were not reported separately as the total effects of the interactions were very low.

Discussion

Consistent with the first hypothesis and the findings of Study 1 of this thesis, the results showed further support for the bifactor model. The fit statistics portrayed an excellent fitting model for the data. On closer inspection of the factor loadings, each item loaded significantly onto their intended specific factor with the exception of one (i.e., "I am worried that I may not meet the expectations of important others") and all intended items loaded significantly onto the general factor.

Support was also found for the second hypothesis, which assumed that perceived control would predict performance over and above cognitive and physiological anxiety. As such, the inclusion of perceived control within the regression model accounted for a significant additional 12%, compared to cognitive and physiological anxiety which only accounted for 2% of the performance variance.

Third, it was predicted that interaction effects would make a significant contribution to performance variance; however, this did not emerge from the analysis. As a result, there was also no support for the fourth and final hypothesis, which predicted that perceived control would attenuate the maladaptive effects of cognitive and/or physiological anxiety intensity upon performance. This contrasts with Cheng et al. (2011), who found a significant interaction between perceived control and physiological anxiety, which illustrated that athletes with high perceived control maintained their performance while experiencing high levels of physiological anxiety. However, none of the interaction effects predicted performance in the present study, suggesting that perceived control had the same impact on athletes' performance, irrespective of their anxiety levels.

The participant sample and self-report measure of performance may explain the absence of interaction effects. Firstly, athletes from team sports were chosen for the participant sample because previous research has only explored individual sports such as tae-kwon-do (Cheng et al., 2011) and running/triathletes (Jones et al., 2019). Therefore, it was advantageous to examine the competitive state anxiety response on a participant sample not yet captured in the literature. However, this approach also has its limitations, as it increases the contextual variables influencing the anxiety-performance dynamics. For example, the quality of the pitch/court, crowd size, the quality of the opposition, the role of the player and behaviour of teammates. In addition, the present study used self-assessed performance over objective measures, as the participant sample comprised of four different invasion game sports and thus the only relevant objective measure would have been a global win/loss criterion, which lacks precision (e.g., Butt et al., 2003; Cheng et al., 2009). Nevertheless, researchers have raised concerns over the use of self-report measures due to effects of social desirability and mood (e.g., Totterdell, 2000). Cheng et al. (2011) argued that social desirability was unlikely to have confounded their results as they produced a significant interaction effect. In relation to the present study, it could be argued that the findings were confounded by social desirability as the data was not sensitive enough for interaction effects to be found. Therefore, these limitations were acknowledged and part 2 of this study attempts to address them.

Study 2b

Introduction

The second part of this study aims to add further support to the predictive validity of the three-factor competitive state anxiety model by utilising an objective measure of performance, players' batting percentage. In addition, only one sport, baseball, was used and all players competed at the highest national level within their age group (under 19). These characteristics were chosen in order to explore the anxiety response on a group of athletes competing in a single team sport, and therefore, may avoid the potentially confounding effects of contextual variables associated with a variety of sports. The hypotheses tested were the same as those used in study 2a (see p. 84).

Method

Participants

The sample comprised 117 male Finnish baseball players across 10 different teams. Participants' mean age was 16.74 years (*SD* = .73) with a mean of 8.80 years playing experience (*SD* = 2.55). They all competed at the highest national level for under 19 age group and all playing positions were represented. Ethical approval for the study was obtained from the institution's ethics committee.

Measures

TFAI-2

This measure was validated in Study 1 of this thesis, see p. 56 and Appendix A for more detail.

Batting Performance

Players' success percentage in batting was obtained from the official Finnish Baseball Association's statistics website; http://www.pesistulokset.fi/cgi-bin/tilastot/lista2.py. These statistics were uploaded during each competitive game by a trained official. If a player succeeds to get to first base or move his teammate forward on the field during his batting turn, the batting attempt is deemed successful. In contrast, if the player or teammate on the field is out during the batting turn, the batting attempt is deemed unsuccessful.

Procedure

The same procedure as Study 2a was adopted with some minor changes. More specifically, early regular competitive season games were targeted (excluding the first game of the season). These games were sought to avoid special circumstances, such as must-win games for a playoff position. In addition, the researcher arranged to meet with the athletes two hours before competition to gain informed consent, collect demographic information and administer the TFAI-2. The measure was completed before the warm-up and approximately 75 to 90 minutes before the game. Lastly, all performance measures were administered using the same procedure as Study 2a, with the addition of adding participants' batting percentage to their performance records.

Data Analysis

The same descriptive and hierarchical regression analyses as Study 2a were adopted (see pp. 87-89).

Results

Descriptive Statistics

The results from the correlation analyses showed strong evidence (BF > 10) for positive relationships between cognitive and physiological anxiety, batting performance and perceived control. The complete correlation matrix is displayed in Table 12 along with means and standard deviations.

Table 12

Mean, Standard Deviation, and Correlation Matrix for the Predictor Variables and Dependent Variable

Variable	Mean (SD)	1	2	3	4
1. Cognitive Anxiety	2.67 (.64)	-	-	-	-
2. Physiological Anxiety	1.98 (.62)	.54***	-	-	-
3. Perceived Control	3.83 (.70)	-.17	-.20	-	-
4. Batting performance	62.77 (21.20)	.06	.13	.33**	-

Note. *BF_{10} > 10, **BF_{10} > 30, ***BF_{10} > 100. Measures of anxiety were scored on a 5-point Likert scale whilst batting performance was measured from 0% to 100%.

Hierarchical Regression

All data were standardised, and normal distribution tests were conducted. As displayed in the correlation matrix (see Table 12), there was not a linear relationship between cognitive and physiological anxiety and the predictor variable, batting performance. However, there was extreme evidence for a linear relationship with batting performance and perceived control (BF_{10} = 68.80). In addition, the predictor variables residuals were normally distributed. Considering the assumptions were partially met, and Bayesian analyses depend less on asymptotic theory (Song & Lee, 2012), hierarchical regression with batting performance as the predictor was still conducted.

The whole model explained 17% of the total performance variance. Cognitive and physiological anxiety (M_1) accounted for only 2% of performance variance and did not predict performance any better than a model with no predictors (BF_{10} = .13; strong evidence for H_0). However, perceived control (M_2) accounted for an additional 13% and predicted the data 380.10 times better than M_1, providing extreme evidence for perceived control predicting batting performance. The interaction effects (M_f) did not make a significant contribution to the model, only accounting for an extra 2% of the performance variance (BF_{10} = .06; extreme evidence for H_0), as shown in Table 13.

Table 13

Hierarchical Model Comparison Predicting Athletes' Batting Performance

Variables Entered	P(m)	P(M|Data)	BF_M	BF_{10}	R^2
Step 1					
Null Model	.33	.03	.07	1.00	.00
Step 2					
M_1 - Cognitive Anxiety and Physiological Anxiety	.33	.09	.20	.13	.02
Step 3					
M_2 - Perceived Control	.50	.98	380.10	380.10	.15
Step 4					
M_f - Interaction Effects	.29	.04	.11	.06	.17

Note. See information underneath Table 11 for more detail.

Discussion

The second part of this study aimed to provide further support for the predictive validity of Cheng et al.'s (2009) reconceptualisation of competitive state anxiety and address the limitations in Study 2a by utilising a sub-group of team sport athletes and an objective performance measure. Based on Cheng et al.'s framework, one of the three predictions for competitive state anxiety on elite Finnish baseball performance was initially supported by the current findings. Further research is warranted to evaluate the second and third hypotheses.

Consistent with the first hypothesis, there was extreme evidence for predicting batting performance over and above cognitive and physiological anxiety. In fact, perceived control was the single best predictor of batting performance, which supports Cheng et al.'s proposition that the regulatory dimension would have a central impact on performance. Conversely, the interaction effects did not contribute to predicting performance once the main dimensions had been accounted for.

General Discussion

The aim of Study 2a and Study 2b was to examine the predictive validity of Cheng et al.'s (2009) three-dimensional model of competitive state anxiety. The first hypothesis proposed that further support would be found for the bifactor model. The model with priors on the main factor loadings, cross-loadings and residual correlations produced an excellent model fit, supporting the first hypothesis and the findings from Study 1 of this thesis. As suggested by Niven and Markland (2016), adopting a BSEM approach in comparison to ICMs, provides a more empirically and theoretically yet parsimonious solution which the present study and Study 1 of this thesis supports. To elaborate, Cheng et al. (2009) could not find support for their initial hierarchical factor structure when using 'traditional' confirmatory factor analysis (CFA), and instead settled on a parcelled model. This result was unsurprising as the use of CFA has consistently led to the rejection of a model (Marsh et al., 2009), leading researchers to resort to employing a series of post hoc model modifications (i.e., parcelled models) in order to improve the fit (MaCallum et al., 1992; see p. 40 for more detail on the disadvantages of employing CFA). With regard to Cheng et al.'s reconceptualisation of competitive state anxiety, resorting to a parcelled model was problematic, because retaining the sub-components is advantageous, particularly as they were proposed to have differential impacts on different aspects of performance (Cheng et al., 2009; Jones et al., 2019). Therefore, developing a measure that more clearly distinguishes between the factors worry, private self-focus, and public self-focus is greatly preferred.

Accordingly, the present study adopted BSEM and has validated the TFAI-2 with a third participant sample. These findings are in line with previous research that has validated sport psychology measures using BSEM, which could not be validated with traditional CFA. For example, Stenling et al. (2015) illustrated that BSEM provided a better representation of their data than CFA when analysing the Sport Motivation Scale II (Pelletier et al., 2013). Although BSEM is becoming more popular within the sport psychology literature, the present study and Study 1 of this thesis are the first to analyse a bifactor model using BSEM. As discussed in Study 1, the bifactor model is particularly useful for multidimensional constructs and has many advantages over higher order models (Chen et al., 2006; Reise, 2012; see p. 53 for more detail). Taken together, the present study illustrates that the adoption of a bifactor model with BSEM creates a potentially strong foundation for the validation of other multidimensional models and theories.

The second hypothesis proposed that perceived control would account for significant additional performance variance over and above that accounted for by cognitive and physiological anxiety, which was supported in both Study 2a and Study 2b. To elaborate, there was extreme evidence for perceived control predicting athletes' self-rated performance (Study 2a), and batting performance (Study 2b), more so than cognitive and physiological anxiety. This is consistent with Cheng et al.'s (2011) and Jones et al.'s (2019) findings, as both reported perceived control to be the single best predictor of performance. In addition, Jones et al. (2019) reported perceived control to be the only significant predictor of performance. Collectively, these findings support Cheng et al.'s proposition that the regulatory dimension is the main feature of their model and has a significant impact on performance.

Third, it was assumed that the interaction effects would make a significant contribution to the performance variance, and as such perceived control would attenuate the maladaptive effects of cognitive and/or physiological anxiety intensity on performance. However, the present study did not support these predictions. There was no evidence to suggest that the interaction effects contributed to performance variance once the main effects were accounted for. Consequently, none of the potential interaction effects were significant predictors, suggesting that perceived control had the same impact on athletes' performance irrespective of their anxiety levels. This contrasts with Cheng et al. (2011), who found support for the interaction between perceived control and physiological anxiety. Consequently, more research is required to further investigate the third and fourth predictions of the present study.

Strengths, Limitations, and Future Research

The present two-part study has a number of strengths and limitations. Firstly, with regards to strengths, the present study addressed the need for both objective and subjective performance measures (e.g., Totterdell, 2000; Cheng et al., 2011). A specific self-report measure of performance was developed for Study 2a; however, this posed problems, thus batting performance formed the objective measure in Study 2b. In so doing, the present study addressed a key limitation within Cheng et al.'s (2011) predictive validity study as they only adopted a self-rated performance measure.

A second strength was the characteristics of the participants; athletes from team sports with a variety of skill levels were chosen because previous research has only explored individual sports such as tae-kwon-do (Cheng et al., 2011) and running/ triathletes (Jones et al., 2019). However, this approach also has its limitations, as this may have increased the contextual variables influencing the anxiety-performance dynamics; therefore, Study 2b included elite athletes from one team sport, Finnish baseball. It was proposed that utilising a specific sub-group of team sport athletes in conjunction with an objective measure, batting percentage, would enhance the effects found in Study 2a. Conversely, no evidence of interaction effects were found.

Although the sampling of team sports can be argued as a strength, it may also be a limitation. Previous research has reported that athletes from individual sports tend to report higher levels of competitive state anxiety than those from team sports (e.g., Dias et al., 2010). On inspection of the Finnish baseball players' TFAI-2 responses, their mean cognitive (M = 2.67) and physiological anxiety (M = 1.98) scores were relatively low compared to those reported by the tae-kwon-do athletes within Cheng et al.'s (2011) study (cognitive anxiety, M = 3.19; physiological anxiety, M = 2.38). Additionally, the athletes' perceived importance of the upcoming baseball match was not measured, therefore the potential (un)importance of the competitive game in question, coupled with the use of team sports may not have elicited high enough levels of competitive state anxiety, perhaps explaining why perceived control did not interact with anxiety to predict performance. To combat this, the present study could have created a "high anxiety criteria" and only conducted hierarchical regression analysis on those participants who reported anxiety scores within the set criteria; however, this was out of scope of the present research programme.

In order to combat the limitations of the present study, future research might adopt an experimental design that implements an anxiety manipulation and perceived control intervention. Therefore, the researcher may have more confidence in participants experiencing a competitive state anxiety response and interaction effects between the regulatory dimension and cognitive and physiological anxiety may be explored more easily.

In summary, the present study provides further support for the bifactor model of competitive state anxiety, validating the TFAI-2 for a third time within this thesis. In addition, Study 2a and Study 2b provided extreme evidence for the predictive validity of perceived control on sporting performance, suggesting that the adaptive potential of the competitive state anxiety response is a crucial factor within the anxiety-performance relationship.

Chapter 5

Testing the Regulatory Dimension of the Three-Dimensional Competitive State Anxiety Model: An Experimental Perspective

(Study 3)

Abstract

The purpose of this study was to examine the regulatory dimension of competitive state anxiety (Cheng et al., 2009) in an experimental setting. More specifically, the present study examined the impact of high and low levels of perceived control on netball players' anxiety responses, shooting performance and self-reported effort in simulated low and high anxiety conditions. Twenty-one participants were randomly assigned to a low (N = 10, M_{age} = 26.70, SD = 11.20) or high (N = 11, M_{age} = 24.73, SD = 9.81) perceived control group. A Bayesian mixed design ANOVA (2x2; Perceived Control × Anxiety, with repeated measures on the anxiety factor) was conducted in Jeffreys's Amazing Statistics Program (JASP; 0.14.0; JASP Team, 2020) to analyse the data and post hoc tests were computed where sufficient evidence for H_1 emerged. In the high anxiety condition, both high and low perceived control groups reported significant increases in heart rate and cognitive anxiety. Participants in the high perceived control group maintained their perceptions of control, netball shooting performance and significantly increased their effort, while those in the low perceived control group maintained their effort, but experienced significant decreases in their perceptions of control and performance. The findings provide further support for the inclusion of the regulatory dimension within Cheng et al.'s conceptualisation of competitive state anxiety, as the beneficial effects of higher perceptions of control (i.e., performance was maintained during competition) were demonstrated. Additionally, the findings have important practical implications for practitioners preparing athletes to perform under pressure.

Keywords: regulatory dimension, perceived control, competitive anxiety, performance

Introduction

Researchers have proposed that anxiety can be adaptive, as there is an underlying regulatory process involved in the dynamics of anxiety that is concerned with individuals' coping capacity in reaction to perceived threat (e.g., Cheng et al., 2009). As described in depth in Chapter 2 (see pp. 28-33), Cheng et al. developed an alternative model of competitive state anxiety that included a regulatory dimension in order to fully capture the potential adaptive nature of anxiety (Carver & Scheier, 1988; Eysenck, 1992; Öhman, 2002). These developments have led to a new stream of research and a better understanding of the impact of competitive state anxiety on sport performance.

