DO CHALLENGE AND THREAT STATES PREDICT PERFORMANCE, ATTENTION AND NONVERBAL BEHAVIOUR DURING THE PERFORMANCE OF A PRESSURISED SOCCER PENALTY TASK?

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Abstract

Athletes who display a challenge state thrive under pressure, while athletes who display a threat state struggle. The present thesis had two main aims. First, it tested the predictions of the integrated framework of stress, attention, and visuomotor performance to better understand how challenge and threat states effect performance. Second, it examined the influence of challenge and threat states on nonverbal behaviour (NVB) to provide a new method of identifying athletes who are experiencing challenge and threat states. Forty-two participants completed a pressurised soccer penalty task. Before the task, challenge and threat states were measured via demand resource evaluations and cardiovascular reactivity. During the task, a mobile eye tracker and digital video camera were used to record attentional control and NVB, respectively. After the task, performance (i.e., distance from the centre of the goal), attentional control (i.e., time to first fixation on goalkeeper, percentage viewing time on the goalkeeper and goal, and quiet eye duration), and NVB (i.e., submissive–dominant, unconfident–confident, on edge–composed, unfocused–focused, and inaccurate–accurate), were determined via video analysis. Finally, challenge and threat states were measured before a second trial on the pressurised soccer penalty task. The results revealed that challenge state was associated with more accurate performance (p = <.001), and more time spent fixating on the goalkeeper (p = .044). Also, the results suggest challenge state might be associated with the amount of time spent fixating on the goal (p = .059), and longer quiet eye durations (p = .066). In addition, a challenge state in trial one might be associated with experiencing a challenge state in trial two (p = .062). While better performance in trial one was linked to challenge evaluations in trial two (p = .009). Finally, a challenge state was associated with more dominant (p = .031), confident (p = .012), composed NVB (p = .004), and associated with increased likelihood of an accurate penalty (p = .045). Collectively, these findings partially support the integrated framework, suggesting that a challenge state might benefit sports performance by optimising goal-directed attentional control. Furthermore, the findings imply that NVB may offer a potential new method of identifying challenge and threat states among athletes in pressurised situations.

Declaration

I declare that the work in this thesis was carried out in accordance with the regulations of the University of Gloucestershire and is original except where indicated by specific reference in the text. No part of the thesis has been submitted as part of any other academic award. The thesis has not been presented to any other education institution in the United Kingdom or overseas.

Any views expressed in the thesis are those of the author and in no way represent those of the University.

Signed .... Date ....04/01/18....................

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"When there's pressure, I believe people will break under it or a diamond will be created."

(Brock Osweiler)

Elite athletes are expected to perform successfully under extreme stress in a variety of enormously pressurised situations (e.g., penalty shootout in the soccer world cup final). Stress, has been reported as the relationship between an athlete and the environment, in which, the situation is significant to the athlete's well-being and appears to exceed the athlete's coping resources (Lazarus, 1966). Yet, as the above quote advocates, any two athletes could respond differently when faced with the same stressor. Typically, stressors are reported to fall into one of three categories, including competitive (e.g., self-doubt, opponents, failure, and injury), organisational (e.g., staff changes, funding, interpersonal relationships, and governing body issues), and personal (e.g., other commitments, traumatic events, lifestyle changes, and underperformance) stressors (McKay, Niven, Lavallee, & White, 2008). While some researchers report stress leading to deteriorations in performance, or an athlete choking under pressure (Baumeister, 1984; Lewis & Linder, 1997), others report improvements in performance, or an athlete displaying clutch performance under pressure (Otten, 2009). How athletes appraise stressors is often thought to determine who 'chokes' and who performs optimally, and can have long-term effects on physical health and psychological well-being (e.g., high blood pressure and burnout; Gallagher, Meany, & Muldoon, 2014; Tenenbaum, Jones, Kitsantas, Sacks, & Berwick, 2003).

A great number of high profile examples of performance variability under pressure have been documented. For example, Jana Novotna provided possibly the greatest demise in Wimbledon final history. Jana Novotna was leading Steffi Graf 6-7 6-1 4-1 (40-15) after winning 10 out of the previous 12 games. However, Jana Novotna double faulted and allowed Steffi Graf back into the game. Steffi Graf then went on to win the next 5 games in a row clinching the 1993 women's Wimbledon title. Jana Novotna can be seen crying profusely at the post-match award presentation upon realising her mistakes. On the other hand, Novak Djokovic provided an excellent example of 'clutch' performance. Novak Djokovic is a world-class player who, when he wins the first set, goes on to win 95% of his matches. However, in 2011, Novak Djokovic found himself 2 sets to love down against world number 3, Roger Federer. What followed, however, was a prime example of improved performance under pressure. From this point in the game, Novak Djokovic managed to completely turn the game on its head and ended up winning the final three sets 6-3 6-2 7-5. This was only the second time Novak Djokovic had ever come back from 2 sets down, and only the second time Roger Federer had ever been defeated from such a position.

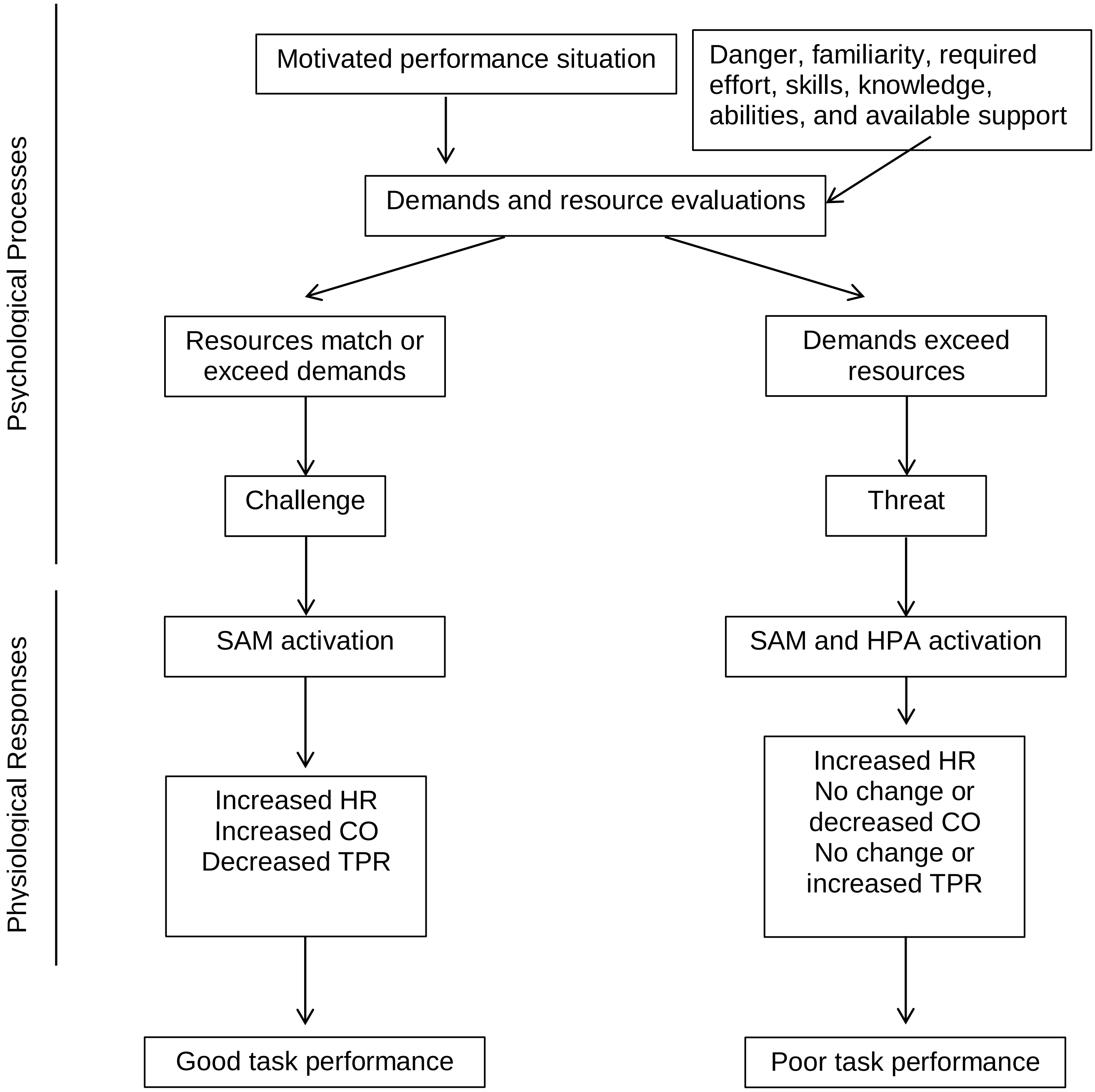
It seems that an inability to cope with stress is a significant factor in the failure of athletes to effectively function during high-pressure situations (Lazarus, 2000). Additionally, it is widely accepted within the realms of sport psychology that being able to cope with competitive stressors is key to athletes reaching their maximum potential, but also, to making their experience in sport as a whole, an enjoyable one (Nicholls & Polman, 2007). Two frameworks that offer potential explanations of performance variability under pressure are the biopsychosocial model (BPSM) of challenge and threat states (Blascovich, 2008a), and a recent evolution of this model called the integrated framework of stress, attention, and visuomotor performance (Vine, Moore, & Wilson, 2016). The aim of this thesis was to test these frameworks and to provide a more detailed understanding of why athletes respond differently under elevated pressure, with some athletes crumbling and choking, and others rising to the occasion and excelling.