The adaptive potential of anxiety reflected by the regulatory dimension in Cheng et al.'s model of competitive state anxiety is consistent with its evolutionary roots that suggest it is a defence mechanism that is meant to be functional (Öhman, 2000). The initial feelings of anxiety are supposed to be helpful as they send warning signals that prepare individuals to respond more effectively to perceived threat. It also provides a protective purpose by mobilising resources to provide energy and prepare individuals for vigorous action (Calvo & Cano-Vindel, 1997). Similarly, Eysenck and Calvo (1992) proposed that anxious individuals are able to monitor performance, regulate the use of processing resources, and allocate additional resource where necessary via a control system that is activated during the anxiety response. Cheng et al.'s regulatory dimension is represented by perceived control as it refers to individuals' perceptions of being able to cope and attain goals under stress (Cheng et al., 2009; Skinner, 1996), thus directly relating to the potential coping capacity involved in the dynamics of anxiety.

Cheng et al.'s rationale is in line with Carver and Scheier's (1988) control process perspective of anxiety, which suggests that the effects of anxiety differ depending on whether individuals' expectancies are in favour of being able to cope and complete desired actions, compared to those who expect they are unable to cope in the stressful situation. As such, Cheng et al. proposed that an individual's perceptions of control are triggered during the anxiety response (i.e., response to sporting competition), and in turn directly impact subsequent behaviours (i.e., sports performance). Similar notions of control have been found to be an essential part of psychological well-being (Thompson & Spacapan, 1991) and have been a recurrent theme for over 50 years in the psychology literature (e.g., Lefcourt, 1966; Seligman, 1975). Extensive research (e.g., Larson, 1989; Rotter; 1966; Zheng et al., 2020) has demonstrated that a sense of control can have a variety of positive impacts, which Thompson and Spacapan (1991) grouped into five types of effects; emotional well-being, successfully coping with stress, positive behaviour changes, physiological and health benefits, and improved performances. In terms of improved performance, earlier research found that greater perceptions of control resulted in better performance on cognitive tasks (Chapman et al., 1990), and significantly better exam results (Liem, 1975), highlighting just a few examples of the documented positive effects of perceived control on intellectual performance.

The potential positive impact of perceived control on athletes' sporting performance has also received attention (Jordet et al., 2006; Wood & Wilson, 2012). Jordet et al. (2006) explored elite soccer players' perceived control by interviewing 10 international soccer players about a penalty shootout they had competed in. Players who reported low perceived control before the penalty shootout also experienced more cognitive anxiety symptoms than those who reported high perceptions of control. Additionally, Wood and Wilson (2012) investigated the impact of quiet eye training on soccer players' control beliefs. They found that those who had completed quiet eye training experienced significant increases in perceived control beliefs, which were maintained during a subsequent pressurised transfer task compared to those who did not receive quiet eye training. Further, those without training experienced a significant decrease in perceptions of control during the transfer task. Although both studies report greater perceptions of control to be beneficial for athletes, they did not examine perceived control in direct relation to the anxiety response or explore how the construct interacts with sporting performance.

In addition, it is important to note that the aforementioned studies (e.g., Jordet et al., 2006) argue that to measure and conceptualise perceived control, researchers should consider both agent-means beliefs and means-ends beliefs (Skinner, 1996; Weisz & Stipek, 1982). However, it should be emphasised here that the use of perceived control in the present thesis, and in Cheng et al.'s competitive state anxiety model, refers to agent-means beliefs as it can be logically inferred that cognitions involving perceptions of control that are triggered during the anxiety response reflect agent-means beliefs only (see pp. 32-33 of this thesis for more detail).

With this in mind, there are just four studies that have tested Cheng et al.'s conceptualisation of competitive state anxiety and these are reviewed in Chapter 2 (see p. 34) of this thesis. For the purpose of the present study, several aspects of those studies are noteworthy. First, Cheng et al. (2011) examined the predictive validity of the three main anxiety dimensions on tae-kwon-do performance and found that perceived control accounted for an additional 20% of performance variance over and above that accounted for by cognitive and physiological anxiety. Second, the regulatory dimension was also found to be the only significant predictor of performance in Jones et al.'s (2019) study, in which triathletes who performed well reported significantly higher levels of perceived control compared to those who performed poorly. Third, Cheng and Hardy (2016) tested the adaptive potential of the regulatory dimension by examining three cognitive techniques that have been found to enhance performance through the regulation of anxiety and tested whether they would positively predict the regulatory dimension of anxiety more than cognitive and physiological anxiety. Findings showed that adaptive dimensions of perfectionism and self-talk (motivational and instructional) positively predicted the regulatory dimension, and the regulatory dimension positively predicted approach coping. Conversely, maladaptive perfectionism and negative self-talk positively predicted cognitive and physiological anxiety.

Even though studies to date have reported perceived control to be an important predictor of sporting performance, no studies have explored this relationship experimentally. The present study aims to bridge this gap and use a perceived control intervention to further explore Cheng et al.'s conceptualisation of competitive state anxiety. More specifically, the main aim was to examine the impact of differing levels of perceived control (high vs. low) on sporting performance in high and low anxiety conditions. In accordance with the assumptions of Cheng et al.'s model, it was hypothesised that: (a) irrespective of perceptions of control, participants would all experience increases in cognitive and physiological anxiety from low to high anxiety conditions; and (b) participants experiencing high perceptions of control would maintain, or improve their performance from low anxiety to high anxiety conditions, whilst those experiencing low perceptions of control would suffer performance impairment in high compared to low anxiety conditions. Additionally, the present study aimed to explore the impact of perceived control on participants' effort levels. It may be suggested that participants experiencing high perceptions of control would increase their effort levels from low anxiety to high anxiety, as they would perceive they had the resources to be able to cope under stress, thus exerting more effort (Eysenck & Calvo, 1992). This aligns with Eysenck et al.'s (2007) suggestion for researchers to explore underlying mechanisms that may cause some athletes to adopt compensatory strategies, whilst others do not. An anxious athlete's level of perceived control may be one mechanism that impacts whether they put additional resources (i.e., effort) into the task at hand.

Method

Participants

The sample comprised 21 female participants with ages ranging between 18 and 45 years (M_{age} = 25.66, *SD* = 10.27). Participants were netball players who competed at different performance levels (national = 1, regional = 2, county = 7, university = 7, and club = 4). They had an average of 10.19 (*SD* = 8.25) years of competitive experience and 2.14 (*SD* = 1.61) years of experience at their highest skill level. Ethical approval was obtained from the institution's ethics committee.

Measures

Health Check Questionnaire

A health check questionnaire was used to enable the collection of reliable heart rate (HR) data. Each participant was health checked to control for any confounding variables and were excluded if they had any of the medical conditions listed on the questionnaire (see Appendix B).

Heart Rate Measure

HR data were recorded using a V800 Polar Heart Rate Monitor (HRM) with a Polar H7 chest strap, at a sampling frequency of 1000 Hz. Raw unfiltered HR data was exported from the Polar Flow web service as a space delimited.txt file.

TFAI-2

This measure was validated in Study 1 and Study 2 of this thesis, see p. 56 and Appendix A for more detail.

Rating Scale of Mental Effort (RSME)

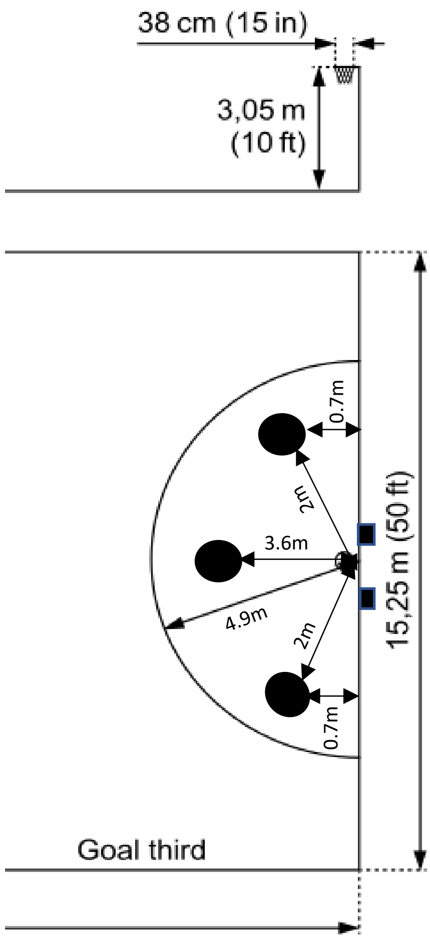
The RSME (Zijlstra, 1993) is a self-report measure of invested mental effort. Participants were asked to mark a point on a 150mm vertical scale to indicate the amount of mental effort they used to execute the task. Nine anchor points were marked along the scale from 2mm to 150mm to indicate ratings from *absolutely no effort* (2mm) to *extreme* *effort* (112mm), with effort operationalised as the distance in mm to this mark (see Appendix C). The RSME has been shown to have adequate validity (see Wilson, 2008, for a review) and reliability scores (r = .88, Zijlstra, 1993).

Performance

A netball shooting task was completed in an indoor sports hall using a regulation standard netball net (height 3.05m), within the standard shooting area (called the "D"), according to Sport England Netball. Participants took a total of 12 shots from 3 different positions in the "D". Four shots were taken from the left-side and four from the right-side of the netball post at a distance of 2m from the post and 0.7m from the baseline. The remaining four shots were taken from directly in front of the netball post at a distance of 3.6m (see Figure 9). For every shot, the experimenter fed the ball in from the backline for the participant to catch and then the participant had 3 seconds to shoot the ball. The task was structured in this way to ensure the shooting performance replicated a match situation. Each shot was scored using a scoring system adapted from Hardy and Parfitt's (1991); 0 for a complete miss; 1 for the ball hitting the rim and not going in the net; 2 for hitting the rim and going into the net; and 3 for a 'clean' net (i.e., the ball going straight through the net without hitting the rim first). Performance was measured by summating the scores of the 12 shots; therefore, it was possible for a participant to score between 0 and 36.

Figure 9

Netball Shooting Performance Dimensions (Not to Scale)



Note. The circles indicate where the participants stood to shoot, and the rectangles indicate where the researcher stood to feed the ball in from the baseline.

Experimental Conditions

An independent design was chosen for the perceived control condition; therefore, participants were randomly allocated to either a high (N = 11, M_{age} = 24.73, SD = 9.81) or low (N = 10, M_{age} = 26.70, SD = 11.20) perceived control group, while all participants experienced both low and high anxiety conditions.

Perceived Control Intervention

Both groups received instructions designed to influence their perceptions of control via an audio recording listened to on a laptop. More specifically, the instructions contained a perceived control intervention in line with the theoretical basis of the regulatory dimension (Turner et al., 2014). Participants assigned to the low perceived control group were informed that, "*While you are familiar with netball shooting, it is unlikely you will have performed in a situation like this before, so you can't be confident that you will be ready for this performance or have the resources to meet the challenge of performing to the best of your ability. Therefore, you might not believe in your ability, or be confident in staying focused during your performance. It is most likely that performing well is out of your control."* (audio was 28 secs). In contrast, participants in the high perceived control group were informed that, "*You are familiar with netball shooting, and it is likely that you have performed it in a situation like this before, so you can feel confident that you are ready for this performance and have the resources to meet the challenge of performing to the best of your ability. Therefore, you can believe in your ability and can be confident in staying focused during your performance. Performing well is in your control*." (audio was 23 secs). Participants listened to these instructions for a second time following the anxiety intervention; however, they were adapted to influence the participants' perceptions of control for the upcoming competition. Therefore, participants assigned to the low perceived control group were informed that, "*While you are familiar with netball shooting, it is unlikely you would have performed it in a situation like this before under so much pressure, so you can't be confident that you are ready for this task or have the resources to meet the challenge of increasing your performance by 20% and being entered into the prize draw. Therefore, you might not believe in your ability or be confident in staying focused during this competition. It is most likely that attaining a monetary prize is out of your control."* (audio was 32 secs). Whereas those in the high perceived control group were instructed that, "*You are familiar with netball shooting, and it is likely that you have performed it in a situation like this under so much pressure, so you can feel confident that you are ready for this task and have the resources to meet the challenge of increasing your performance by 20% and being entered into the prize draw. Therefore, you can believe in your ability and can be confident in staying focused during this competition. It is most likely that attaining a monetary prize is in your control."* (audio was 28 secs).

Anxiety Intervention

A 'high anxiety' phase of the experiment was created for all participants using a competitive situation. Participants were informed of the competition via a video (1.23 mins) played on a laptop. The video involved a sport psychologist introducing himself as a professional consultant and explaining that the participant's performance in the subsequent block of attempts would be videoed and their shooting performance would be assessed in conjunction with the player's team coach. Participants were also informed that they would be paired with another participant in the study, where both would have the chance to be entered into a £100 prize draw; however, for the participants to be entered, they *both* had to improve their performance by 20%. The participants then learnt that their partner had already completed this phase of the experiment and successfully improved their performance by more than 20% (DeCaro et al., 2011). Finally, participants were informed that the performance scores would be circulated to all of the other participants in a league table format via email. Similar types of instructions have been successfully used in previous competitive settings as a stressor (e.g., Barker et al., 2010; Turner et al., 2013), although introducing a sport psychologist via a video was a novel aspect (for the full video script please see Appendix D).

Manipulation Checks

Perceived Control Intervention

To assess whether the perceived control condition had the desired effect, at the end of the experiment, participants were asked to indicate to what degree, "I felt I had mental control over the situation to demonstrate my skills and perform to the best of my ability", on a five-point Likert scale from *not at all* (0) to *extremely* (4), see Appendix E (Meijen et al., 2014).

Anxiety Intervention

In addition to the TFAI-2, participants' resting HR (participants' average bpm during the last minute of resting) was compared to their average HR (bpm) whilst watching the anxiety intervention.

Procedure

Following institutional ethical approval, netball players were recruited from Welsh Universities and local netball clubs. Once netball players confirmed they could participate, they were asked to refrain from consuming any beverages containing alcohol and caffeine and not complete vigorous exercise (exercise for ≥ 20 minutes that produces sweating or hard breathing and a HR of 60%-80% of maximum) during the 24 hours preceding the experiment. On arrival, participants completed informed consent, demographic information, and the health check questionnaire. Participants were then fitted with the Polar V800 HRM and chest strap and asked to rest (sitting in silence) for 5 minutes in order to obtain a recording of their resting HR (an average was calculated from the fifth minute). Following 5 minutes of rest, participants were asked to warm-up by completing the netball shooting task for familiarity; however, their performance was not recorded. Participants were then asked to listen to the perceived control instructions and answer the TFAI-2 before completing the netball shooting task where their performance score was recorded (low anxiety performance). Participants were then asked to relax for one minute (sitting in silence) to allow their HR to return to resting. The anxiety simulation video was then shown. Average HR during the 1.23-minute video was calculated and compared to average resting HR in order to examine the effects of the anxiety intervention on HR. Following the anxiety intervention, the perceived control instructions were replayed in relation to the upcoming competition, and the TFAI completed for a second time. The participants were then asked to complete the netball shooting task again. The order of the experimental conditions was therefore fixed; all participants experienced the low anxiety condition and then the high anxiety condition. This fixed order was chosen as previous research using counterbalancing found that participants who experienced an anxiety condition first (i.e., receiving a set of test instructions), presumed that the second condition would also impose a further set of instructions upon them (Mullen & Hardy, 2010). Finally, the RSME was completed following both low and high anxiety conditions, and the perceived control manipulation check was administered at the end of the high anxiety condition. Participants were then debriefed, asked to provide secondary informed consent and thanked for their participation in the study.

Data Analysis

The statistical analyses were conducted using JASP software (0.14.0; JASP Team, 2020). Prior to the main analyses, the data were visually checked via box plots and Q-Q plots for violation of the normality assumptions (Tijmstra, 2018); none were found. Next, Bayesian *t*-tests were conducted to examine the two manipulation checks; 1) a Bayesian paired samples *t*-test was used to check the impact of the anxiety intervention on participants' HR by examining the differences between resting HR and HR during the anxiety intervention, and 2) a Bayesian independent samples *t*-test was used to check the impact of the perceived control intervention by examining the differences in participants' responses to the perceived control manipulation question.

To assess the impact of the anxiety and perceived control interventions on performance, cognitive anxiety, physiological anxiety, and effort, the main analysis comprised a Bayesian mixed two-way ANOVA (2 × 2; Perceived Control × Anxiety Condition, with repeated measures on the anxiety factor). Bayesian analysis was employed for the same reasons outlined in Study 2 and the resulting Bayes factors were interpreted using the evidence categories created by Lee and Wagenmakers (2013), see pp. 87-89 and Table 7 for more detail.

For the Bayesian *t*-tests, in addition to the interpretation of the Bayes factors, BF_{10} and BF_{01}, the median and the 95% central credibility interval of the posterior distribution for the standardized effect size (δ) (i.e., the population version of Cohen's *d*) were calculated. Magnitudes of the posterior distribution for the standardised effect size were classified as: trivial (<0.2); small (0.2-0.6); moderate (0.6-1.2); large (1.2-20); and very large (2.0-4.0) (Batterham & Hopkins, 2006).

Additional evaluation of the Bayesian ANOVA included the comparison between the model's prior model probability, P(M), with the resulting posterior model probability given the data, P(M|D). The BF_M value quantifies this change from prior odds to posterior odds for each model. The results were also averaged across the models, which produced an inclusion Bayes factor (BF_{incl}) that quantifies the change from prior inclusion odds to posterior inclusion odds (van den Bergh et al., 2020b). However, it should be highlighted that the model averaged results were calculated for "matched" models only. This is because, in JASP models are excluded from consideration when they violate the principle of marginality, that is, they feature an interaction effect but lack the subsequent main effects (Nelder, 1977). Therefore, when calculating model averages across all potential models the equation is not balanced. Further, Mathôd (2017) strongly advised the computation of inclusion probabilities for "matched" models *only* where interaction effects are concerned. As such, the model with the interaction effect is compared against models with the subsequent main effect and not against any other models (van den Bergh et al., 2020b). Lastly, where the results of the ANOVA showed evidence for supporting H_1, posterior post hoc tests were carried out. All variables were normally distributed; thus, comparisons were based on the Bayesian independent samples *t*-test with a Cauchy prior (o, $r = 1/\sqrt{2}$). The posterior odds were corrected for multiple testing by fixing to 0.5, the prior probability that the null hypothesis holds across all comparisons (Westfall et al., 1997).

The calculated error percentage for each model was also inspected, which indicates the precision of the numerical approximations. It is suggested that error percentages below 20% are acceptable. This is because, with such an error rate it is unlikely that the resulting qualitative conclusion will change, thus this amount of numerical error is not problematic (see Jeffreys, 1961 and van Doorn et al., 2020).

Results

Perceived Control Manipulation Check

The Bayesian independent samples *t*-test comparing the low and high perceived control groups' perceptions of control provided extreme evidence for H_1 (BF_{10} = 1924.5, error % = .66), with a very large effect size (δ = -2.41; see Figure 10). Participants in the low perceived control group felt they had significantly less control over the situation compared to those in the high perceived control group, indicating that the perceived control intervention had the desired effect (see Table 14 and Figure 10).

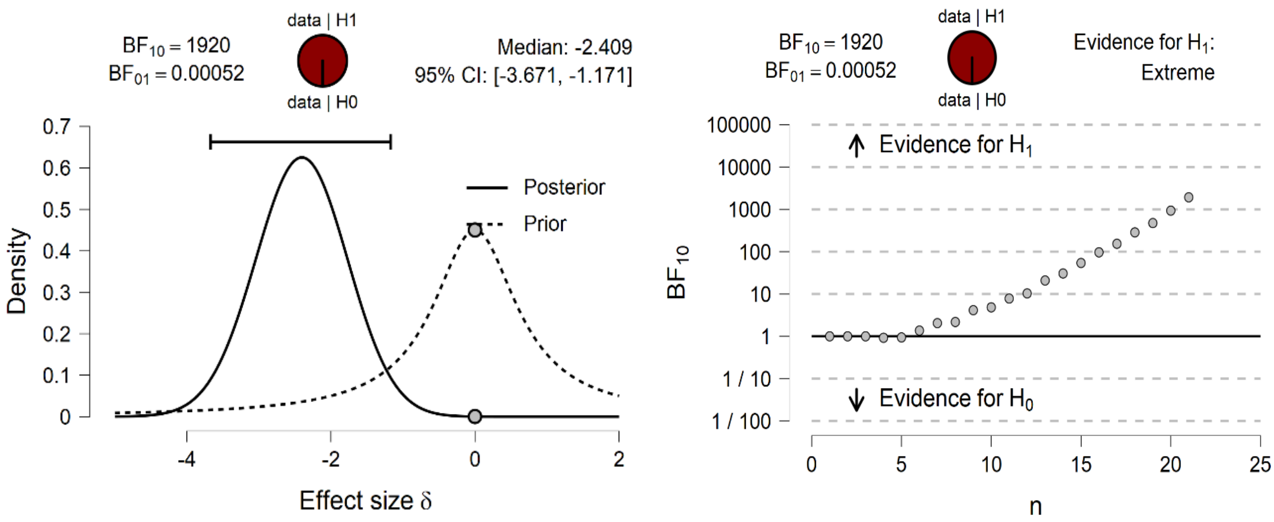
Table 14

Descriptive Statistics for the Perceived Control (PC) Manipulation Check

						95% Credible Interval	
	Group	N	Mean	SD	SE	Lower	Upper
Perceived Control Manipulation	Low PC	10	1.80	0.63	0.20	1.35	2.25
	High PC	11	3.27	0.47	0.14	2.96	3.59

Figure 10

Bayesian Independent Samples T-Test for the Perceived Control Manipulation Check



Note. The probability wheel on top visualises the evidence that the data provide for the alternative hypothesis. The two grey dots on the left panel indicate the prior and posterior density at the test value (Dickey & Lientz, 1970; Wagenmakers et al., 2010). The median and the 95% central credible interval of the posterior distribution are shown in the top right corner. The right panel shows the evidence accumulating for the alternative hypothesis as participants are entered into the calculation.

Heart Rate Manipulation Check

The Bayesian paired samples *t*-test comparing participants' resting HR to their HR during the anxiety intervention revealed extreme evidence for H_1 (BF_{10} = 180.65, error % = 3.57), with a moderate effect size (δ = 1.03; see Figure 11). Table 15 shows that participants' HR increased during the anxiety intervention compared to their resting HR, indicating that the anxiety intervention had the desired effect.

Table 15

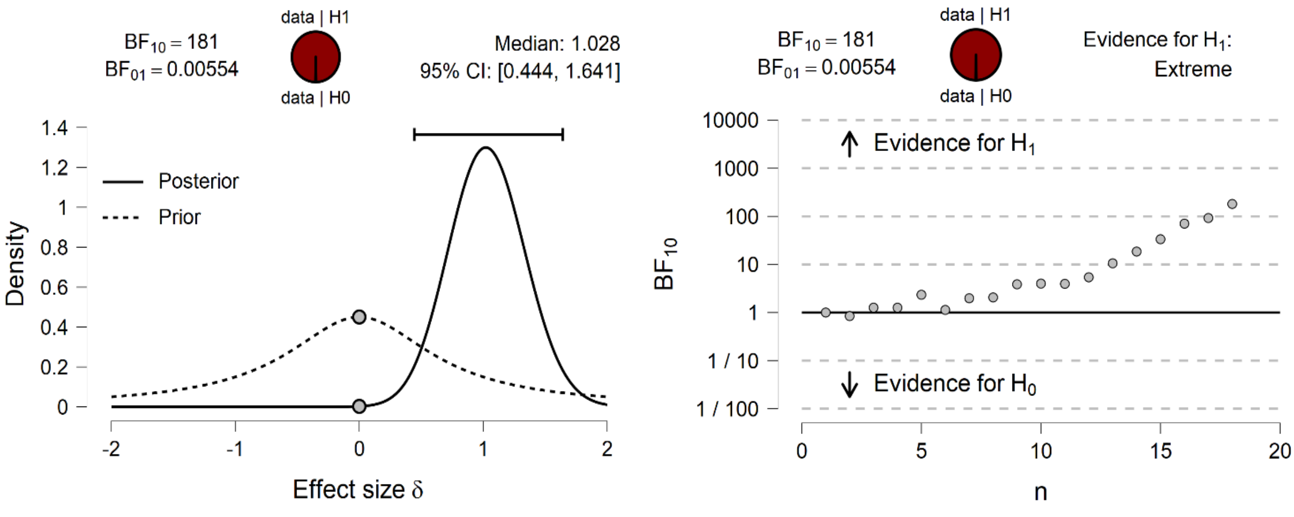
Descriptive Statistics for the Heart Rate Manipulation Check

					95% Credible Interval	
	N	Mean	SD	SE	Lower	Upper
Resting HR	18	82.48	12.82	3.02	76.11	88.86
HR during anxiety intervention	18	86.67	13.36	3.15	80.02	93.31

Note. Resting HR = participants’ average heart rate (bpm) during the last minute of the five-minute baseline phase of the experiment; HR during anxiety intervention = participants’ average heart rate (bpm) during the anxiety video; N = number of participants (three out of the 21 participants’ HR data was not useable; two participants from the high perceived control group and one participant from the low perceived control group); SD = Standard Deviation; SE = Standard Error.

Figure 11

Bayesian Independent Samples T-Test for the Heart Rate Manipulation Check



Note. See information under Figure 10 for more detail.

Cognitive Anxiety, Physiological Anxiety, and Perceived Control

Cognitive Anxiety

A 2 × 2 Bayesian mixed ANOVA was conducted to explore differences in cognitive anxiety among the experimental conditions. Table 16 displays the descriptive statistics and Table 17 shows all potential models with their predictive performance given the data. For example, the data are about 11 times more likely under the model that incorporates the anxiety main effect than under the model with perceived control (see column BF_{01}). When comparing all potential models, the model with the anxiety condition as the only factor is the best for predicting cognitive anxiety, with moderate evidence for H_1 ($BF_{10} = 6.70$, error % = 23.78).

Table 16

Descriptive Statistics for Cognitive Anxiety

	PC Group	N	Mean	SD	Minimum	Maximum
Cognitive Anxiety in Low Anxiety Condition	Low PC	10	2.41	0.60	1.36	3.46
	High PC	11	2.50	0.85	1.27	4.00
Cognitive Anxiety in High Anxiety Condition	Low PC	10	2.97	0.89	1.55	4.36
	High PC	11	2.95	1.32	1.09	4.73

Table 18 displays the analysis of effects across matched models. Before the data is included in the models, JASP calculates a prior inclusion probability which is .40 for the main effects and .20 for the interaction effect. The posterior inclusion probability is then calculated given the data and the BF inclusion value quantifies this change from prior to posterior inclusion. The result shows that the anxiety intervention had an effect and should be retained in the model, however perceived control and the interaction did not influence participants' cognitive anxiety. As depicted in Table 16, both perceived control groups' cognitive anxiety increased from low to high anxiety, indicating that the anxiety intervention had the desired effect.

Table 17

Comparing Each Model's Ability to Predict Cognitive Anxiety

Models	P(M)	P(M|Data)	BF_M	BF_{01}	BF_{10}	Error %
Anxiety	0.20	0.51	4.11	1.000	6.70	23.78
Anxiety + PC Condition	0.20	0.25	1.34	2.02	2.50	1.51
Anxiety + PC Condition + Anxiety × PC Condition	0.20	0.10	0.45	5.04	1.04	1.84
Null Model	0.20	0.10	0.43	5.18	1.00	1.71
PC Condition	0.20	0.04	0.19	11.40	0.45	0.67

Note. PC condition = perceived control groups; Anxiety = anxiety condition; The term Anxiety × PC condition = the interaction effect between the two factors; The 'Models' column shows the predictors included in each model; P(M) = prior model probability; P(M|data) = posterior model probability; BF_M = a Bayes factor which quantifies the change between prior probability to posterior probability; BF_{01} = Bayes factor of all models compared to the best model; BF_{10} = Model's Bayes factor compared to the null model; Error % = is an estimate of the numerical error in the computation of the Bayes factor. All models are compared to the best model and are sorted from lowest Bayes factors to highest.

Table 18

Analysis of Effects Across Matched Models for Predicting Cognitive Anxiety

Effects	P(incl)	P(incl|data)	BF_{incl}
Anxiety	0.40	0.76	5.32
PC Condition	0.40	0.30	0.49
Anxiety × PC Condition	0.20	0.10	0.40

Note. Compares models that contain the effect to equivalent models stripped of the effect. Higher-order interactions are excluded. Analysis suggested by Mathôd (2017).

Physiological Anxiety

Table 19 displays the descriptive statistics, while the ANOVA revealed that the null model is the best model given the data for predicting participants' physiological anxiety. It is 1.4 times better at predicting the data compared to the second-best model which just includes the anxiety factor and 7.7 times better than a model that includes all potential predictive factors. On inspection of the B_{10} values, every model is absent of an effect, as there is no strong evidence for H_1 or H_0, as shown in Table 20.

Table 19

Descriptive Statistics for Physiological Anxiety

	PC Group	N	Mean	SD	Minimum	Maximum
Physiological in Low Anxiety Condition	Low PC	10	1.41	0.34	1.1	2.2
	High PC	11	1.52	0.43	1.1	2.4
Physiological Anxiety in High Anxiety Condition	Low PC	10	1.65	0.77	1.00	3.3
	High PC	11	1.71	0.83	1.00	3.7

Table 20

Comparing Each Model's Ability to Predict Physiological Anxiety

Models	P(M)	P(M|Data)	BF_M	BF_{01}	BF_{10}	Error %
Null Model	0.20	0.38	2.47	1.00	1.00	
Anxiety	0.20	0.28	1.54	1.37	0.73	1.99
PC Condition	0.20	0.17	0.80	2.29	0.44	0.55
Anxiety + PC Condition	0.20	0.12	0.56	3.11	0.32	1.55
Anxiety + PC Condition + Anxiety × PC Condition	0.20	0.05	0.21	7.67	0.13	3.89

Note. Please see explanation underneath Table 17 for more information.

Table 21 displays the analysis of effects across matched models. Although the anxiety factor's posterior inclusion probability is the same as the prior inclusion probability, the BF_{incl} values suggest that none of the factors should be retained in the model, which is consistent with the model comparison results.

Table 21

Analysis of Effects Across Matched Models for Predicting Physiological Anxiety

Effects	P(incl)	P(incl|data)	BF_{incl}
Anxiety	0.40	0.40	0.73
PC Condition	0.40	0.29	0.44
Anxiety × PC Condition	0.20	0.05	0.41

Note. Please see explanation underneath Table 18 for more information.