Literature Review

The Biopsychosocial Model

The BPSM of challenge and threat states has become a marquee figure within literature relating to individual performance variability under stress (Blascovich, 2008a). According to the BPSM, for challenge and threat states to occur, an individual must be both cognitively and behaviourally engaged in the stressful situation, and performance must be motivated, evaluated, and goal-relevant (Blascovich & Mendes, 2000). Example motivated performance situations include a driving test, giving a speech, a job interview, finding a romantic partner, or a sporting competition (Seery, 2011). Due to the stressful nature of these situations, and the important outcomes arising from them (e.g., driving license, embarrassment, employment, romantic rejection, or trophies), it is typical for an individual to be actively engaged when performing important tasks within these situations. Once engaged within a motivated performance situation, as evidenced by increases in heart rate or the number of heart beats per minute (Seery, 2011), the BPSM states that an individual first responds to a stressful situation with a psychological assessment of the situation and their ability to cope, and this assessment is followed by a corresponding physiological response (see Figure 1 for an overview of the BPSM).

Figure 1 An overview of the biopsychosocial model of challenge and threat states (Blascovich, 2008a).



Note: SAM = sympathetic-adrenomedullary; HPA = hypothalamic-pituitary-adrenal; HR = heart rate; CO = cardiac output; TPR = total peripheral resistance

The psychological response. The origin of the psychological response of the BPSM stems from cognitive appraisal theory (Lazarus & Folkman, 1984; Lazarus, 1991). Lazarus and colleagues (1984) suggest that cognitive appraisal occurs when an individual considers two main factors when dealing with a stressor. These two factors include: (1) the threat the stressor could cause the individual or the damage it could have on the individual's well-being, and (2) the coping resources the individual has available to endure or eliminate said stressor (Lazarus & Folkman, 1984). Typically, cognitive appraisal is divided into two types: primary and secondary appraisals. During primary appraisal, an individual assesses what the stressor and/or situation mean, and whether or not it poses potential harm to their well-being. Lazarus and Folkman (1984) suggest that at this point, one of three typical responses occur including: (1) 'this is not important' (i.e., benign or irrelevant), (2) 'this is good' (i.e., positive), or (3) 'this is stressful' (i.e., negative). The second part of primary appraisal is classifying a stressful situation as harm-loss, threat, or challenge. While harm-loss appraisals refer to previously experienced psychological harm, threat appraisals are viewed as something that will cause the individual future harm, and challenge appraisals refer to the expectation of positive outcomes in the future. Secondary appraisal refers to an individual's feelings regarding their personal coping resources and whether they are sufficient to allow the individual to cope with the demands of the situation. The primary and secondary appraisals combine to determine how an individual reacts to a stressful situation including emotional responses and coping efforts (Lazarus, 1991).

The work of Lazarus and colleagues (1984) depicts challenge and threat as two opposing dichotomous appraisals, and suggest that an individual can appraise a stressful situation as both a challenge and a threat simultaneously (Lazarus & Folkman, 1984). Contrary to this, the BPSM suggests that challenge and threat states represent two bipolar ends of a singular continuum, meaning that an individual can be more or less challenged or threatened, and that relative differences in challenge and threat (i.e., greater vs. lesser challenge or threat) are conceivable and often investigated (Blascovich, 2008a). Additionally, while Lazarus and Folkman (1984) denote challenge and threat as different types of primary appraisal, the BPSM states that challenge and threat states occur as a product of what Lazarus refers to as primary and secondary appraisals (Seery, 2011). Specifically, during motivated performance situations, challenge and threat evaluations are determined by an individual's assessment of the demands of the situation (i.e., primary appraisal), and the resources they have available to cope with those demands (i.e., secondary appraisal). When an individual perceives himself or herself to have sufficient resources to meet the demands of a stressful situation, they are said to evaluate the situation as a challenge. In contrast, when an individual believes the situation to be too demanding for their coping resources, they are said to evaluate the situation as a threat (Seery, 2011).

As part of the BPSM, Blascovich and colleagues also denounce the term ‘appraisal’ used in Lazarus and Folkman’s (1984) cognitive appraisal theory (Blascovich, 2008a). They argue that using the term ‘appraisal’ suggests that challenge and threat evaluations are the result of deliberate and conscious processing. Instead, Blascovich and colleagues (2008a) prefer to use the term ‘evaluation’, which is believed to have less conscious and cognitivistic connotations, implying that challenge and threat evaluations arise in a more automatic and subconscious manner outside of conscious control (Blascovich, 2008a). However, the BPSM does concur with the cognitive appraisal theory (Lazarus & Folkman, 1984), in that it believes the demand resource evaluation process to be dynamic, with evaluations constantly changing throughout a motivated performance situation (Blascovich, 2008a), a process known as reappraisal in the work of Lazarus and colleagues (Lazarus & Folkman, 1984). For example, initial assessment may lead to a threat evaluation, however, after a few minutes, following successful performance for example, this evaluation could change and lead to a re-evaluation of the situation as a challenge. Finally, the BPSM proposes that a range of interrelated factors might influence both demand and resource evaluations including danger, familiarity, uncertainty, perceived effort, skills, knowledge, ability, external support, and previous performance (McGrath, Moore, Wilson, Freeman, Vine, 2011). Although, to date, limited research has explicitly tested these antecedents. Indeed, in a rare study, Moore and colleagues (2014) found that participants in a low perceived effort group evaluated the task as more of a challenge (i.e., personal coping resources match or outweigh task demands), displayed a cardiovascular response more typical of a challenge state (i.e., increased HR and CO, and decreased TPR), and performed better on the task compared to the high perceived effort group (Moore, Vine, Wilson, Freeman, 2014).

The physiological response. The demand resource evaluation process is thought to be followed by distinct cardiovascular responses (Blascovich, 2008a; Seery, 2011). In order to explain the different physiological responses, the BPSM draws upon Dienstbier’s (1989) theory of physiological toughness. Dienstbier (1989) noted two distinct cardiovascular responses amongst animals that appeared to thrive during active coping situations, and animals that did not fare so well in the same active coping situations (Blascovich, 2008b). Specifically, Dienstbier (1989) distinguished these cardiovascular patterns as adaptive (i.e., physiological toughness), and malignant (i.e., physiological weakness), responses to stress. For those animals deemed physiologically tough, sympathetic-adrenal-medullary (SAM) activation led to the production of epinephrine and norepinephrine; which in turn further increased heart rate (HR: the number of times the heart beats per minute), and decreased total peripheral resistance (TPR: a measure of the net constriction versus dilation in the arterial system), resulting in a relatively large increase in cardiac output (CO: the amount of blood in litres pumped by the heart per minute; Seery, 2011). However, animals noted as physiologically weak, had a near-simultaneous activation of the hypothalamic-pituitary-adrenal (HPA) axis as well as SAM activation. The activation of the HPA axis inhibited the effect of SAM activation on HR and TPR by releasing cortisol, which led to no change or small increases in TPR, and little change or small decreases in CO (Blascovich, 2008b). These activation patterns influence energy mobilisation, with SAM activation allowing for a short and fast spike in energy mobilisation, preparing the body for immediate action, and HPA activation resulting in a slow and more prolonged release of energy, preparing the body for an extended struggle (Seery, 2013). In addition to the cardiovascular responses, Dienstbier (1989) suggested physiologically tough animals were more likely to evaluate a stressful situation positively (i.e., perceiving themselves more capable of coping with the demands of the stressful situation), than physiologically weak animals (Dienstbier, 1989).

Challenge states are predicted to share the same neuroendocrine and cardiovascular responses referred to by Dienstbier (1989). Specifically, according to the BPSM (Blascovich, 2008a), an individual who evaluates himself or herself to have sufficient resources to cope with a motivated performance situation (i.e., challenge evaluation), will display a cardiovascular response more akin to that of physiological toughness, including increases in HR and CO, and decreases in TPR. This response is deemed more efficient and increases oxygenated blood flow to the brain and muscles (Seery, 2011). Alternatively, an individual who evaluates a motivated performance situation to be too demanding for their coping resources (i.e., threat evaluation), will display a cardiovascular response more consistent to that of physiological weakness, including a small increase in HR, little change or a small decrease in CO, and little change or a small increase in TPR (Blascovich, 2013). This pattern is considered less efficient and results in less oxygenated blood flow to the brain and muscles (Seery, 2011). Thus, while increases in heart rate are expected across both challenge and threat states, and is assumed to indicate task engagement (a prerequisite of challenge and threat states; Seery, 2011), a cardiovascular response consisting of relatively higher CO and lower TPR is considered more reflective of a challenge state (Seery, 2011). Given the automatic and subconscious nature of the demand resource evaluation process, and the bias that can accompany self-report items (e.g., social desirability), Blascovich and colleagues prefer to measure challenge and threat states objectively via these cardiovascular indices, which have been extensively validated (Blascovich, 2008a).

Blascovich and colleagues initially conducted three validation studies to test the predictions of the BPSM, and the proposed link between demand and resource evaluations and cardiovascular responses (Tomaka, Blascovich, Kelsey, & Leitten, 1993). In all three studies, Tomaka and colleagues (1993) found that evaluating a mental arithmetic or serial subtraction task as a challenge (i.e., personal coping resources match or outweigh the demands of the task), was associated with a cardiovascular response more representative of a challenge state (i.e., higher CO and lower TPR reactivity). In contrast, evaluating the task as a threat (i.e., task demands outweigh personal coping resources) was associated with a cardiovascular response more akin to a threat state (i.e., lower CO and higher TPR reactivity). To further understand the relationship between demand and resource evaluations and cardiovascular markers, Tomaka and colleagues (1997) adopted an experimental approach in subsequent validation studies, manipulating demand and resource evaluations and then measuring cardiovascular responses (i.e., Tomaka, Blascovich, Kibler, & Ernst, 1997). In study one, an individual who received verbal instructions designed to manipulate them into a challenge state displayed demand and resource evaluations (i.e., personal coping resources match or surpass task demands), and a cardiovascular response (i.e., higher CO and lower TPR reactivity), more reflective of a challenge state. In studies two and three, using aerobic exercise or rest (study two), and cold or warm water immersion (study three), to create the cardiovascular responses associated with challenge and threat states had no effect on subsequent demand and resource evaluations. Thus, demand and resource evaluations appear to influence cardiovascular responses rather than vice versa. Importantly, this work by Tomaka and colleagues (1997) also began a line of research exploring the effects of challenge and threat states on task performance, with these states having little effect on mental arithmetic performance in study one (Tomaka et al., 1997).

Indeed, while widely acknowledged as an appropriate model within the literature, the cardiovascular measures of the BPSM have been subject to scrutiny. For instance, Wright and Kirby (2003) showcased a number of problems with the cardiovascular indices within the BPSM. First, the idea that the release of epinephrine and norepinephrine are exclusively related to vessel dilation is rejected. Indeed, Wright and Kirby (2003) note that while epinephrine is related to the dilation of blood vessels, norepinephrine is associated solely with the constriction of the vessels. Therefore, even if the circulating of epinephrine did create vessel dilation, it is not farfetched to state that the simultaneous release of norepinephrine would counter this action. Moreover, to date, no research has incorporated hormonal (i.e., catecholamines and cortisol) measures in order to offer a more complete test of the predictions of the BPSM. Second, a lack of consideration for the impact of challenge and threat states on blood pressure is noted as a criticism given that diastolic blood pressure is directly related to TPR (Wright & Kirby, 2003). Therefore, if a challenge state is represented by a decrease in TPR, a decrease in diastolic blood pressure should also be present. Indeed, while a tentative link to this research, work in social psychology has found that feeling ‘threatened’ leads to increased blood pressure (e.g., Scheepers & Ellemers, 2005). For example, Scheepers and Ellemers (2005) found that individuals in a low social status group displayed significantly higher blood pressure in comparison to those in the high social status group in response to status related feedback. Finally, the idea that increases/decreases in HR do not allow one to distinguish between challenge and threat states, but rather represent task engagement is reported as a problem (Wright & Kirby, 2003). More specifically, research notes that HR is just as susceptible to increases in epinephrine or norepinephrine as other cardiac measures (Brownley, Hurwitz, & Schneiderman, 2000). This is a concern, in that, given the suggestions made by the BPSM that challenge and threat states lead to different epinephrine and norepinephrine responses, there should also visible differences in HR between the two states (Wright & Kirby, 2003). However, if the BPSM's suggestions regarding HR and challenge and threat states are correct, then differences between the responses must be driven by stroke volume, given that CO is calculated by HR x stroke volume. Therefore, the lack of any real mention of stroke volume as a key physiological variable in the BPSM is also concerning.

In response to this critique, Blascovich and colleagues (2003) argued against the propositions of Wright and Kirby (2003). First, in regards to the counter-effect norepinephrine would have on the dilation experienced via the release of epinephrine, Blascovich and colleagues (2003) stated that while SAM activation does lead to the release of both catecholamines, typically, epinephrine circulation tends to inhibit norepinephrine circulation (Brownley et al., 2000). Second, regarding the issue surrounding blood pressure. Initially, Blascovich and colleagues (2003) acknowledged that early suggestions stating that there is little or no change in blood pressure during a challenge state may be a little too general and represent the exception rather than the rule. In addition, Blascovich and colleagues (2003) stand by the fact that blood pressure cannot be considered a definitive indicator of the hemodynamic patterns that underpin challenge and threat states (Blascovich, Mendes, Tomaka, Salomon, Seery, 2003). Finally, the issue concerning the lack of difference in HR between those experiencing a challenge state compared to those experiencing a threat state receives somewhat less attention. However, it is important to note that in spite of the comments made by Wright and Kirby (2003), the aforementioned have little to no empirical evidence to reinforce their counter-claims against the theories of the BPSM. Despite these criticisms, research has used the cardiovascular markers identified by the BPSM to examine the effects of challenge and threat states on the performance of stressful tasks.

Performance outcomes. According to the BPSM, a challenge state is more desirable for performance than a threat state, and research has offered support for this assertion (Blascovich 2008a). For instance, Tomaka and colleagues (1993) provided early evidence, demonstrating that a challenge group, determined via a median split of self-reported demand and resource evaluations, reported higher perceived performance, and completed more successful subtractions during a mental arithmetic task, than a threat group (Tomaka et al., 1993). Since this initial evidence, a large body of evidence has emerged revealing that challenge and threat states have distinct effects on task performance in both cognitive and motor tasks (Tomaka et al., 1993; Schneider, 2004;

O'Connor, Arnold, & Maurizio, 2010; Moore, Wilson, Vine, Coussens, & Freeman, 2013; Turner, Jones, Sheffield, Slater, Barker, & Bell, 2013).

Typically, research has either employed subjective (i.e., self-report), or objective (i.e., cardiovascular responses), measures of challenge and threat states, generally supporting the notion that a challenge state is more optimal for performance than a threat state. In particular, a number of studies have reported a positive relationship between challenge evaluations and task performance, and a negative relationship between threat evaluations and task performance (e.g., Drach-Zahavy & Erez, 2002; Feinberg & Aiello, 2010; Vine, Uiga, Lavric, Moore, Tsaneva-Atanasova, & Wilson, 2015). For example, Roberts and colleagues (2016) asked a group of trainee anaesthetists to report demand and resource evaluations before completing five test stations (i.e., structured interview, portfolio review, presentation, mannequin-based simulation, and telephone communication task; Roberts, Gale, McGrath, & Wilson, 2016). The results revealed that anaesthetists who evaluated the stressful test stations as a challenge (i.e., perceived resources match or outweigh task demands), performed significantly better on the test stations in comparison to those who evaluated the test stations as a threat (Roberts et al., 2016). In addition, Moore and colleagues (2013) asked 199 experienced golfers to self-report demand and resource evaluations just before commencing an important golf competition (Moore et al., 2013). The results revealed that golfers who evaluated the golf competition as a challenge (i.e., sufficient resources to cope with the demands of the competition), performed better (i.e., shooting lower scores) than golfers who reported evaluating the competition as a threat (i.e., insufficient resources to cope with the demands of the competition; Moore et al., 2013).