Perceived Control

In addition to analysing the perceived control manipulation question, the perceived control subscale within the TFAI-2 was examined. Table 22 displays the descriptive statistics and Table 23 shows that the model including the anxiety main effect was the best predictor of the data with extreme evidence for H_1. In addition, there was also strong evidence for the model with both main effects and the model with the interaction effect.

Table 22

Descriptive Statistics for Perceived Control

	PC Group	N	Mean	SD	Minimum	Maximum
PC in Low Anxiety	Low PC	10	3.53	0.53	2.75	4.5
Condition	High PC	11	3.50	0.46	3.00	4.25
PC in High Anxiety	Low PC	10	3.03	0.74	2.00	4.00
Condition	High PC	11	3.34	0.41	2.75	4.00

Table 23

Comparing Each Model's Ability to Predict Perceived Control

Models	P(M)	P(M|Data)	BF_M	BF_{01}	BF_{10}	Error %
Anxiety	0.20	0.44	3.23	1.00	32.36	4.97
Anxiety + PC Condition + Anxiety × PC Condition	0.20	0.29	1.62	1.55	20.84	1.70
Anxiety + PC Condition	0.20	0.25	1.29	1.83	17.66	1.44
Null Model	0.20	0.01	0.06	32.36	1.00	4.97
PC Condition	0.20	0.01	0.03	61.51	0.53	1.41

Note. Please see explanation underneath Table 17 for more information.

When exploring the analysis of effects across matched models, the posterior inclusion probabilities show that the anxiety main effect and interaction effect should be retained in the model (see Table 24). Post hoc options are limited for Bayesian two-factor models. To follow-up the significant interaction in this study, comparisons were made using Bayesian paired and independent *t*-tests to examine the cells as outlined in Figure 12, below. To account for multiplicity the resulting Bayes factors were multiplied by 0.4142 (see van den Bergh et al., 2020b).

Table 24

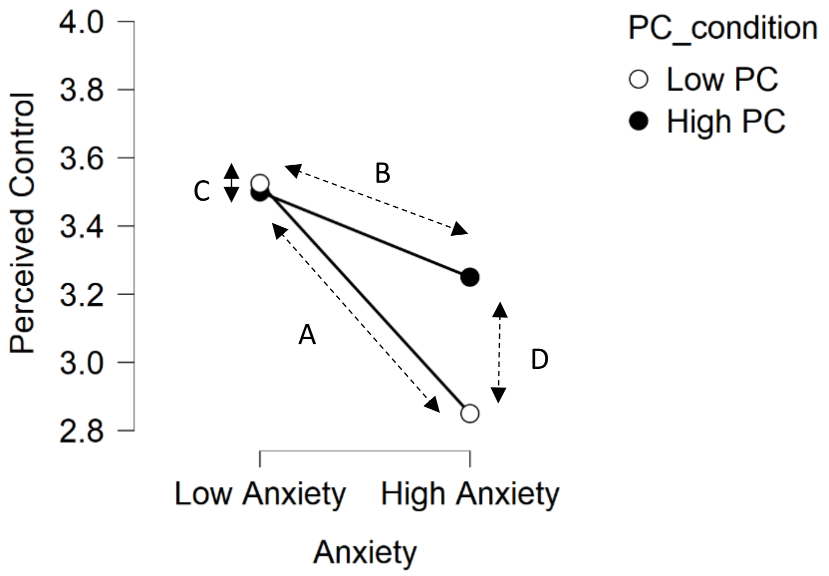
Analysis of Effects Across Matched Models for Predicting Perceived Control

Effects	P(incl)	P(incl|data)	BF_{incl}
Anxiety	0.40	0.69	32.77
PC Condition	0.40	0.25	0.55
Anxiety × PC Condition	0.20	0.29	1.18

Note. Please see explanation underneath Table 18 for more information.

Figure 12

The Anxiety × Perceived Control Interaction for Perceptions of Control From the TFAI-2



Note. The letters A, B, C, and D highlight the four post hoc t-tests that were carried out.

Results from the post-hoc analyses are shown in Table 25. One significant difference was found, which showed that those in the low perceived control group reported significantly lower perceptions of control during the high anxiety condition compared to the low anxiety condition (BF_{10} correction = 4.12, error % = 15.10; moderate evidence for H_1).

Table 25

Bayesian Post Hoc T-Tests Examining the Impact of the Anxiety × Perceived Control Interaction on Perceptions of Control From the TFAI-2

	Measure 1	Measure 2	BF_{10}	BF_{10} correction (×0.4142)	Error %
Low PC Group	Perceptions of control at low anxiety	Perceptions of control at high anxiety	9.92	4.12	15.10
High PC Group	Perceptions of control at low anxiety	Perceptions of control at high anxiety	0.78	0.32	0.01
Low Anxiety Condition	High PC Group	Low PC Group	0.39	0.16	0.03
High Anxiety Condition	High PC Group	Low PC Group	0.66	0.27	0.004

To summarise, results showed extreme evidence for an anxiety main effect (BF_{10} = 32.36, error % = 4.97), suggesting that the impact of the anxiety intervention superseded the effects of the perceived control intervention on participants' reported perceptions of control. However, there was also strong evidence for the model with an interaction effect (BF_{10} = 20.84, error % = 1.7). Post hoc tests revealed that participants in the low perceived control group reported decreases in perceptions of control in the high anxiety condition compared to the low anxiety condition, whereas those in the high perceived control group maintained their perceptions of control during the high anxiety condition.

Performance

Table 26 displays the descriptive statistics and the findings from the ANOVA are shown in Table 27. The results illustrate that the model including both main effects and the interaction effect is the best predictor of the data. For example, the data are about 8.3 times more likely under this model than under the model with just the two main effects; anxiety and perceived control, suggesting that the interaction effect had the biggest effect (see BF_{01}

column). The best model has a BF_{10} value of 3.17 (error % = 2.17), which suggests there is moderate evidence for H_1.

Table 26

Descriptive Statistics for Performance

	PC Group	N	Mean	SD	Minimum	Maximum
Performance in Low Anxiety Condition	Low PC	10	19.50	6.17	9.00	29.00
	High PC	11	17.55	3.39	12.00	21.00
Performance in High Anxiety Condition	Low PC	10	16.30	5.48	10.00	27.00
	High PC	11	18.27	3.07	13.00	23.00

Table 27

Comparing Each Model's Ability to Predict Performance

Models	P(M)	P(M|Data)	BF_M	BF_{01}	BF_{10}	Error %
Anxiety + PC Condition + Anxiety × PC Condition	0.20	0.53	4.53	1.00	3.17	2.17
Null Model	0.20	0.16	0.77	3.31	1.00	2.11
Anxiety	0.20	0.16	0.76	3.33	0.70	27.45
PC Condition	0.20	0.09	0.37	6.22	0.53	2.57
Anxiety + PC Condition	0.20	0.06	0.27	8.29	0.38	2.75

Note. Please see explanation underneath Table 17 for more information.

Table 28 displays the analysis of effects across matched models, which also highlights an absence of an effect for the main factors. However, it shows further evidence for a significant interaction effect as the posterior inclusion probability is greater than the prior inclusion probability which resulted in a large Bayes factor inclusion value (BF_{incl} = 8.29).

Table 28

Analysis of Effects Across Matched Models for Predicting Performance

Effects	P(incl)	P(incl|data)	BF_{incl}
Anxiety	0.40	0.22	0.91
PC Condition	0.40	0.15	0.47
Anxiety × PC Condition	0.20	0.53	8.29

Note. Please see explanation underneath Table 18 for more information.

As the ANOVA revealed moderate evidence for an interaction effect, posterior post hoc tests explored the differences between the cell means. To account for multiplicity the resulting Bayes factors were multiplied by 0.4142 (see van den Bergh et al., 2020b). There was one significant post hoc analysis (BF_{10} correction = 3.50, error % = 21.11; moderate evidence for H_1), which showed that those in the low perceived control group experienced a decrease in performance during the high anxiety condition compared to their performance in the low anxiety condition (see Table 29 and Figure 13).

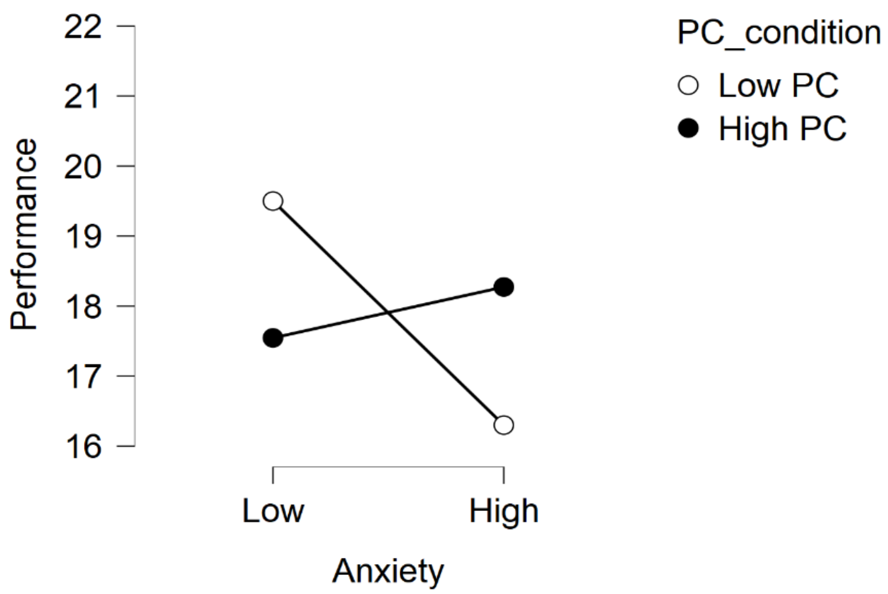
Table 29

Bayesian Post Hoc T-Tests Examining the Impact of the Anxiety × Perceived Control Interaction on Performance

	Measure 1	Measure 2	BF_{10}	BF_{10} correction (×0.4142)	Error %
Low PC Group	Performance at low anxiety	Performance at high anxiety	8.44	3.50	21.11
High PC Group	Performance at low anxiety	Performance at high anxiety	0.41	0.17	0.02
Low Anxiety Condition	High PC Group	Low PC Group	1.91	0.79	0.001
High Anxiety Condition	High PC Group	Low PC Group	0.57	0.23	0.003

Figure 13

The Anxiety × Perceived Control Interaction for Performance



Perceived Effort

Descriptive statistics for perceived effort are displayed in Table 30. Table 31 shows the results of the ANOVA, which revealed that the best model only includes the anxiety factor. This model is 11 times better at predicting the data compared to the model with perceived control as a predicting factor. When comparing it to the null model there is moderate evidence for H_1, suggesting anxiety had an influence on participants' perceived effort. In addition, the model with both main effects and the model with the interaction effect also display moderate evidence for $H_{1,}$ suggesting that there may also be an interaction effect present in the data.

Table 30

Descriptive Statistics for Perceived Effort

	PC Group	N	Mean	SD	Minimum	Maximum
Effort in Low Anxiety Condition	Low PC	10	77.00	25.19	50.00	120.00
	High PC	11	78.64	12.36	60.00	105.00
Effort in High Anxiety Condition	Low PC	10	80.50	17.87	60.00	110.00
	High PC	11	89.82	16.17	60.00	115.00

Table 32 displays the analysis of effects across matched models, which further highlights the significant effect anxiety had on the data. This is because the posterior inclusion probability increased from the prior inclusion probability and the Bayes factor inclusion value is large (BF_{incl} = 7.01). In addition, the interaction effect's posterior inclusion probability is larger than its prior inclusion probability and the Bayes factor inclusion value is close to one, which suggests this effect should also be retained in the model.

Table 31

Comparing Each Model's Ability to Predict Perceived Effort

Models	P(M)	P(M|Data)	BF_M	BF_{01}	BF_{10}	Error %
Anxiety	0.20	0.40	2.66	1.00	6.95	2.75
Anxiety + PC Condition	0.20	0.26	1.39	1.55	4.49	3.12
Anxiety + PC Condition + Anxiety × PC Condition	0.20	0.25	1.33	1.60	4.34	3.22
Null Model	0.20	0.06	0.24	6.95	1.00	2.75
PC Condition	0.20	0.04	0.15	11.002	0.63	2.84

Note. Please see explanation underneath Table 17 for more information.

Table 32

Analysis of Effects Across Matched Models for Predicting Perceived Effort

Effects	P(incl)	P(incl|data)	BF_{incl}
Anxiety	0.40	0.66	7.01
PC Condition	0.40	0.25	0.64
Anxiety × PC Condition	0.20	0.25	0.97

Note. Please see explanation underneath Table 18 for more information.

Post hoc tests were conducted to follow up the significant interaction and the resulting Bayes factors were multiplied by 0.4142 to account for multiplicity (see van den Bergh et al., 2020b). There was only one significant post hoc analysis (BF_{10} correction = 5.46, error % = 11.52; moderate evidence for H_1), showing that participants in the high perceived control group significantly increased their effort in the high anxiety condition compared to the low anxiety condition (see Table 33 and Figure 14).

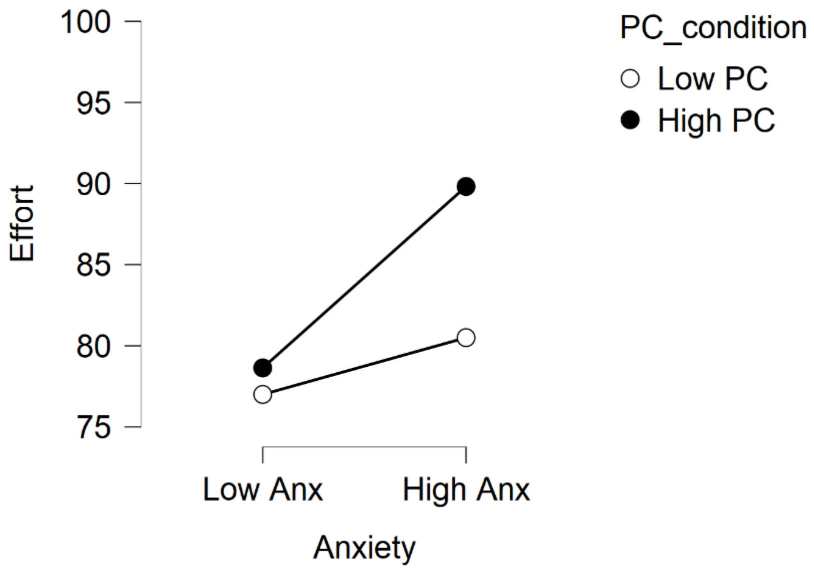
Table 33

Bayesian Post Hoc T-Tests Examining the Impact of the Anxiety × Perceived Control Interaction on Perceived Effort

	Measure 1	Measure 2	BF_{10}	BF_{10} correction (×0.4142)	Error %
Low PC Group	Effort at low anxiety	Effort at high anxiety	0.45	0.19	0.004
High PC Group	Effort at low anxiety	Effort at high anxiety	13.18	5.46	11.52
Low Anxiety Condition	High PC Group	Low PC Group	0.39	0.16	0.03
High Anxiety Condition	High PC Group	Low PC Group	0.68	0.28	0.004

Figure 14

The Moderate Anxiety × Perceived Control Interaction for Perceived Effort



Discussion

The current study is unique as it was the first to attempt to manipulate participants' perceptions of control and explore how this is directly associated with the anxiety-performance relationship. To summarise the findings, all participants reported similar scores on all measures (heart rate, cognitive anxiety, physiological anxiety, perceived control, performance and effort) during the low anxiety condition. However, following the anxiety intervention and subsequent perceived control instructions, participants in the high perceived control group reported significant increases in heart rate and cognitive anxiety, but maintained their perceptions of control, netball shooting performance and significantly increased their effort during the competition. Whilst those in the low perceived control group experienced significant increases in heart rate and cognitive anxiety, maintained their effort, but suffered significant decreases in their perceptions of control and netball shooting performance in the competition.