Research that has focused on cardiovascular indices has also supported the idea that a challenge state is more optimal for task performance compared to a threat state (e.g., Chalabaev, Major, Cury, Sarrazin, 2009; Scholl, Moeller, Scheepers, Nuckr, & Sassenberg, 2015). For example, Blascovich and colleagues (2004) conducted a study using baseball and softball players who were asked to deliver sport-irrelevant (i.e., about friendship) and sport-relevant (i.e., about an upcoming critical game) speeches, several months before the start of the competitive season (Blascovich, Seery, Mugridge, Norris, & Weisbuch, 2004). Cardiovascular measures were obtained throughout both speech tasks and used to predict performance four to six months later once the competitive season had finished. The results revealed that athletes who displayed a cardiovascular response more typical of a challenge state (i.e., increased HR and CO, and decreased TPR) during the sport-relevant speech performed better during the competitive season (i.e., creating more runs), than athletes who exhibited a cardiovascular pattern more typical of a threat state (i.e., increased HR, little change or decreased CO, and little change or increased TPR; Blascovich et al., 2004). In a follow-up study, Seery and colleagues (2010) asked participants to complete two speeches before the academic year had begun, and recorded cardiovascular reactivity during the speeches and academic performance throughout the year (Seery, Weisbuch, Hetenyi, & Blascovich, 2010). The results revealed that students who displayed a cardiovascular response more representative of a challenge state (i.e., increased HR and CO, and decreased TPR) during the academic speech, performed better during the school year (i.e., achieving better grades and a higher points total) compared to students who displayed a cardiovascular response more typical of threat state (i.e., increased HR, little change or decreased CO, and little change or increased TPR; Seery et al., 2010).

Like the aforementioned studies, Turner and colleagues (2012, 2013) also set out to extend previous correlational research and study the effects of the cardiovascular measures of challenge and threat states on task performance (i.e., Turner, Jones, Sheffield, & Cross, 2012; Turner et al., 2013). For example, in two studies, Turner and colleagues (2012) tested whether cardiovascular indices of challenge and threat states were related to improvements or deteriorations in performance during cognitive (i.e., Stroop) and athletic (i.e., netball) tasks. The results revealed that a cardiovascular response more typical of a challenge state (i.e., increased HR and CO, and decreased TPR) predicted superior performance in both the cognitive and athletic tasks when compared to a cardiovascular response more typical of a threat state (i.e., increased HR, little change or decreased CO, and little change or increased TPR; Turner et al., 2012). In a follow-up study, Turner and colleagues (2013) conducted a project with elite cricketers to see whether cardiovascular markers of challenge and threat states predicted performance on a pressurised batting task. Once again, the results showed that a cardiovascular response more representative of a challenge state (i.e., increased HR and CO, and decreased TPR) was linked to superior performance (i.e., more runs) compared to a cardiovascular response more indicative of a threat state (i.e., increased HR, little change or decreased CO, and little change or increased TPR; Turner et al., 2013).

Research in this area has also moved away from correlational designs, instead using experimental methods to develop a more causal understanding of the relationship between challenge and threat states and task performance (e.g., Gildea, Schneider, Schebilske, 2007; O'Connor et al., 2010; Turner, Jones, Sheffield, Barker, & Coffee, 2014). For instance, Moore and colleagues (2012) conducted a study using novice golfers who were asked to complete a series of six golf putts after being issued manipulation instructions designed to encourage them into either a state of challenge or threat (Moore, Vine, Wilson, & Freeman, 2012). The results revealed that participants who received the challenge manipulation instructions reported evaluating the pressurised golf-putting task as more of a challenge (i.e., personal coping resources match or outweigh task demands), and displayed a cardiovascular response more typical of challenge state (i.e., increased HR and CO, and decreased TPR), and ultimately, performed better on the task (i.e., lower mean radial error) in comparison to those participants who received the threat manipulation instructions (Moore et al., 2012). In a subsequent study, Moore and colleagues (2013) manipulated experienced golfers into either a challenge or threat state immediately before a pressurised golf putting task (Moore et al., 2013). After successfully manipulating the golfers into challenge and threat states, the results revealed that the golfers in the challenge group outperformed the golfers in the threat group, holing a higher percentage of putts and also leaving the ball nearer to the hole on misses (Moore et al., 2013).

The aforementioned studies provide support for the notion that challenge and threat states impact task performance differently (Blascovich, 2008a). However, to date, comparatively few studies have investigated the underlying mechanisms that explain precisely why a challenge state benefits performance more than a threat state. One theory, the integrated framework of stress, attention, and visuomotor performance (Vine et al., 2016), offers one potential explanation, describing how challenge and threat states influence task performance via their divergent effects on attentional control.

Challenge and Threat States and Attentional Control

An individual experiencing a challenge state is proposed to have more effective attentional control in comparison to an individual experiencing a threat state (Jones, Meijen, McCarthy, & Sheffield, 2009). Specifically, in a challenge state, the focus of attention is thought to be on task relevant cues, whereas in a threat state, attention is predicted to be directed towards task irrelevant and/or potentially threatening cues (Moran, Byrne, & McGlade, 2002; Jones et al., 2009). One contemporary theory that attempts to understand the effect of acute stress on visually guided performance is the integrated framework of stress, attention, and visuomotor performance (Vine et al., 2016; see figure 2 for an overview). The aforementioned framework incorporates elements of the BPSM within it. More specifically, the framework suggests that motivated performance situations are initially appraised via demand and resource evaluations, and followed by distinct cardiovascular patterns (as Blascovich, 2008a; Vine et al., 2016).

From here, the psychophysiological responses experienced during challenge and threat states are followed by a particular pattern of attentional control. More precisely, the framework suggests that an individual in a challenge state will experience a perfect balance between goal-directed and stimulus-driven attentional systems, whereas, an individual in a threat state will experience heightened activity of the stimulus-driven attentional system (Vine et al., 2016). Anatomically, the goal-directed control system is centred within the dorsal posterior parietal and frontal cortex, and is concerned with selecting goal-directed stimuli and action responses (Corbetta & Shulman, 2002). In comparison, the stimulus-driven control system is situated within the temporoparietal cortex and inferior frontal cortex, the majority of which is located within the right hemisphere of the brain (Corbetta & Shulman, 2002). This stimulus-driven system acts as a circuit breaker for the dorsal system, and is concerned with greater vigilance to negative and potentially threatening stimuli (Vine et al., 2016). Typically, both systems work harmoniously to optimise attention and information pick-up, but over activity of the stimulus-driven system leads to a loss of relevant information, possible disrupting the performance of visuomotor tasks (Corbetta & Shulman, 2002).

During a threat state, increases in the stimulus-driven system is expected to lead to increased focus on negative or potentially threatening stimuli at the expense of the most vital cues (i.e., heightened distractibility; Vine et al., 2016). Therefore, an individual experiencing a threat state will not pick up all the relevant information to successfully perform the visuomotor task. Alternatively, as a result of the dominant goal-directed system, a challenge state is predicted to allow the individual to effectively control attention, and focus on the areas of greatest interest and most relevant for the optimal performance of the task at hand (Vine et al., 2016). Indeed, research offers support for this assumption of the framework. For example, Frings and colleagues (2014) had participants complete a visual search task in which they had to locate a target in one of two areas (Frings, Rycroft, Allen, & Fenn, 2014). One area was related to gaining points, and the other area was related to avoiding the loss of points. Halfway through the task, participants received either challenge or threat manipulation instructions in the form of false feedback regarding performance. The results revealed that an individual manipulated into a challenge state spent a greater amount of time fixating on the area associated with gaining points, compared to those manipulated into a threat state, who spent a greater amount of time fixating on the area associated with avoiding the loss of points (i.e., the negative or threatening area of the display; Frings et al., 2014). This study is one of few that has tested the frameworks prediction that threat state leads to increased focus on negative and/or potentially threatening stimuli (Vine et al., 2016).

Indeed, while research provides support for this prediction of the integrated framework, opposing research suggests that focusing on stimuli labelled 'threatening' by the integrated framework may in fact be commonly used in pressurised situations. More specifically, research examining soccer penalty kicks has purported that utilising a 'keeper-dependent' (KD) strategy is often preferred by athletes (Kuhn, 1988). Moreover, Kuhn (1988) noted that 70% of all soccer penalty shots utilise the KD strategy. This is surprising given that the goalkeeper has been reported as the main source of threat in goal achievement during soccer penalty kicks and may well be perceived as a 'threat' (Wilson, Wood, & Vine, 2009). Moreover, Wood and Wilson (2010) found that soccer players that used a KD strategy performed less accurate penalty kicks in comparison to soccer players that utilised a 'target-focused' approach. In addition, and contrary to the application of the KD strategy, more recent research has suggested that penalty takers should select a desired target location prior to initiating the run-up and disregard the actions of the goal-keeper (van der Kamp, 2011). More specifically, van der Kamp (2011) reported that a successful penalty kick was more likely when the athlete was able to fixate the target location prior to the kick, and not have to make late directional adjustments in relation to goal-keeper movement.

Various studies have been conducted using eye-tracking technology to assess the relationships between challenge and threat states, attentional control, and performance (e.g., Moore et al., 2012; Vine, Freeman, Moore, Chandra-Ramanan, & Wilson, 2013). For example, Vine and colleagues (2013) asked a cohort of fifty-two novice medics to perform a stressful laparoscopic surgery task while self-reported measures of challenge and threat states (i.e., demand and resource evaluations), gaze behaviour, and performance were recorded. The results revealed that, as well as performing better on the task (i.e., completing the task quicker and with fewer errors), medics who reported experiencing more of a challenge state (i.e., coping resources match or outweigh task demands) experienced greater goal-directed attentional control, indicated by focusing on the ball and target locations rather than fixating regularly between the laparoscopic tool and target (i.e., a higher target locking score; Vine et al., 2013). In another study, Vine and colleagues (2015) used a cohort of sixteen pilots who performed a highly stressful flight simulation task (i.e., engine failure on take-off), while self-reported measures of challenge and threat states (i.e., demand and resource evaluations), gaze behaviour, and task performance were recorded. The results revealed that pilots who reported experiencing more of a threat state (i.e., insufficient resources to cope with task demands), performed poorer on the simulation according to both subjective (i.e., instructor's evaluation) and objective (i.e., deviations in heading and speed provided by the flight simulator) measures. In addition, pilots experiencing more of a threat state displayed more disrupted attentional control including more fixations of a shorter duration around the cockpit (i.e., higher search rate), more randomness of visual scanning (i.e., greater entropy), and greater attention to task-irrelevant regions of the display or stimulus-driven attention (e.g., areas outside of the cockpit window; Vine et al., 2015). These studies support the integrated frameworks prediction that the goal-directed attentional system is dominant, or equivalent to the stimulus-driven attentional system, during a challenge state, but that the stimulus-driven attentional system is more dominant during a threat state (Vine et al., 2016).

Research notes that effective attentional control can be characterised by longer quiet eye durations (Vine, Moore, & Wilson, 2014). The quiet eye is a key factor within attentional research that is defined as the final fixation toward a relevant target before the initiation of a critical movement (Vickers, 2007). Indeed, expert athletes tend to display longer quiet eye durations than novices, and longer quiet eye durations tend to accompany successful attempts compared to unsuccessful attempts (Lebeau, Liu, Saenz-Moncaleano, Sanduvete-Chaves, Chacon-Moscoso, Becker, & Tenenbaum, 2016). Longer quiet eye durations are thought to benefit performance by lengthening the critical period of information processing, in which the movement is selected, fine-tuned, and programmed (Vine et al., 2014). Importantly, research has shown that a challenge state is linked with longer quiet eye durations (indicative of superior goal-directed attentional control), while a threat state is linked to shorter quiet eye durations (indicative of an increased influence of the stimulus-driven attentional system; Moore et al., 2012). For example, Moore and colleagues (2013) used quiet eye duration as their sole measure of gaze behaviour during a golf-putting task. The results revealed that experienced golfers who were manipulated into a challenge state (i.e., coping resources match or outweigh task demands; increased HR and CO, and decreased TPR) displayed significantly longer quiet eye durations than golfers manipulated into a threat state (Moore et al., 2013). These findings support the prediction that a challenge state is associated with superior goal-directed attentional control (Vine et al., 2016).

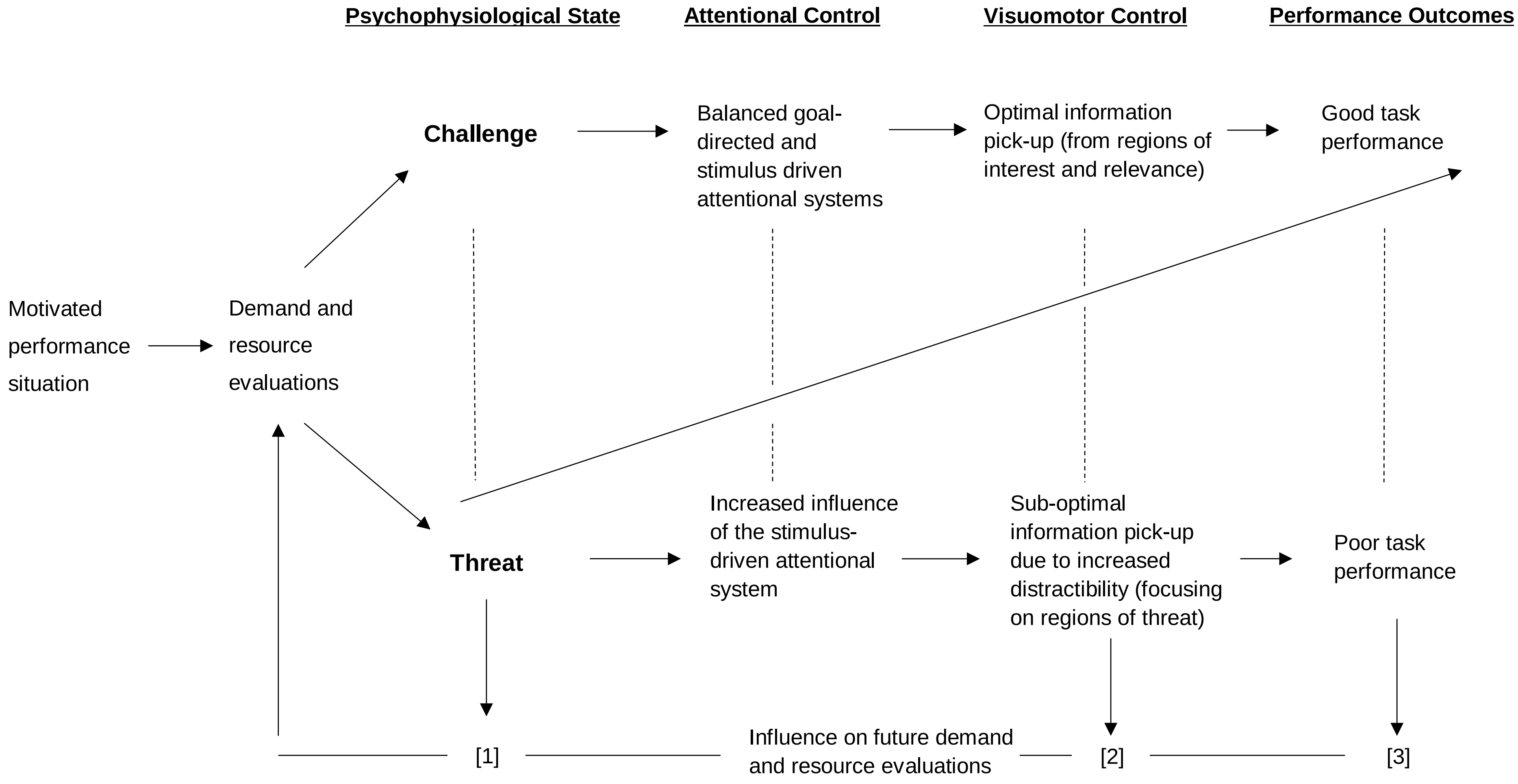
The final predictions of the integrated framework are concerned with three feedback loops, which emphasise that an individual's response to stress may be self-perpetuating (Vine et al., 2016). The first feedback loop proposes that the cardiovascular response displayed after an individual evaluates a situation as a threat (i.e., increased HR, little change or decreased CO, and little change or increased TPR), increases the likelihood of future tasks being evaluated as a threat. Moreover, the heightened arousal and anxiety becomes an extra processing demand for the individual to evaluate making subsequent threat evaluations more likely (Vine et al., 2016). The second feedback loop suggests that following a threat state (i.e., insufficient resources to cope with task demands combined with increased HR, little change or decreased CO, and little change or increased TPR), an individual focuses excessively on negative or threatening stimuli owing to an over activation of the stimulus-driven attentional system, which, in turn, increases the likelihood of adopting a threat state in subsequent tasks. Indeed, the anxiety felt by an individual in a threat state is likely to lead to a focus on sources of threat and a tendency to pessimistically assess the situation (Vine et al., 2016).

Finally, the third feedback loop predicts that poor task performance is likely to lead to future tasks of a comparable nature being evaluated as more of a threat. Likewise, good task performance is expected to lead to an individual evaluating similar tasks in the future as a challenge (Vine et al., 2016). Moreover, it is purported that successful task performance is perceived as a resource in future evaluations, whereas poorer task performance is perceived as an additional demand during future evaluations (Vine et al., 2016). While interesting, these feedback loops have received sparse attention within the literature. Indeed, to date, only Quigley and colleagues (2002) have provided evidence for the third feedback loop, showing that task performance and cardiovascular reactivity during a mental arithmetic task significantly predicted post-task appraisals of subsequent tasks, with good task performance and a cardiovascular response more indicative of a challenge state (i.e., increased HR and CO, and decreased TPR), associated with evaluating the future task as more of a challenge (i.e., coping resources match or outweigh task demands). Alternatively, poor task performance and a cardiovascular response more representative of a threat state (i.e., increased HR, little change or decreased CO, and little change or increased TPR), was associated with evaluating the future task as more of a threat (i.e., insufficient resources to cope with task demands; Quigley, Feldman-Barrett, & Weinstein, 2002). In addition to showing that challenge and threat states have distinct effects on attentional control, Moore and colleagues (2012) showed that these states also influence behaviour and movement, with the challenge group displaying more optimal movements during the golf putting task (i.e., less acceleration of the clubhead) than the threat group (Moore et al., 2012). However, the impact of challenge and threat states on behaviour has received little attention in the literature to date.