The findings support the first hypothesis, which proposed all participants would experience increases in cognitive and physiological anxiety from low to high anxiety conditions, irrespective of perceptions of control. To achieve such increases, the anxiety intervention was adapted from previous research that attempted to foster task engagement (e.g., Moore et al., 2012) with the addition of a novel aspect, as the instructions were presented via video by a professional sport psychologist. The present findings suggested that this was successful and provide further support for the utility of such interventions to simulate competition.

Additionally, this video technique combined a number of factors that may have enhanced the pressure situation including social evaluation, performance-contingent monetary rewards, and the added responsibility of becoming a team with another participant (see Appendix D for the full script). It is not certain which pressure techniques had the biggest impact on the participants; one suggestion is that self-presentation related pressure manipulations elicit choking effects more so than motivational incentives such as money (Mesagno et al., 2011). Competitive state anxiety studies rely on competition simulation; thus, an avenue of further research could examine the impact of each aspect of pressure interventions in order to understand potential differential impacts on participants' competitive state anxiety with regard to Cheng et al.'s (2009) three-dimensional model.

The perceived control intervention also had the desired effect. It should be highlighted, however, that in the low anxiety condition, both groups reported similar perceptions of control. This suggests that non-anxious individuals are not influenced by negatively toned control statements such as, "you can't be confident that have the resources to meet the challenge", or positively toned control statements such as, "you can feel confident that you are ready for this performance", but are more susceptible to such statements when their competitive state anxiety becomes elevated. One explanation for this finding may be that non-anxious individual's thoughts about whether they have the means to be able to cope (i.e., agency beliefs), are not at the forefront of their cognitions, conversely as competitive state anxiety increases, perceptions of control are directly triggered within the anxiety response (Carver & Scheier, 1988; Cheng et al., 2009). Thus, it appears that the perceived control instructions become more relatable to the participants' thought processes when they are anxious, significantly decreasing control beliefs for those in the low perceived control group, and maintaining control beliefs for those in the high perceived control group.

An interaction effect was found between anxiety and perceived control for netball shooting performance supporting the second hypothesis. This effect revealed that participants in the low perceived control group suffered a significant decrease in their netball shooting performance during competition, compared to those in the high perceived control group, who maintained their netball shooting performance. The difference in netball shooting performance mirrors the difference in participants' perceptions of control, which suggests that the anxious netball players in the high perceived control group were able to maintain their performance during the competition because they also maintained their control beliefs. This finding is consistent with Cheng et al.'s (2009) competitive state anxiety model and provides support for the inclusion of the regulatory dimension (e.g., Carver & Scheier, 1988; Cheng et al., 2009). Cheng et al. hypothesised that these cognitions regarding higher levels of perceived control would attenuate the maladaptive effects of cognitive and/or physiological anxiety on performance, which is in accordance with the present study's findings.

The third hypothesis proposed that those experiencing high perceptions of control would increase their effort levels from low anxiety performance to high anxiety performance, as they would perceive they had the resources to be able to cope under the stress, thus exerting more effort (Eysenck & Calvo, 1992). This third hypothesis was fully supported and Eysenck et al.'s (2007) attentional control theory (ACT) can be drawn upon to explain such findings. Considering all participants reported an increase in cognitive anxiety, ACT would also predict that participants experienced a disruption to their processing efficiency of the central executive of working memory. However, some individuals will respond with compensatory strategies such as increased effort (Eysenck & Calvo, 1992). Moreover, Eysenck et al. also addressed the need for investigation into the mechanisms behind such compensatory strategies; what causes some individuals to adopt increased effort whilst anxious when others do not. From the present findings, perceived control appears to be one mechanism that determines whether an anxious individual will put more effort into a task. An individual who has higher perceptions of control, believing that they have the resources to meet the challenge and the ability to achieve their goals under pressure, may be more likely to exert more effort towards the task at hand, compared to those with low perceptions of control who do not believe they are prepared or possess the requisite resources. Future research should explore this potential mechanism and the impact perceived control may have on anxious individual's adopting compensatory strategies.

These findings have substantial applied implications for sport psychologists. First, practitioners involved in preparing athletes to perform under pressure should promote control beliefs and readiness strategies in order to enhance athletes' perceptions of being able to cope. Second, the present study further supports the notion that perceived control reflects the adaptive nature of anxiety, thus promoting the usefulness of administering the TFAI-2 to gain insight into athletes' cognitive and physiological anxiety symptoms and perceptions of control. Psychologists could use this tool to understand their athletes' perceptions of control while anxious and create tailored interventions to increase perceived control.

While the efficacy of this type of approach warrants investigation, the theoretical basis of some established interventions provides promising platforms. For example, perceptions of control and causality are at the centre of attribution training approaches (Biddle, 1999; Rees et al., 2005). Traditionally, however, attribution training is primarily about interpretation and identifying causes of outcomes, rather than appraising whether the athlete has access to these causes. Therefore, using Skinner's (1996) control definitions, attribution training is concerned with retraining means-ends beliefs rather than agent-means beliefs. As the regulatory dimension within the competitive state anxiety response refers to agent-means beliefs, future research could adapt attribution training so that its main premise is concerned with retraining agent-means cognitions in response to competitive state anxiety. This may prove fruitful in helping athletes cope with competitive pressure and maintain their sporting performance while anxious. In addition, interventions already widely implemented by sport psychologists may hold secondary benefits in terms of increasing psychological control but have yet to be examined. One example of this is the use of quiet eye training, which emerged in the 1990's (e.g., Vickers, 1996), however it was only recently that the intervention was linked to perceived control (Wood & Wilson, 2012). Wood and Wilson (2012) conducted an experiment that implemented quiet eye training and specifically measured athletes' perceptions of control, finding quiet eye training to have positive impacts on control beliefs. Future research needs to conduct more empirical investigations on interventions that may be indirectly increasing perceived control in order to facilitate performance under pressure.

Although the results were in the hypothesised direction and reveal considerable support for Cheng et al.'s model and the inclusion of the regulatory dimension, there are potential caveats to the conclusions drawn. The main limitation to note is the small sample size, 10 participants in the low perceived control group and 11 participants in the high perceived control group. Conducting Bayesian statistics in JASP allows researchers to analyse the data as it accumulates in that the sequential Bayes factor plot shows the evidence flow as a function of increasing sample size (van Doorn et al., 2020). The analyses conducted in this study found anecdotal or moderate evidence for the null and alternative hypotheses tested. For example, when examining the difference in performance scores, it was concluded that the high perceived control group were able to maintain their performance under pressure; however, the evidence was anecdotal (see Appendix F). It is more than likely that this finding would trend towards moderate or even strong evidence if the sample size were increased providing further confidence in the present study's conclusions (Stefan et al., 2019).

Second, several post hoc tests yielded high error percentages. Increasing sample size would also combat this problem (van den Bergh, 2020b; van Doorn et al., 2020). For example, it was concluded that participants' performance in the low perceived control group decreased from low anxiety to high anxiety with moderate evidence ($BF_{10} = 3.50$), however the error percentage was 21.106. This suggests that the BF_{10} value could fluctuate between 4.24 and 2.76 (van Doorn et al., 2020), changing from moderate to anecdotal evidence. If accessible, future research should adopt the Bayes factor sequential design. In sequential designs it is proposed that researchers should set a decision rule before the start of the experiment that establishes when sampling will stop. For example, a researcher may decide to aim for a strength of evidence of 10 (i.e., strong evidence, BF_{10} = 10 or 1/10), and can monitor the resulting error percentage yielded (Stefan et al., 2019). This is particularly easy to do within a Bayesian framework as the Bayes factor is robust, thus no correction algorithm is needed for looking at the data before the data collection is complete (Rouder, 2014). Unfortunately, this was not possible for the present study due to the constraints of time-bounded PhD data collection and regulations regarding COVID-19.

In conclusion, the results of this study provide further support for the proposition that perceived control is as important to understanding the anxiety-performance relationship as cognitive and physiological anxiety (Cheng et al., 2009). It was the first to incorporate a perceived control intervention that had the desired effect during the high anxiety condition and subsequently influenced netball shooting performance in the hypothesised direction. More specifically, participants in the high perceived control group maintained their perceptions of control and performance during the high anxiety condition, whereas those in the low perceived control condition suffered decreases in their perceptions of control and performance. Considering the apparent benefits of perceived control on sporting performance, future research should investigate applied interventions that promote positive perceptions of control in response to competitive state anxiety.

Chapter 6

Thesis General Discussion

Introduction

The purpose of this final chapter is to draw together the findings from each empirical study and discuss their implications in the context of the competitive state anxiety literature. In order to achieve this, the chapter is divided into the following five sections: (1) the purpose and findings of each study, (2) an examination of the overall methodological and theoretical implications, (3) a discussion of the most pertinent practical implications for coaches, parents and sport psychologists (4) recommendations for future research that will extend researchers and sport psychologists understanding of the anxiety-performance relationship, and (5) a consideration of the strengths and limitations of the research programme.

Summary of Studies

The central aim of this thesis was to examine the competitive state anxiety model proposed by Cheng et al. (2009) and its extensions by Jones and associates (2019). In order to achieve this purpose, the present programme of research aimed to re-examine the self-report measure associated with Cheng et al.'s (2009) competitive state anxiety model by implementing a more robust and flexible measurement model and analytical strategy (Study1); examine the assumptions of this model by administering the validated self-report measure and explore the relationships between the regulatory dimension, cognitive anxiety, physiological anxiety and athletes' self-reported performance (Study 2a) and performance measured objectively (Study 2b); and explore the impact of a perceived control intervention on athletes' performance levels and cognitive and physiological anxiety during simulated competition (Study 3). A summary of each empirical study is detailed below.

Study 1

The purpose of the first study (Chapter 3) was to further examine the 25-item competitive state anxiety measure proposed by Jones et al. (2019), and to achieve this the aims were threefold. First, to address the measurement limitations inherent in formative model specification (e.g., Edwards, 2011) by implementing bifactor modelling. Second, two different bifactor models were tested in order to examine competing factor structures of the physiological anxiety dimension in light of previously reported dimensionality issues (Cheng et al., 2009; Jones et al., 2019). Third, to address calls from previous researchers to utilise Bayesian structural equation modelling (BSEM) due to its many advantages over traditional frequentist approaches (e.g., Gucciardi & Zyphur, 2016; Muthen & Asparouhov, 2012; Niven & Markland, 2016). To achieve these aims, two participant samples from Jones et al.'s study were re-examined. All participants completed the competitive state anxiety measure (see Appendix A) one hour before a competitive sports event. The first participant sample (N = 516) was re-analysed using BSEM to compare two hypothesised bifactor models; one bifactor model retained all items and factors from Jones at al.'s conceptualisation (i.e., worry, private self-focus, and public self-focus specific factors with these items reflecting a cognitive anxiety general factor, and autonomous hyperactivity and somatic tension specific factors with these items reflecting a physiological anxiety general factor, and a perceived control specific factor), while the second bifactor model retained all items but proposed a unidimensional physiological anxiety specific factor (i.e., items indicative of autonomous hyperactivity and somatic tension were loaded onto this one specific factor). A significantly better statistical fit was found for the latter bifactor model. To explore the validity of this finding, the bifactor model with the unidimensional physiological anxiety specific factor was tested again using the second participant sample (N = 174). The results provided further support for this model as an excellent statistical fit was found, given the data. Additionally, the measure was renamed the Three Factor Anxiety Inventory-2 (TFAI-2) due to the significant changes made to the measurement model specification. It was concluded that future research should continue to examine the physiological dimension of competitive state anxiety, as theoretically it is multidimensional in nature; however, empirically there is strong support for a single specific factor. Study 1 also illustrated the advantages of using bifactor models when a construct is multidimensional in nature (Chen et al., 2006), and supports the calls for the use of BSEM (e.g., Niven & Markland, 2016) over frequentist approaches.

Study 2a and 2b

The purpose of Study 2 was to administer the TFAI-2 to two new participant samples, examining measurement validity for a third time and also examining the relationships and interactions between the competitive state anxiety dimensions and sports performance. The first participant sample (Study 2a) consisted of athletes about to compete in invasion game sports (e.g., rugby, basketball and football). Participants (N = 159) completed the TFAI-2 one hour before a competitive match and then answered questions regarding their performance within 30 minutes of the end of the match. Study 2b followed the same study design, but the sample consisted of Finnish baseball players (N = 117) and included a more objective measure of performance; athletes' batting performance percentage obtained from the official Finnish Baseball Association's statistics website. TFAI-2 responses from Study 2a and 2b were combined (N = 278) and subject to BSEM in order to test the stability of the TFAI-2 for a third time, again revealing an excellent statistical fit, given the data, and providing further support for the bifactor model proposed in Study 1. Additionally, Bayesian hierarchical regression was conducted on both participant samples and the results showed extreme evidence for perceived control predicting athletes' self-rated performance (Study 2a) and objective batting performance (Study 2b) over and above cognitive and physiological anxiety and the associated two- and three-way interaction effects. Taken together, the findings reflect Cheng et al.'s (2011) suggestion that perceived control is central to the dynamics of the anxiety-performance relationship.

Study 3

In light of the impact of perceived control on competitive sporting performance (Study 2a and 2b), the purpose of study 3 was to examine the effect of differing levels of perceived control (high vs. low) on cognitive anxiety, physiological anxiety, self-reported effort and netball shooting performance during high and low anxiety conditions. The sample consisted of 21 netball players who were randomly assigned to either a high (N = 11) or low (N = 10) perceived control group. Participants in both groups completed a netball shooting task in low and high anxiety conditions. Bayesian *t*-tests showed that both the perceived control and anxiety interventions had the desired effect. A Bayesian mixed two-factor ANOVA revealed that all participants reported similar scores on all the measures during the low anxiety condition; however, following the anxiety intervention, participants in the high perceived control group experienced significant increases in heart rate and reported a significant increase in self-reported effort and cognitive anxiety, but maintained their perceptions of control and netball shooting performance. Conversely, those in the low perceived control condition experienced significant increases in heart rate and cognitive anxiety, maintained their self-reported effort, but experienced significant decreases in perceptions of control and netball shooting performance. These findings suggest that athletes with higher perceptions of control are better able to maintain their performance while anxious, supporting the main assumption of Cheng et al.'s model, which proposes that perceived control will attenuate the maladaptive effects of competitive anxiety on performance. Additionally, the findings of Study 3 found that athletes who perceive they have the resources to be able to cope (i.e., higher levels of perceived control), are more likely to exert further effort compared to those with low perceptions of control, illustrating a potential mechanism that explains how perceptions of control aid performance under pressure. Therefore, Study 3 informs the use of strategies that sport psychology consultants, coaches and athletes could utilise in response to increased competitive state anxiety, such as promoting control beliefs and readiness strategies that enhance athletes' beliefs about their ability to cope under pressure.

Theoretical and Methodological Implications

A number of pertinent findings emerged from the programme of research that inform both the theoretical development and measurement of the anxiety-performance relationship. The findings and their theoretical and methodological implications will be addressed.

Theoretical Implications

This thesis adds significant support to Cheng et al.'s (2009) reconceptualisation of competitive state anxiety and the hypothesised relationships between cognitive anxiety, physiological anxiety, perceived control and sports performance. These findings further our understanding of the anxiety-performance relationship in a variety of important ways. The first prominent finding was the impact of perceived control on anxious athletes' sporting performance.