Challenge and Threat States and Nonverbal Behaviour

Within the BPSM, Blascovich and colleagues (2008b) link a challenge state to approach motivation or energisation of behaviour directed to desirable situations, and a threat state to avoidance motivation or energisation of behaviour directed away from undesirable situations (Blascovich, 2008b; Elliot & Thrash, 2002). More specifically, it is predicted that during a threat state the body adopts an avoidance or protective stance, often symbolised by closed body posture and orientation away from negative or threatening stimuli (Jones et al., 2009). Despite these predictions, to date, limited research has examined the effects of challenge and threat states on body language and nonverbal behaviour (NVB; Mendes, Blascovich, Hunter, Lickel, & Jost, 2007; O'Connor et al., 2010; Weisbuch, Seery, Ambady, & Blascovich, 2009).

Figure 2 The integrated framework of stress, attention, and visuomotor performance (Vine et al., 2016).



First, Mendes and colleagues (2007) conducted a study in which participants had interactions with confederates who either violated or confirmed participant expectations in terms of the accent they spoke with. The results revealed that when a participant interacted with a confederate who violated expectations, a threat state was recorded. In addition, these participants displayed greater freezing (i.e., less feet, hand, and head movement), more avoidance posture, and less positive behaviour (i.e., giggling, smiling, and positive affirmations) in the interaction compared to those who interacted with a confederate who met expectations (which prompted a challenge state; Mendes et al., 2007).

Expanding on this study, Weisbuch and colleagues (2009) suggested that the distinct physiological patterns marking challenge and threat states would be accompanied by psychologically meaningful differences in NVB (Weisbuch et al., 2009). In this study, ninety undergraduate students engaged in a 'getting to know you' exercise with an unfamiliar experimenter. The authors took cardiovascular measures to assess challenge and threat states, and used facial and vocal confidence as measures of NVB. The results revealed that participants who exhibited a cardiovascular response more typical of a challenge state (i.e., increased HR and CO, and decreased TPR), displayed higher vocal confidence and lower facial confidence when compared to participants who exhibited a cardiovascular response more representative of a threat state (Weisbuch et al., 2009). These findings suggest that participants in a challenge state were more confident (i.e., high vocal confidence), but less concerned with appearing confident to others (i.e., low facial confidence). In contrast, participants in a threat state tried to appear more confident (i.e., high facial confidence), but their voice indicated that they were less confident (i.e., low vocal confidence). In a third study on this topic, O'Connor and colleagues (2010) had would-be negotiators undergo a number of business related negotiations. The results revealed that, in addition to obtaining higher quality deals, negotiators who evaluated the situation as more of a challenge (i.e., coping resources match or outweigh task demands), were reported to appear less passive and more competitive by fellow negotiators (O'Connor et al., 2010). Despite these interesting findings, to date, no research has examined the influence of challenge and threat states on NVB in a sporting context. This is surprising given the abundance of research conducted into NVB in sport (e.g., Greenlees, Bradley, Holder, & Thelwell, 2005; Greenlees, Leyland, Thelwell, & Filby, 2008; Furley, Dicks, & Memmert, 2012a; Furley & Dicks, 2012).

Within sport, matches can often be won or lost before the game has even begun. This is due to the idea that sports performers often form opinions on their opponent's ability based on NVB (e.g., body language, facial expression, eye contact etc.). Early work in this area was conducted by Greenlees and colleagues (2005) who investigated the effect of body language on the perceptions of table tennis players (Greenlees et al., 2005). The results revealed that players who displayed positive NVB (i.e., erect posture, head up, chin level with the ground, and eyes looking at the camera), were perceived as more competent by opposing table tennis players than players who exhibited negative NVB (i.e., slouched posture, head and chin pointed at the ground, and eyes looking down; Greenlees et al., 2005). In a similar study, Greenlees and colleagues (2008) asked soccer goalkeepers to watch video footage of outfield soccer players preparing to take a soccer penalty kick (Greenlees et al., 2008). The results revealed that players who looked directly at the goalkeeper for 90% of the preparation time were perceived as more composed, confident, and assertive, as well as more likely to score, than players who only looked at the goalkeeper for only 10% of the time (Greenlees et al., 2008). Collectively, these studies suggest that NVB, and how we present ourselves to others, can have a significant impact on how others perceive us and our ability.

More recent work has provided further insight into the role of NVB in sport. For instance, Furley and colleagues (2012a) tested the impact of different NVB (i.e., dominant versus submissive) on impression formation and outcome expectancy among soccer goalkeepers, and found that outfield soccer players who displayed dominant NVB (i.e., erect posture, shoulders back, chest out, chin up, and maintained eye-contact with the camera) were perceived by the goalkeepers to be more confident, focused, and relaxed, and were expected to perform better, than players who displayed submissive NVB (i.e., slouched posture, shoulders hanging in front, chin down, and maintained eye-contact at the ground; Furley et al., 2012a). In a follow up study among baseball players, Furley and Dicks (2012) found that submissive NVB was more potent than dominant or neutral NVB, and was associated with a baseball pitcher being perceived as unconfident, unassertive, inexperienced, on edge, unfocused, and tense. Furthermore, in another study, Furley and colleagues (2012b) illustrated how the speed of NVB and eye contact influenced the perceptions of soccer goalkeepers, with outfield soccer players who displayed hastening (i.e., short preparation speed) and hiding (i.e., low frequency of gaze in the direction of the goal and/or goalkeeper) NVB, perceived as unassertive, inexperienced, unconfident, unfocused, and tense by the soccer goalkeepers (Furley, Dicks, Stendtke, & Memmert, 2012b). Finally, in a series of studies, Furley and Schweizer (2014, 2016) showed that NVB had a significant effect on an athlete's ability to determine whether a side was leading or trailing. The results indicated that basketball players who displayed NVB representative of a 'trailing' side (i.e., slouched posture, shoulders hanging in front, chin down, and maintained eye-contact at the ground), were perceived as easier to defeat and lower in confidence compared to basketball players who displayed NVB typical of a 'leading' side (i.e., erect posture, shoulders back, chest out, chin up, and maintained eye-contact with the camera; Furley & Schweizer, 2014; Furley & Schweizer, 2016).

Research on NVB in sport supports the idea that NVB displayed prior to the execution of a task can give an opponent vital information about an individual in terms of their confidence, skill-level, anxiety, and focus. More specifically, displaying positive or dominant NVB (i.e., erect posture, head up, chin level with the ground, and eyes looking at the camera) corresponds with perceptions of being confident, highly skilled, less tense, and more focused, while negative or submissive NVB (i.e., slouched posture, head and chin pointed at the ground, and eyes looking down) is linked with appearing less confident, less skilled, more tense, and less focused (Furley et al., 2012a; Greenlees et al., 2008). Furthermore, individuals are more confident of beating opponents who display submissive NVB, and so such displays should be avoided, particularly given the positive relationship between self-confidence and sports performance (Woodman & Hardy, 2003). Despite this interesting research, to date, no research has examined the factors that cause individuals to display dominant or submissive NVB in sport, despite the suggestion from the social psychology literature that challenge and threat states might have an impact on NVB in stressful scenarios. This is surprising given that the possible link between challenge and threat states and NVB could offer a potential new method for identifying individuals who are experiencing these states in a highly pressurised situation. This is important given the issues associated with using self-report (e.g., social desirability bias) and objective (e.g., limited portability of equipment) measures to assess challenge and threat states in applied settings.

The Present Thesis

Given the limited research conducted to date, the first aim of this thesis was to offer an empirical test of the integrated framework of stress, attention and visuomotor performance (Vine et al., 2016). Specifically, this thesis investigated the influence of challenge and threat states on task performance and attentional control during a pressurised soccer penalty task (see hypothesis 1). In addition, the present thesis was the first to test the integrated framework's prediction regarding the three feedback loops. More specifically, the present thesis assessed whether cardiovascular responses, attentional control, and prior performance in the pressurised soccer penalty task influenced challenge and threat states in a subsequent trial of the pressurised soccer penalty task (see hypothesis 2). The second aim of this thesis was to explore the effects of challenge and threat states on NVB, in order to extend previous research and develop a new measure of these states that might be more appropriate for applied settings (see hypothesis 3).