Athletes' perceptions of control predicted their self-rated sporting performance scores (Study 2a) and their batting performance (Study 2b) over and above cognitive and physiological anxiety. Despite previous research hypothesising that perceived control would be an important factor in the anxiety response (Carver & Scheier, 1988; Eysenck & Calvo, 1992; Öhman, 2000), and its inclusion within Cheng et al.'s (2009) competitive state anxiety model, very little research has examined this relationship. This is surprising as many researchers have set out to explain why some athletes' performance deteriorates when anxious while others maintain or improve their performance levels; a question at the forefront of sport psychology anxiety literature with equivocal findings (e.g., Beilock & Carr, 2001; Guccairdi & Dimmock, 2008; Otten, 2009). The only three previous studies that have explored the predictive power of perceived control found the construct accounted for a significant proportion of performance variance, more so than cognitive and physiological anxiety (Cheng et al., 2011; Jones et al., 2019). Similarly, Otten (2009) found that the best predictor of performance under pressure was perceived control. As such, perceived control may be the under-exploited construct that is key to providing greater clarity in our understanding of the anxiety-performance relationship.

In light of the dearth of empirical studies exploring the impact of perceived control on competitive sporting performance, Study 3 is the first experimental study to employ an intervention that manipulated athletes' perceptions of control during simulated competition. Subsequently, three findings are noteworthy. First, interaction effects emerged that add support to Cheng et al.'s (2009) conceptualisation for including the regulatory dimension within their competitive state anxiety model. In particular, their proposal that athletes can experience pre-competition anxiety, or negatively toned affective states while concurrently believing they have the resource and ability to meet the demand of the situation, was supported. Such a finding is salient, as previous research suggested that perceived control is related to the level of anxiety symptoms experienced. For example, Jordet et al. (2006) proposed that low levels of perceived control are associated with higher anxiety symptoms, whereas high levels of perceived control are associated with lower anxiety symptoms. Conversely, Study 3 of this thesis provides evidence to suggest this may not always be the case, contributing to the theoretical understanding of perceived control within the anxiety-performance relationship and supporting Cheng et al.'s model.

Second, with the inclusion of the regulatory dimension it was assumed that high levels of perceived control would attenuate the maladaptive effects of anxiety symptoms on sporting performance (Cheng et al., 2011), which is a relationship that has emerged in every study testing Cheng et al.'s framework, including Study 3 of the present thesis. This relationship has also been highlighted in the theory of challenge and threat states for athletes (TCTSA; Jones et al., 2009) and its revised version (TCTSA-R; Meijen et al., 2020), which posits that athletes can approach sporting competitions in either a challenge state that promotes successful performance, or a threat state that inhibits performance (Jones et al., 2009). There are many physiological and psychological characteristics that describe either a challenge or threat state, but in relation to the present thesis findings, one psychological characteristic of a challenge state is high perceptions of control, where athletes perceive they have the resources to deal with the demands of the situation (Meijen et al., 2020). This perception echoes the definition of the regulatory dimension in Cheng et al.'s model and Trotman et al. (2018) argued that perceptions of control are integral to promoting a challenge state. Therefore, it may be suggested that participants in Study 3 of the present thesis experienced psychological characteristics indicative of a challenge state. In contrast, previous research exploring the relationship between perceived control and a challenge state has revealed mixed findings (e.g., Meijen et al., 2013; Turner et al., 2013), which may be explained by the weak measures used for measuring perceived control. For example, Turner et al. measured perceived control via a self-report question about effort (see Turner et al., 2013, p. 389). Instead, it may be suggested that future research brings the TCTSA-R and Cheng et al.'s model together, using the regulatory dimension within the TFAI-2 to measure perceptions of control. This approach may strengthen the reported relationship between perceived control and a challenge state, and enhance researchers understanding of the regulatory dimension within Cheng et al.'s model.

The third notable finding was the relationship between athlete's perceived control and effort levels (Study 3). Athletes who had higher perceptions of control, also significantly increased their effort levels during the competition simulation, while those with low levels of perceived control maintained their effort. This finding supports the attentional control theory (ACT; Eysenck et al., 2007), which suggests that some anxious individuals (i.e., all participants in Study 3 experienced increases in cognitive anxiety) will respond with compensatory strategies, such as increased effort, in order to maintain performance. Additionally, Nieuwenhuys and Oudejans (2012) built upon ACT and proposed an integrated model of anxiety and perceptual-motor performance. Within this model Nieuwenhuys and Oudejans suggested that anxious individuals will exert more mental effort for three different reasons: (1) in an attempt to lower their anxiety; (2) inhibit stimulus driven impulses, or (3) enforce goal-directed control. An increase in mental effort during competition has been widely documented in the literature testing ACT (e.g., Ansari & Derakshan, 2011; Broadbent et al., 2018; Cocks et al., 2015). However, in relation to the present findings, little research has explored the mechanisms behind what motivates some anxious individuals to increase their effort while others do not. The present findings revealed favourable control beliefs to be important in the context of increasing effort, providing a conceptual link between the regulatory dimension of competitive anxiety and ACT. Further research examining the mechanisms (e.g., perceived control) behind the adoption of compensatory strategies (e.g., increased effort), is warranted (Sammy et al., 2017).

Intuitively, it is not surprising that Study 3 of the present thesis revealed a direct relationship between perceived control and effort expenditure. Drawing upon Cheng and associates research, Cheng and Hardy (2016) found that the regulatory dimension positively predicted approach coping strategies, and adaptive dimensions of perfectionism and self-talk (motivational and instructional) positively predicted the regulatory dimension. Wider research has positively associated motivational self-talk (e.g., Bellomo et al., 2020; Hatzigeorgiadis, 2006) and approach coping (e.g., Hanton et al., 2013) with increased effort expenditure. Subsequently, these constructs and strategies seem to conceptually overlap. Taken together, this body of research supports the third notable finding of this thesis, which suggests that favourable control beliefs are important in the context of increasing effort.

Despite the findings from this thesis illustrating the important role of perceived control within the anxiety-performance relationship, the anxiety dimensions did not interact to predict performance in Study 2. Although interaction effects between anxiety components have been central to predicting performance (Cheng et al., 2011; Edwards & Hardy, 1996; Liebert & Morris, 1967; Woodman & Hardy, 2003), and are one of the key assumptions associated with Cheng et al.'s model, Study 2 did not support this prediction. More specifically, Cheng et al.'s (2011) predictive validity study illustrated that the interaction effects of cognitive anxiety, physiological anxiety, and perceived control significantly accounted for 15% of the performance variance after the three main effects were controlled for. Conversely, once the main effects were accounted for in Study 2 of this thesis, the interaction effects did not predict any further performance variance. Instead, as outlined above, perceived control was the biggest predictor of both self-rated performance (Study 2a) and batting performance (Study 2b), again highlighting the importance of perceived control.

It is perhaps surprising that the construct did not interact with cognitive and/or physiological anxiety to predict performance in Study 2. This is because Cheng et al. (2011) found that performance was significantly enhanced by increased perceived control when athletes reported low levels of physiological anxiety, while performance was maintained by increased perceived control when athletes experienced high levels of physiological anxiety. Similarly, performance was maintained by increased perceptions of control under high cognitive anxiety and increased HR in Study 3 of this thesis. If favourable perceptions of control maintain athletes' performance when they are anxious, then it is possible that the construct has even more of a positive influence on sporting performance for non-anxious athletes, as shown in Cheng et al.'s (2011) findings. However, this interaction did not emerge in Study 2 of this thesis, therefore further research exploring how perceived control interacts with low and high levels of cognitive and physiological anxiety is warranted.

Methodological Implications

In order to further our understanding of the competitive state anxiety response and relationships between the three main constructs involved, a re-examination of existing measurement tools was warranted. Previously, the CSAI-2 and CSAI-2R were the *gold-standards* when measuring pre-competition anxiety, even though researchers have raised concerns about the wording of some of the items (Woodman & Hardy, 2001) and the poor overall fit of the model (Lane et al., 1999). Although these limitations have been widely documented, researchers continued to use the CSAI-2 and CSAI-2R as there was no obvious alternative validated measure available (Woodman & Hardy, 2003). This led to equivocal findings and little clarity over the anxiety-performance relationship. Thus, it is paramount that the measurement tool for Cheng et al.'s (2009) re-conceptualisation of competitive state anxiety is theoretically and psychometrically robust; a finding that was particularly salient throughout the present thesis with the development of the TFAI-2 (Study 1 and Study 2).

In a bid to address the limitations associated with previous attempts to validate a measure based upon Cheng et al.'s (2009) model, Study 1 of this thesis specified a bifactor model to account for its multidimensional nature. Myers et al. (2014) suggested that there is a strong conceptual fit between the bifactor model and the way in which theory-driven multidimensional scales are developed in sport, exercise, and performance psychology and that the usefulness of the bifactor model may be more persuasive to sport psychology researchers if there were more relevant empirically-based studies illustrating their potential value. To date, the construct of motivation (Gunnell & Gaudreau, 2014), and the psychological needs thwarting scale (Myers et al., 2014) have been re-conceptualised as bifactor models within the sport psychology literature with positive results. The use of a bifactor model in Study 1 adds to the evidence base supporting the utility of these models. A bifactor representation has important implications for how competitive state anxiety can be more clearly elucidated, in terms of being able to simultaneously examine both the specific and general factors. As such researchers should continue to explore the utility of bifactor models.

The flexibility of bifactor models should also be highlighted, as Study 1 did not employ a bifactor model in the traditional sense. Traditionally, a bifactor model comprises a single general factor that represents a common theme running throughout all of the items, and numerous specific factors that capture more narrowly defined subscales (Reise, 2012). Hyland (2015) described this bifactor model as ‘restrictive’ and introduced the term ‘unrestricted bifactor models’ for occasions when the traditional constraint of one general factor is relaxed, as there is nothing inherent in bifactor models that limits the general factor to a single dimension. Study 1 employed these recommendations when specifying the competitive state anxiety model as a bifactor model and first included two general factors: cognitive anxiety and physiological anxiety. A relatively poor fit was found for this model, which was likely due to wider issues with modelling the physiological dimension and not because two general factors were specified. Therefore, bifactor models offer a highly effective analytical method for sport psychology researchers developing measurement tools, even when theories present more than one general factor (Boduszek et al., 2016; Hyland, 2015).

As for the modelling of the physiological anxiety dimension, Study 1 found an excellent fit for the bifactor model that included a unidimensional physiological anxiety specific factor. This finding is not unique to this thesis, but instead is representative of the methodological challenges associated with the measurement of the physiological dimension more broadly. Both Cheng et al. (2009) and Jones et al. (2019) reported violating discriminant validity when specifying autonomous hyperactivity and somatic tension as separate first order factors and physiological anxiety as a second order factor. This resulted in Cheng et al. collapsing their hierarchical model into a parcelled model. Therefore, it is not surprising that Study 1 found a considerably better fitting model with a unidimensional physiological anxiety specific factor, rather than two specific factors reflected by somatic tension and autonomous hyperactivity with a general physiological anxiety factor. For the better fitting model, even though the physiological anxiety dimension was collapsed into one specific factor, all items reflecting autonomic hyperactivity and somatic tension were retained, so that the challenges associated with modelling the physiological anxiety dimension could be explored further in future research.

In addition, BSEM was employed throughout the present thesis to overcome the inherent limitations of frequentist statistics, particularly confirmatory factor analysis (CFA) for Study 1. The most pertinent problem with the use of CFA is the highly restrictive rules imposed on measurement models (e.g., fixing cross loadings and restraining residual correlations to zero; Marsh et al., 2009) which will more than likely result in a poor fitting model. Instead, the use of BSEM has grown within the sport psychology literature (e.g., Faull & Jones, 2018; Gucciardi & Jackson, 2015; Niven & Markland, 2016), due to its advantages over CFA. One example is that the Bayesian approach is more flexible as researchers can specify informative priors on cross-loadings and residual correlations combating the restrictions of CFA. For this reason and more (see p. 54 of this thesis for a comprehensive review), many researchers have advocated the use of BSEM over CFA. The implementation of BSEM resulted in consistent validation of the TFAI-2 in Study 1 and Study 2 of the present thesis.

In a similar vein, Study 2 and Study 3 of this thesis continued to implement Bayesian statistics for hypothesis testing. This is because there is a rising awareness of the limitations inherent in the frequentist approach to null-hypothesis significance testing, while the Bayesian approach has numerous pragmatic advantages (Kruschke et al., 2012, Wagenmakers et al., 2018). For example, by using Bayes factors and their descriptive interpretation in Study 2 and Study 3, the confidence for a parameter being in any particular range could be conveyed more clearly (Morey et al., 2016), as evidence for or against hypotheses was provided on a continuous scale (Jeffreys, 1961). Implementing Bayes factors in Study 3 also allowed for all potential statistical models to be compared (Wagenmakers, 2007) and the evidential direction of the results were monitored in real time, as data accumulated (Rouder, 2014; see Appendix F).

Although the benefits and advantages of a Bayesian approach are persuasive, the uptake of Bayes factors in the sport psychology literature has been limited. A key reason, as with any new methodological approach, may be the challenge of investing the necessary time and effort into the learning process (Kruschke et al., 2012). In addition, there is little user-friendly software that supports Bayesian methods for common statistical tests (Marsman & Wagenmakers, 2017). For example, the R programming language has become the programme of choice for statisticians and methodologists; however, it has not been adopted widely among researchers as its convoluted and intricate nature is believed to be a barrier (Love et al., 2019). To overcome this barrier, a free and open-source statistical software programme, JASP (JASP Team, 2020; jasp-stats.org), has been developed that allows researchers to conduct popular tests (e.g., *t*-tests, ANOVA’s, and regression modelling) using pre-programmed Bayesian syntaxes in R using a menu-driven structure (see Love et al., 2019 for a comprehensive review of JASP). There are many researchers encouraging the use of JASP (e.g., Perezgonzalez & Frías-Navarro, 2017; Quintana & Williams, 2018) and a growing number of publications providing tutorials on how to use JASP (e.g., van Doorn et al., 2020; Wagenmakers et al., 2018), allowing future sport psychology researchers to be able to implement Bayesian statistics with ease. For these reasons, a Bayesian approach was adopted throughout the present thesis; beyond the BSEM used for the measurement modelling in Study 1.

Practical Implications

There are four notable practical implications that emanated from the findings of this thesis for sport psychology consultants, coaches, and parents involved in supporting and preparing athletes to perform under pressure in competition. Although specific to sporting competition, the practical implications may also be relevant to wider performance situations that evoke an anxiety response, such as public speaking, musical performances, and job interviews.