Overview of Hypothesis

1) It was hypothesised that participants who evaluated the pressurised task as more of a challenge (i.e., coping resources match or outweigh task demands), and displayed a cardiovascular response more typical of a challenge state (i.e., increased HR, increased CO, and decreased TPR), would perform the task more accurately and exhibit more optimal attentional control (i.e., a later first fixation on the goalkeeper, a lower percentage viewing time directed towards the goalkeeper,

a greater percentage viewing time directed towards the goal, and longer quiet eye durations) under pressure.

2) It was hypothesised that a cardiovascular response more typical of a challenge state (i.e., increased HR, increased CO, and decreased TPR), a shorter percentage viewing time on the goalkeeper (i.e., threatening stimuli), and better task performance in trial one would lead to more of a challenge evaluation (i.e., coping resources match or outweigh task demands), and a cardiovascular response more typical of a challenge state (i.e., increased HR, increased CO, and decreased TPR), before trial two.
3) It was hypothesised that an individual who evaluated the task as more of a challenge (i.e., coping resources match or outweigh task demands), and displayed a cardiovascular response more typical of a challenge state (i.e., increased HR, increased CO, and decreased TPR), would be perceived as more dominant, confident, composed, focused, and competent via the NVB they displayed before the pressurised soccer penalty task.

Methods

Design

Due to its scientific nature, the present thesis adopted a positivist philosophical approach. In light of this, the present thesis implemented a realist ontological position and opted to use quantitative methodology to collect data. Specifically, the present thesis employed psychophysiological recording methods and used a correlation or predictive within-subjects experimental design.

Participants

The study consisted of 42 participants (35 males and 7 females) with a mean age of 23.5 years (*SD* = 6.62), mean height of 178.49 cm (*SD* = 7.71), and mean mass of 78.41 kg (*SD* = 12.87). All participants were recruited from within the University of Gloucestershire. Participants were required to have soccer experience of at least two years to be included in the study (mean experience = 12.42 years, *SD* = 6.53). In addition, participants played an average of 31.26 (*SD* = 22.25) games of soccer per season, and took an average of 3.14 (*SD* = 4.01) penalties per season. All participants were abstinent from alcohol 48-hours prior to completion of the study. In addition, participants refrained from vigorous activity 24-hours prior to the study, and were free from any known injury or illness. Before data collection began, institutional ethics approval was obtained and participants gave written and informed consent. Specifically, participants were made aware of their right to withdraw from the study without giving a reason, and that their data would be stored both anonymously and securely.

Task Setup

A standard-sized indoor soccer ball (20.57 cm diameter) was kicked toward a soccer goal which measured 3.6 m x 1.2 m, and complied with indoor soccer goal regulations (JP Lennard, Ltd., Warwickshire, U.K.). Similar to previous research (e.g., Wilson et al., 2009), the goal was split into twelve 30 cm vertical zones to allow for a measure of penalty accuracy to be determined (see task performance subsection below). Penalties were taken 5 m back from the centre of the goal, in accordance with standard indoor soccer rules (as Wilson et al., 2009). To accurately observe NVB, participants were told to walk up, place the ball on the spot, and walk back to a predefined mark (as Furley et al., 2012a). However, Furley et al. (2012a) used a full-sized soccer goal with a 2.5 m gap between the penalty spot and predefined mark. This was adapted to a 1.5 m gap in the present thesis due to the use of an indoor soccer goal, therefore, creating a more accurate representation of an indoor penalty run-up.

Throughout testing, the same goalkeeper was used and instructed to stand in the centre of the goal with bent knees and arms to the side (as Furley et al., 2012a). The positioning and posture of the goalkeeper was standardised as these variables have been shown to influence penalty-taking performance and visual attentional control (van der Kamp & Masters, 2008; Wood, Vine, Parr, & Wilson, 2017). The goalkeeper's movements were kept to a minimum to ensure that participants did not attempt to anticipate goalkeeper movement, but instead selected their own goal-directed targets (as Furley et al., 2012a). That said, to elevate the pressure of the task, and ensure adequate task engagement, participants were falsely instructed that the goalkeeper would attempt to save each penalty kick. Participants completed two trials of this pressurised soccer penalty task, however, the participants were unaware that they would be performing a second trial during the first trial.

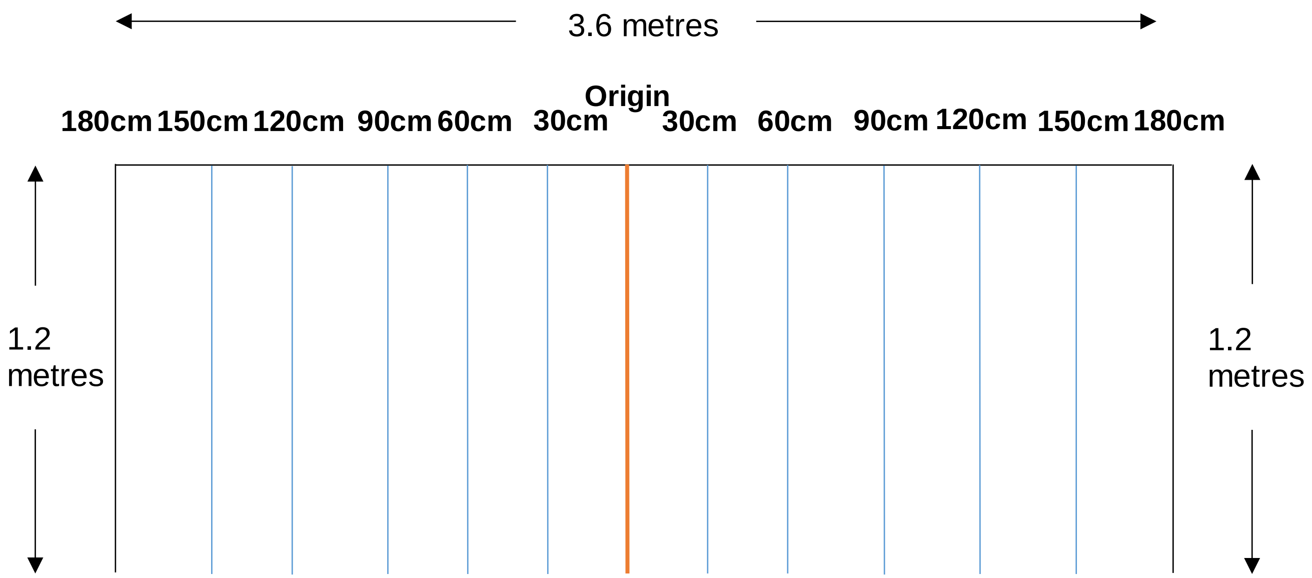
Measures

Demand and resource evaluations. Before each trial of the soccer penalty task, two self-report items from the cognitive appraisal ratio were used to assess evaluations of task demands and personal coping resources (Tomaka et al., 1993). Demand evaluations were assessed by asking 'How demanding do you expect the upcoming soccer penalty task to be?', while resource evaluations were assessed by asking 'How able are you to cope with the demands of the upcoming soccer penalty task?' Both questions were rated on a 6-point Likert scale (1 - *not at all* to 6 - *extremely*). A demand resource evaluation score was calculated by deducting evaluated task demands from evaluated personal coping resources (range: -5 to +5), with a positive score more representative of a challenge state (i.e., coping resources match or outweigh task demands), and a negative score more representative of a threat state (i.e., task demands outweigh coping resources). Previous research has used this measure to assess challenge and threat states (e.g., Vine et al., 2015; Moore, Young, Freeman, & Sarkar, 2017).

Cardiovascular measures. A non-invasive impedance cardiograph device (Physioflow Enduro, Manatec Biomedical, Paris, France) was used to estimate HR, CO, and TPR. The theoretical basis for this device and its validity during rest and exercise testing has been published previously (e.g., Charloux et al., 2000). The Physioflow measures impedance changes in response to a high frequency (75 kHz) and low-amperage (1.8 mA) electrical current emitted via electrodes. Following preparation of the skin, six spot electrodes (Physioflow PF-50, Manatec Biomedical, Paris, France) were positioned onto the participant: two on the supraclavicular fossa of the left aspect of the neck, two on the chest (ECG1 and ECG2), one on the central aspect of the xiphisternum, and one on the rib closest to V6. After entering participant demographic details (i.e., height, weight, etc.), the Physioflow was calibrated over 30 heart cycles while participants sat still and quietly in an upright position. Two resting systolic and diastolic blood pressure readings were taken (one prior to the 30 heart cycles and one immediately after) using an automatic blood pressure reader (Omron M4 Digital BP Meter, Cranlea & Co., Birmingham, UK). To complete the calibration process, mean blood pressure values were entered into the Physioflow. HR, CO, and TPR were estimated throughout a baseline time period (5 minutes) and after the pressure manipulation instructions were delivered (1 minute). Participants remained quiet and still throughout both of these time periods. Reactivity, or the difference between the final minute of baseline and the minute after the pressure manipulation instructions, was examined for all cardiovascular variables before each trial of the pressurised soccer penalty task. Indeed, these particular measures, and this particular cardiographic device, have been used successfully within previous research in this area (e.g., Moore et al., 2013).