First, Study 1 and Study 2 of this thesis consistently found support for the newly developed TFAI-2, providing a reliable tool for researchers to measure competitive state anxiety and test hypotheses grounded in the theory. Additionally, reliable measures are helpful to sport psychology consultants for two main reasons. They can help screen for psychological factors that need to be addressed, such as those that may be negatively impacting an athlete's performance or development (e.g., competitive anxiety). Moreover, self-report measures can help monitor any important changes during or post-intervention (Horvath & Röthlin, 2018). Thus, a sport psychologist can administer the TFAI-2 and understand their athlete's levels of cognitive anxiety, physiological anxiety and perceived control, as well as gain an insight into whether their athletes worry, or focus on the private and/or public self. This granularity is particularly important, as no other measure distinguishes between worry, private and public self-focus, therefore it may facilitate the creation of more tailored interventions. For example, an athlete who is suffering a decrease in performance when competing under pressure may complete the TFAI-2 and find that they score highly on the worry subscale in comparison to the private and public self-focus scales. With this knowledge a sport psychology consultant would be able to develop an intervention that focuses on reducing their athlete's worrying thoughts, such as introducing cognitive restructuring techniques (Beck, 2011; Mace, 1990) which aim to enhance performance by replacing irrational thought patterns with more adaptive cognitions (Hanton et al., 2008). Conversely, an athlete that scores highly on private self-focus may be more concerned about their inner thoughts and feelings, becoming increasingly aware of their movements, and subsequently lapse into conscious processing, resulting in performance disruption (Masters, 1992). With this additional knowledge a sport psychology consultant would be able to specifically pinpoint where performance was breaking down and develop an intervention targeting their athlete's increase in private self-focus, such as developing holistic process goals (Kingston & Hardy, 1997). In contrast, an athlete highly concerned with their public self during a competition may be too focused on how they were being perceived by significant others, and consequently their performance may deteriorate due to missing vital performance-related cues from their teammates or opponents (e.g., Geukes et al., 2012). With this information, a sport psychologist may develop an intervention centred on promoting sport-specific relevant focus of attention, such as implementing self-talk cues (Hatzigeorgiadis et al., 2011; Mallet & Hanrahan, 1997). These examples highlight that interventions for high levels of worry, private and public self-focus are very different, thus administering the TFAI-2 would greatly benefit both the sport psychology consultant and athlete when working together to understand the athlete's competitive anxiety, which in turn would encourage the development of better tailored interventions.

Second, Study 2 and Study 3 of this thesis illustrated the importance of perceptions of control for sporting performance. Coaches preparing their athletes for competition should be aware of this effect. There is one coach intervention already in use that taps into the regulatory dimension of Cheng et al.'s (2009) model; coach effectiveness training (CET; Smith et al., 1979). More specifically, CET was developed to help coaches create a motivational climate for their athletes by firstly focusing on controllable factors such as effort, rather than uncontrollable outcomes (Vazou et al., 2006). Similarly, Wood & Wilson (2012) suggested coaches should exercise caution when using language highlighting an uncontrollable outcome, such as “penalties are a lottery”. The intervention also encourages coaches to focus on athletes’ self-referenced goals (Duda & Ntoumanis, 2005), and athletes’ personal skill development and ability for competition (Smith et al., 2007). CET specifically targets factors within the regulatory dimension, such as controllable resources and attaining goals under pressure, suggesting that it may be increasing athletes’ perceptions of control. In line with this proposal, the intervention has been found to create a more favourable balance between demands of the competition and athletes’ coping resources (Smith et al., 2007). Therefore, interventions for coaches that increase athletes’ perceived control already exist and should continue to be implemented and developed with Cheng et al.’s (2009) model in mind.

Third, in the academic literature, children’s perceived ability is typically linked with their parent’s expectations of them, more so than their own previous and current performance (e.g., Frome & Eccles, 1998). Similarly, parents’ perceptions of their child’s competence (e.g., Bois et al., 2005) and parental achievement standards (Schwebel et al., 2016) have been linked to their child’s own perceived competence and ability in sport. For these reasons, the present findings suggest that interventions for parents that promote high control beliefs would also be beneficial. For example, Smoll et al., (2007) administered CET alongside a ‘mastery approach to parenting in sports workshop’. The parenting in sports workshop complemented CET by focusing on the same areas inherent in the regulatory dimension of Cheng et al.’s (2009) competitive state anxiety theory, which are detailed above. Athletes’ parents and coaches receiving this dual intervention reported decreases in anxiety over the course of the season compared to athletes’ whose coaches and parents did not receive the intervention. Further research could employ workshops grounded in the regulatory dimension of Cheng et al.'s theory in order to promote positive perceptions of control when approaching sporting competition.

Lastly, sport psychology consultants are also well placed to enhance an athlete's adaptive response to competitive state anxiety by increasing their awareness of the importance of perceived control and developing interventions that reduce the detrimental effects of low perceived control. Based on athletes' responses to the perceived control manipulation in Study 3, these interventions should include working with athletes to develop positive cognitions about agent-means beliefs, such as the familiarity of performing in competitions, believing in their ability to meet the challenge, having confidence in their readiness to perform, and believing that performing well is within their control. Promoting these positive cognitions within the instructional statements in Study 3 resulted in athletes maintaining their perceptions of control during the competition and in turn maintaining their performance whilst anxious.

Moreover, there are existing interventions that were not developed to specifically target the regulatory dimension of the competitive anxiety response but may hold such benefit. These include quiet eye training (Wood & Wilson, 2012), pre-performance routines (Dale, 2004; Hanton et al., 2008), simulation training and overlearning of skills (Hanton et al., 2008). For example, quiet eye training was initially developed to enhance athletes' coordination of effective gaze and motor control, but additionally, Wood and Wilson (2012) found that it increased athletes' perceptions of contingency attributing the outcome of a penalty kick to skill, rather than luck. The quiet eye training administered also included a set of attention-focused instructions informing the athlete that they had control over where they aimed and that if the shot was well-placed, the goalkeeper had little chance. Consequently, all athletes benefited from increased levels of perceived competence following the training. Similarly, it has been reported that pre-performance routines enhance perceptions of control by increasing attentional focus. In Hanton et al.'s

(2008) study, one participant reported, “A pre-performance routine stops you from being distracted by irrelevant things, which helps you feel more settled and more in control beforehand.” (p. 483). Moving forward, further research is required to understand how some psychological strategies may be enhancing performance by influencing the regulatory dimension of competitive state anxiety.

Future Research Directions

Based on the findings of this thesis there are numerous areas that warrant future research attention that can be grouped into theoretical and applied research directions.

Theoretical Research Directions

The present thesis has focused on the three main dimensions of Cheng et al.’s model; cognitive anxiety, physiological anxiety, and perceived control, however, the specific factors also warrant research attention. The reconceptualisation of competitive state anxiety (Cheng et al., 2009; Jones et al., 2019) provides greater differentiation than previous theories as the cognitive dimension is reflected by worry, private self-focus, and public self-focus. Further research into the specific factors would afford a deeper understanding of individual’s cognitive anxiety (e.g., whether an individual responds with increases in public self-focus, or whether an individual is more attuned to directing their attention inward) and consequently a more refined analysis of cognitive anxiety could be made. This would have theoretical benefits as well as practical; sport psychologists could adopt more precise intervention strategies targeting either worry, private self-focus or public self-focus, and in so doing facilitate performance under pressure, providing the basis for future experimental research.

Additionally, Study 3 of this thesis was the first experimental study to manipulate participants’ perceptions of control, therefore further research is needed to replicate these findings. Research specifically manipulating the regulatory dimension of the anxiety response will provide additional support for the relationships illustrated within this thesis and assumptions inherent within Cheng et al.'s (2009) reconceptualisation of competitive state anxiety.

Moreover, future research exploring the regulatory dimension could include additional measures such as heart rate variability. Heart rate variability has been widely used as a psychophysiological measure to detect changes in emotional state (Friedman, 2007; Grossman & Taylor, 2007), reflect changes in mental effort (Mulder, 1992) and has been included in a functional framework that integrates heart rate variability with affective regulation and attentional regulation (Thayer & Lane, 2000). Within the functional framework it has been proposed that high vagal tone is associated with the ability to self-regulate, to have greater behavioural flexibility, and have the ability to allocate resources in a challenging or stressful environment (Porges, 1992; Thayer & Lane, 2000; 2002). Grossman and Taylor (2007) suggested that a higher vagal tone is adaptive, because "it reflects a functional energy reserve capacity from which the organism can draw during more active states" (p. 279). Whereas low vagal tone is associated with poor self-regulation (Thayer & Lane, 2000), symptoms of panic anxiety and poor attentional control (Friedman & Thayer, 1998). Thus, potentially, variations in vagal tone may also be associated with the regulatory dimension of competitive state anxiety, a direction future research may wish to explore.

Collaborating with researchers in other sport science disciplines, such as experts in physiological measures (e.g., heart rate variability) would also address calls for more interdisciplinary research (Piggot et al., 2018). Despite sport performance involving multiple interacting components, sport science research is inherently confined to one sub-discipline (Glazier, 2017), which describes the research grounded in Cheng et al.'s model thus far. There are several advantages to an interdisciplinary approach, including the ability to provide a more in-depth profile of an athletes' strengths and limitations with regards to many areas (e.g., biomechanical, physiological, psychological) of their performance (Beukers et al., 2016). Importantly, some previous competitive state anxiety research has taken this approach. For example, kinematic measures (Mullen & Hardy, 2000), heart rate variability (Mullen et al., 2005; Mullen et al., 2016) and Salivary Alpha Amylase (Mullen et al., 2016) were included in tests of the conscious processing hypothesis. Owing to the complex interplay between the body's systems, future research testing Cheng et al.'s model should also adopt this integrated approach to understand how this reconceptualisation of competitive state anxiety interacts with more refined outcome measures, such as kinematic movement.

The final future research direction is the need to test the competitive anxiety trait-state relationship with regard to Cheng et al.'s (2009) theory. Despite the proliferation of competitive state anxiety investigations, the potential role competitive trait anxiety may have on the anxiety-performance relationship has received little attention. Spielberger (1966) originally suggested that high trait anxious performers would respond to stressful situations with higher levels of state anxiety, thus impacting performance. Conversely, Hardy et al. (1996) questioned the simplicity of this hypothesis, arguing that trait anxiety does not just influence performance via changes in state anxiety. For instance, trait and state anxiety may interact to determine attentional selectivity (Eysenck, 1992). Given the six components of competitive state anxiety (worry, public self-focus, private self-focus, autonomous hyperactivity, somatic tension, and perceived control), it would be interesting to explore how competitive trait anxiety interacts with each. The present thesis provides evidence to suggest perceptions of control attenuate the maladaptive effects of state anxiety on performance and the impact trait anxiety has on this relationship is worthy of future attention.

Additionally, the competitive trait anxiety construct has faced measurement issues similar to those associated with competitive state anxiety, as discussed in Chapter 2 of this thesis (see p. 40). For example, the Competitive Trait Anxiety Inventory (Albrecht & Feltz, 1987), the multidimensional Sports Anxiety Scale (SAS; Smith et al., 1990) and SAS-2 (Smith et al., 2006) have been developed; however, problems such as conflicting factor loadings, and poor construct and discriminant validity have emerged. These problems may be solved by implementing the recommendations from Study 1 of this thesis. In particular, the SAS-2 model incorporates three first-order factors (worry, somatic anxiety, and concentration disruption) and a second-order global trait anxiety factor. Instead, a bifactor model could be employed where the three first-order factors are specified as specific factors and the second-order trait anxiety factor is specified as a general factor, again highlighting the utility of bifactor models. Additionally, BSEM could be implemented in an attempt to eradicate the issues of CFA, such as substantially correlated subscales.

Applied Research Directions

The findings of this thesis validate and support the use of the TFAI-2 in future research and provide a useful tool for sport psychologists to administer in applied settings, as outlined previously. However, it should be noted that measures developed in the research field are not always adopted in applied settings, rather, a sample of sport psychology consultants revealed that they constructed their own instruments specific to the sport and/or athlete they are working with (Gould et al., 1989; O'Connor, 2004). Horvath and Röthlin (2018) suggested numerous reasons for this, including elite athletes having many time constraints, young athletes unable to understand the questions, the benefits of completing self-report measures are not always clear, they are not always suitable for different sports, and similarly worded items become monotonous. As such, Horvath and Röthlin (2018) called for this gap between psychological research and sport psychology counselling to be filled. Therefore, in future, researchers should collaborate with athletes and applied practitioners to ensure the TFAI-2 does not suffer with these problems, confirming that it is practical for both applied practitioners and athletes.

A significant finding throughout this thesis was the positive effect perceptions of control had on sporting performance; thus, researchers should direct their attentions towards modifying existing interventions and developing new interventions that increase perceptions of control. While there are interventions that have perceived control elements (e.g., CET, quiet eye training and pre-performance routines), this adaptive nature of anxiety has only recently been established and tested within the sport psychology literature, and to the author's knowledge, there is not an intervention grounded in, or specifically aimed at increasing perceived control (in the form of agent-means beliefs). Attribution training techniques are centred in control beliefs but are more concerned with retraining means-ends beliefs (Biddle, 1999); exploring and identifying causes of outcomes, rather than appraising whether the athlete has access to these causes. Therefore, attribution re-training could be adapted, focusing on increasing agent-means beliefs in the face of competition.

Lastly, to understand the effectiveness of a novel intervention, such as attribution re-training for agent-means beliefs, future applied research should include single-subject study designs (Barker et al., 2013). The use of a single-case approach is particularly useful when embarking on new research areas, as it can detect positive effects that may have been masked in a large group design that revealed non-significant results (Barker et al., 2013) and can demonstrate that the intervention in question was the cause of performance improvements (Barker et al., 2011). Taken together, single-subject designs would be particularly useful for future explorations into new interventions grounded in the regulatory dimension of competitive state anxiety. This would bridge the gap between the theoretical reconceptualisation of competitive state anxiety and its application within sport psychology practices.

Strengths and Limitations

The present thesis exhibits a number of strengths. These include measurement (Study 1), field (Study 2) and experimental (Study 3) designs, where complex statistical analyses were used (e.g., BSEM) in order to examine competitive state anxiety. As a consequence of these methodological strengths, Study 1 is the first to use a bifactor model specification with BSEM, resulting in the newly developed TFAI-2 that has a very stable factor structure.

Study 2 adopted a number of methodological recommendations proposed by previous researchers, including the need for research to adopt (a) prospective designs when measuring competitive state anxiety, rather than retrospective designs, which are potentially inaccurate due to outcome biases (e.g., Brewer et al., 1991); (b) the development and validation of a self-rated performance measure specific to Study 2a's participant sample (Hardy & Hutchinson, 2007) and the inclusion of an objective performance measure in Study 2b (Totterdell, 2000); and (c) a homogenous sample with respect to team sports (Cheng et al., 2011). Taken together, the use of five different team sports, varying performance measures and the application of Bayes factors in Study 2 may represent one of the most comprehensive field examinations in the competitive state anxiety literature.

Finally, Study 3 provided two firsts for the sport psychology literature examining the competitive state anxiety response: 1) it was the first to attempt to manipulate participants' perceptions of control; and 2) it was the first to adopt Bayesian ANOVA modelling. Findings suggest that the novel intervention influencing participants' perceptions of control had the desired effect and thus not only advanced our understanding of the relationships between the regulatory dimension, cognitive anxiety, and physiological anxiety, but also provides applied implications for future sport psychology interventions. As a result of these methodological strengths, the present thesis offers significant support for Cheng et al.'s (2009) framework and moving forward this theory should provide the foundations for future theoretical and applied research.

Despite these strengths, the present thesis is not without its limitations. One example is the reliance on quantitative assessments of competitive state anxiety in all of the studies within this programme of research. There are many examples of quantitative and qualitative studies examining previous competitive state anxiety theories (e.g., Multidimensional Anxiety Theory, MAT; Martens et al., 1990); however, this is not the case for Cheng et al.'s (2009) reconceptualisation. As a result, a potentially incomplete picture of the adaptive nature of anxiety may have been presented. Although the quantitative results provide support for the inclusion of the regulatory dimension, qualitative methods could be used in conjunction to build and refine the theory (e.g., modified analytic induction; Bogdan & Biklen, 1992; Gilgun, 1995). More precisely, a qualitative enquiry into the perceptions of control that are triggered when athletes experience pre-competitive anxiety would provide rich information about the regulatory dimension, strengthening the quantitative findings of this thesis.

Second, Study 2 failed to find the predicted interaction effects between the three main anxiety dimensions, cognitive anxiety, physiological anxiety, perceived control and performance. The sampling of athletes from team sports may be one reason, as previous research has reported that athletes from individual sports tend to report higher levels of competitive state anxiety than those from team sports (e.g., Dias et al., 2010). Additionally, the athletes' perceived importance of the upcoming match was not measured, therefore the potential (un)importance of the competitive game in question coupled with the use of team sports may not have elicited high levels of competitive state anxiety responses and thus interaction effects could not be found.

In hindsight, when developing Study 3, a third condition where the athletes experienced the anxiety condition but did not receive the perceived control manipulation would have extended the research findings in relation to the impact of the manipulation. Therefore, the potential benefit this may have provided should be acknowledged. To elaborate, it was clear that the manipulation had the desired effect, however, exploration into whether the instructions heightened the athletes' perceptions of control beyond solely responding to the anxiety condition could have been made. In other words, it would have been interesting to examine the athletes' perceptions of control in response to the anxiety condition without the perceived control manipulation, compared to their response when receiving the manipulation.

A final limitation relates to the measurement of the physiological dimension. Study 1 of this thesis illustrated the challenges of modelling a multidimensional physiological anxiety construct, as the analyses supported a single physiological anxiety factor rather than the two-factor model originally proposed by Cheng et al. (2009). Although Cheng et al. proposed a multidimensional physiological anxiety structure, they did not find statistical support for a two-factor solution, instead merging autonomous hyperactivity and somatic tension to form a single factor. Study 1 of this thesis put forward a similar solution to that settled on by Cheng and associates, that is, a final single factor that retained the items indicative of both proposed subcomponents. All items were retained so that the single factor still represented both somatic tension and autonomous hyperactivity, in line with the DSM-III-R (APA, 1987) and Cheng et al.'s original proposal. Problems with self-report physiological anxiety measures have been documented since the late 1900's (e.g., McLeod et al., 1986). For example, there is no evidence supporting significant correlations between self-report measures and physiological measures, suggesting that individuals cannot reliably perceive physiological changes experienced under stress (e.g., McLeod et al., 1986; Yamaji et al., 1992). Psychophysiological approaches combined with self-report measures may provide further benefits. To elaborate, psychophysiological tests have been employed to measure muscle tension (Electromyographic (EMG); Lundberg et al., 1999;

Reitmann 2001) and sweat response (Yoshie et al., 2008), whilst cortisol levels have been used as a measure of hypothalamic-pituitary-adrenocortical (HPA) axis, and salivary alpha amylase (sAA) has become an established biomarker of the psychosocial stress response within the sympathetic adrenomedullary (SAM) systems (Maruyama et al., 2012). In relation to Cheng et al.'s proposed distinction between the different components of physiological anxiety, EMG is indicative of somatic tension, and cortisol levels and sAA reflect autonomous hyperactivity. Thus, implementing psychophysiological markers indicative of Cheng et al.'s original proposal may extend our knowledge of the physiological anxiety dimension and its interactions with the other components of competitive state anxiety, again highlighting the need for an interdisciplinary approach.

Conclusion

The purpose of the present thesis was to address measurement issues within the anxiety literature and to examine Cheng et al.'s (2009) model of competitive state anxiety. First, this thesis supports a bifactor representation of Cheng et al.'s (2009) three-dimensional competitive state anxiety model. Second, the results of this thesis reinforce the central role the regulatory dimension plays in the anxiety-performance relationship. As such, Cheng et al.'s framework should provide the foundations for future theoretical and applied research moving forward. Additionally, the use of BSEM and Bayes factor analyses within this thesis provide researchers with a useful alternative to frequentist approaches that allow them to examine both null and alternative hypotheses simultaneously. Taken together, the findings present herein makes a significant and unique contribution to the anxiety-performance literature base.

Chapter 7

References and Appendices

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Appendices

Appendix A – Competitive State Anxiety Measure, renamed the Three Factor Anxiety Inventory-2 (TFAI-2)

<u>Instructions – Complete approximately an hour before competition</u>

The effects of highly competitive sports can be powerful and very different among athletes. Some very common statements that athletes have used to describe their psychological states when anticipating or performing sports under pressure are given below. The inventory you are about to complete measures <u>how you feel at this moment</u>. Please complete the inventory as honestly as you can. Read each statement and then circle the appropriate number. There are no right or wrong answers. Your answers will be kept completely confidential, and we will only be looking at group responses. Do not spend too much time on any one statement, but choose the answer which describes your feelings right now.

	Totally disagree				Totally agree
1) My heart is racing………….........……………………	1	2	3	4	5
2) I feel I have the capacity to cope with this performance…	1	2	3	4	5
3) I am conscious that others will be judging my performance	1	2	3	4	5
4) I believe in my ability to perform…………………………..	1	2	3	4	5
5) I am worried that I may make mistakes..............................	1	2	3	4	5
6) I feel physically nervous……………………………...……	1	2	3	4	5
7) My chest feels tight………………………………………….	1	2	3	4	5
8) I am worried about the uncertainty of what may happen….	1	2	3	4	5
9) I find myself trembling…….……………………..………..	1	2	3	4	5
10) I tend to dwell on shortcomings in my performance……..	1	2	3	4	5
11) I am worried about the outcome of my performance…….	1	2	3	4	5
12) I feel tense in my stomach………………………………..	1	2	3	4	5
13) I am prepared for my upcoming performance……………	1	2	3	4	5
14) I am conscious about the way I will look to others………	1	2	3	4	5
15) I have a slight tension headache…………………………..	1	2	3	4	5
16) I am worried that I may not perform to the best of my ability	1	2	3	4	5
17) I am confident that I will be able to reach my target……….	1	2	3	4	5

18) I am aware that I will scrutinise my performance………...	1	2	3	4	5
19) I feel lethargic…………………………..………………………..	1	2	3	4	5
20) My body feels tense………………………….………………	1	2	3	4	5
21) I feel a lump in my throat……………………………………	1	2	3	4	5
22) I am aware that I will be conscious of every movement I make	1	2	3	4	5
23) I am worried about the consequence of failure…………….	1	2	3	4	5
24) I am worried that I may not meet the expectations of important others……………………………...…….……………	1	2	3	4	5
25) My hands are clammy…………………………...……	1	2	3	4	5

Appendix B – Health Check Questionnaire

Medical History Questionnaire

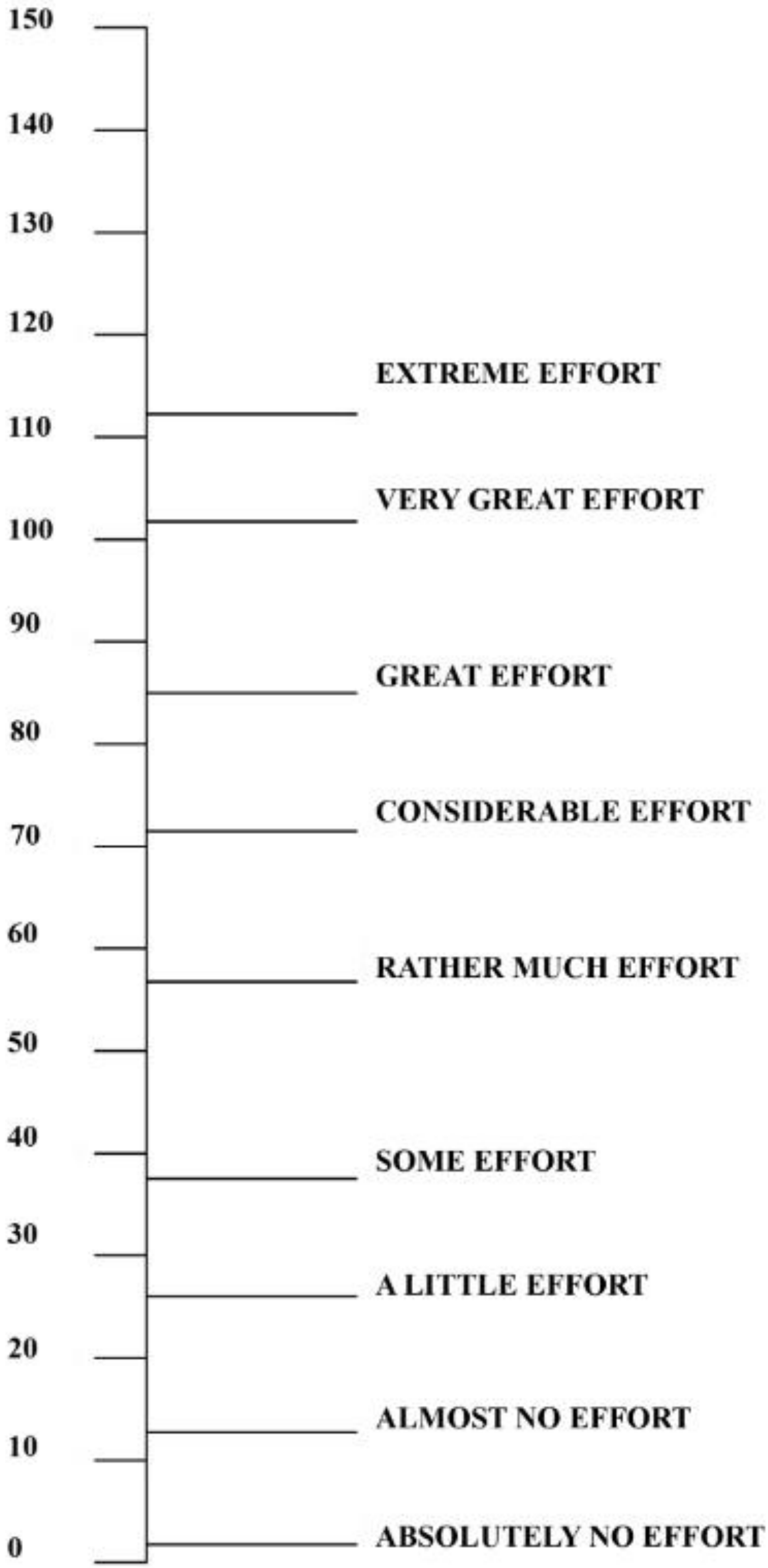
Name………………………………………………………………………………………………………..

Please indicate whether any of these statements apply to you by placing a [✓] in the yes or no boxes provided and please add any additional information on the dotted lines:

		YES	NO
1.	History of heart problems (ie. Chest pains, heart murmur, or stroke)		
2.	Diabetes Mellitus		
3.	Asthma, breathing or lung problems		
4.	Allergies		
5.	Seizures, seizure medication, neurological problems or dizziness		
6.	High blood pressure		
7.	Recent surgery (last 12 months)		
8.	Hernia or any condition that may be aggravated by exercise		
9.	History of high cholesterol		
10.	Family history of coronary heart disease		
11.	Do you smoke or chew tobacco products? If past, when did you stop smoking? …………………………………		
12.	Do you smoke E-cigarettes or herbal cigarettes? If past, when did you stop smoking? …………………………………		
13.	Do you consume alcohol?		

When was the last time you consumed alcohol?.....................		
14. Do you consume caffeine? When was the last time you consumed caffeine?.......................		
15. Have you completed any vigorous exercise (exercise for ≥ 20 minutes that produces sweating or heavy breathing and a heart rate of 60%-80% of maximum) in the past 48 hours? If so, what type of exercise?...		
16. Are you on any form of medication? If so, what for?..		
17. Are you pregnant?		

Appendix C - Rating Scale of Mental Effort (RSME; Zijlstra, 1993)


150
140
130
120
EXTREME EFFORT
110
VERY GREAT EFFORT
100
90
GREAT EFFORT
80
CONSIDERABLE EFFORT
70
60
RATHER MUCH EFFORT
50
40
SOME EFFORT
30
A LITTLE EFFORT
20
ALMOST NO EFFORT
10
0
ABSOLUTELY NO EFFORT

Appendix D – Anxiety Intervention Video Script

Anxiety Intervention Video Script – Dr Rich Mullen was videoed reading this information.

Thank you for taking part in this study so far, my name is Professor Rich Mullen, and I'm a professional Sport Psychologist. I have worked with many elite athletes to develop their psychological skills. You will now be entering the final phase of the experiment and it is important that you complete this phase to the best of your ability. During this final phase, your performance will be videoed. The video will be assessed by myself along with your coach. We are very interested in seeing how you perform as a participant in this study.

You will also be paired with another participant in the study and you have the chance to be entered into a £100 prize draw. However, to be entered you and your partner both have to improve your performance by 20%. Therefore, if you do not improve your performance in the next block by 20%, neither you nor your partner will be entered into the prize draw. It is therefore extremely important that you perform well in this phase so that you and your partner have the best chance of being entered into the prize draw. Your partner has already completed this phase of the study and has successfully improved by more than the 20%. I can tell you who they are once you have completed your throws. Everyone's performance will also be circulated to all other participants in a league table format via email, so all names and scores will be available for all participants to see.

Good Luck!

Appendix E – Perceived Control Manipulation Check

<u>Perceived Control Manipulation Check</u>

In relation to the competition you just experienced please indicate to what degree

"I felt that I had mental control over the situation to demonstrate my skills and perform to the best of my ability"

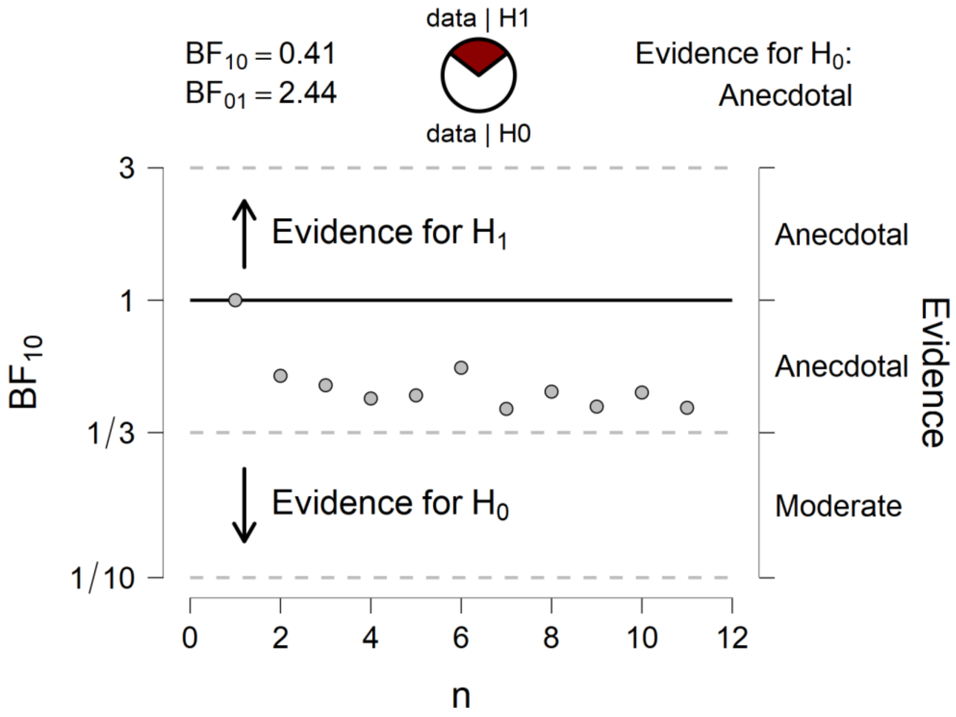
0	1	2	3	4

Not at all Extremely

Appendix F – Example of a Bayesian Sequential Plot

Figure 15

The Evidence Accumulating for H_0 When Comparing Participants' Performance in the High Perceived Control Group from Low Anxiety to High Anxiety



Note. This sequential plot shows the effect of the data as it accumulates. It is slowly moving towards evidence for H_0 and it is likely that a larger sample size would have gained greater evidence for H_0. Evidence for the null hypothesis also accumulates at a slower rate than evidence for the alternative hypothesis (Johnson & Rossell, 2010).