An increase in HR is acknowledged as a cardiovascular marker of task engagement, while CO and TPR are considered cardiovascular indicators of challenge and threat states, with higher CO and lower TPR reactivity more representative of a challenge state (Seery, 2011). The Physioflow directly estimated CO, however, TPR was calculated using the formula [mean arterial pressure x 80 / cardiac output] (Sherwood et al., 1990). Mean arterial pressure was calculated using the formula [(2 x diastolic blood pressure) + systolic blood pressure / 3] (Cywinski, 1980). Unfortunately, due to technical issues, cardiovascular data from one participant could not be recorded before trial one of the pressurised soccer penalty task, and cardiovascular data from six participants could not be recorded before trial two of the task.

Figure 4. A schematic diagram highlighting goal set-up and location of scoring zones.



Task performance. The accuracy of each soccer penalty kick was measured in terms of distance from the centre of the goal (in cm) via frame-by-frame analysis of the gaze footage using quiet eye solutions software (www.quieteyesolutions.com; as Wilson et al., 2009). Each half of the goal consisted of six zones of 30 cm, starting from an "origin" in the centre and moving out to 180 cm at the post (see figure 4 for a schematic diagram depicting the goal set-up used for performance assessment). Higher scores therefore reflected more accurate penalties that were placed further away from the goalkeeper (van der Kamp, 2006). Penalties that either: (1) hit the post (n = 2), (2) hit the crossbar (n = 1), (3) hit the goalkeeper (n = 1), or (4) missed the target completely (n = 7), were given a score of zero.

Attentional control. Gaze behaviour was measured using a SensoMotoric Instruments (SMI; Boston, MA) mobile eye tracking system. By using dark pupil tracking to calculate the point of gaze, this lightweight (76 g) binocular system can record the visual scene at a spatial resolution of 0.1° and a temporal resolution of 30 Hz. Gaze was monitored in real time using a laptop (Lenovo, ThinkPad) installed with iViewETG software. Participants were connected to the laptop by a 3.8 m USB cable, and the laptop was located behind and to the right of the participant to minimise distraction. Before the task, the mobile eye tracking device was calibrated using the four corners of the goal. Gaze data was recorded during the first trial of the pressurised soccer penalty task for subsequent analysis. Unfortunately, due to technical issues with the mobile eye tracking system, data from one participant was not recorded.

Gaze data was analysed frame-by-frame using quiet eye solutions software (www.quieteyesolutions.com). Three gaze measures were assessed for each participant during trial one of the pressurised soccer penalty task. These included: (1) time to first fixation on the goalkeeper, (2) percentage viewing time on the goalkeeper and goal, and (3) quiet eye duration. For a fixation to occur, gaze must have been maintained on a location within 1° of visual angle for at least 120 ms (Vickers, 2007). Time to first fixation on the goalkeeper referred to the amount of time (in ms) that it took each participant to record their first fixation on the goalkeeper. Percentage viewing time referred to the percentage of total viewing time spent fixating on the goalkeeper and goal area (i.e., net, goal posts, crossbar). Finally, quiet eye duration referred to the duration (in ms) of the final aiming fixation before initiating the run-up (as Wood & Wilson, 2011).

Nonverbal behaviour. The NVB of each participant during the first trial of the soccer penalty task was recorded on a tripod mounted digital video camera (GoPro HERO, GoPro, California, United States) at a height of 1.6 m and a distance of 3 m, in line with the left hand goal-post (from the perspective of the goalkeeper; as Furley et al., 2012a). Furthermore, consistent with Furley and colleagues (2012a), videos began with each participant holding the ball in two hands in front of their stomach, and spanned from the initiation of movement to place the ball on the spot, to just before contact was made with the ball. This eliminated the possibility of the NVB raters being able to anticipate the outcome of the penalty kick. Following this, 71 independent raters (55 males, 17 females; 29 British, 43 German; mean age = 25.33, *SD* = 6.98) were asked to watch a short video clip of each participant completing trial one of the pressurised soccer penalty task. The videos had a mean duration of 8.50 s (*SD* = 2.28). Following the thin slice approach adopted in previous research (e.g., Furley & Schweizer, 2013), after every video, the raters assessed the NVB of each participant on five 11-point digital semantic differential scales. The scales included: (1) submissive – dominant, (2) unconfident – confident, (3) on edge – composed, (4) unfocused – focused, and (5) inaccurate – accurate. The first four scales reflected the raters perception of the participant's NVB, with a high rating representative of a positive impression (i.e., dominant, confident, composed, and focused). The fifth scale was concerned with the raters expectancy of the accuracy of the penalty, with a high score indicative of a more accurate penalty.

Procedure

Upon arrival at the laboratory, participants were asked to read an information sheet, provide written informed consent, and provide basic demographic information (e.g., age, soccer experience in years, etc.). Next, participants were fitted with the impedance cardiograph device and mobile eye-tracker, which were then calibrated. Once this was complete, participants were seated and asked to remain quiet and still for a period of 5 minutes while baseline cardiovascular data was obtained. At the end of this 5-minute rest period, participants received instructions about the pressurised soccer penalty task (see pressure manipulation instructions below). Cardiovascular data was then recorded for a further minute while the participant reflected upon these instructions, and thought about the upcoming task. Next, participants completed the two self-report items designed to assess demand and resource evaluations. Participants then completed the task, which consisted of a single pressurised soccer penalty kick. Prior to this, if necessary, the mobile eye-tracker was re-calibrated and the digital video camera was set to record the participant complete the task (allowing for subsequent analysis of NVB). This procedure was then repeated for a second trial on the soccer penalty task. Finally, participants were debriefed about the aims of the thesis and thanked for their participation. See figure 3 for a full schematic diagram of the study protocol.

Pressure Manipulation Instructions

Before each trial on the soccer penalty task, participants received instructions designed to elevate pressure. Importantly, these instructions have been successful in increasing pressure in previous research (e.g., Moore et al., 2017). Specifically, the importance of the task was stressed to participants who were informed that they must perform the most accurate penalty kick they can, and that the goalkeeper would attempt to save their penalty. In addition, participants were told that their performance would be entered into a competition and placed onto a leader board, with the five most accurate participants awarded prizes, and the five least accurate participants interviewed at length about their poor performance. Finally, participants were told that their performance was being recorded on a digital video camera and would be sent for analysis by a soccer penalty expert (see Appendix for complete task instructions). The instructions were similar for the second trial on the soccer penalty task, but participants were informed that their performance on their second penalty kick would be combined with their performance on their first penalty kick to determine the best and worst performers. In reality, only the prizes for the best performing participants existed, and participants were informed of this deception in the debrief they received immediately after completion of the task.

Statistical Analysis

Consistent with previous research (e.g., Moore et al., 2017), in order to distinguish between challenge and threat states, a single challenge/threat index (CTI) was created. TPR and CO reactivity were combined to create the index score by converting reactivity scores into *z*-scores and then summing them. CO was assigned a weight of +1, while TPR was allocated a weight of -1 (i.e., reverse scored), therefore, a higher index value corresponded to a cardiovascular response more reflective of a challenge state (i.e., higher CO and lower TPR reactivity; as Moore et al., 2013). Before final analyses were performed, outlier analyses were conducted, in which data with *z*-scores greater than 2 were excluded (as Moore et al., 2017). This resulted in three values being removed for each of trial one CTI and trial one percentage viewing time on the goalkeeper. In addition, two values were removed for trial one quiet eye duration, trial one percentage viewing time on the goal area, and the inaccurate – accurate NVB scale. Finally, one value was removed for both trial two CTI and the unfocused – focused NVB scale. Following these analyses, all data were normally distributed (i.e., skewness and kurtosis did not exceed 1.96).

Descriptive statistics and bivariate correlations were first calculated (see Tables 1, 2, and 3). Next, in order to assess task engagement, a prerequisite of challenge and threat states (Seery, 2011), a dependent *t*-test was conducted on the heart rate reactivity data from each trial of the pressurised soccer penalty task. This was intended to establish if, as a whole, the sample experienced a significant increase in heart rate from baseline in each trial (i.e., if heart rate reactivity was significantly different from zero; as Seery, Weisbuch, & Blascovich, 2009). Next, a series of simple linear regression analyses were conducted to measure the extent to which challenge and threat states, assessed via both demand and resource evaluation score (DRES) and cardiovascular response (i.e., CTI), predicted (1) task performance (i.e., accuracy of penalty kick); (2) attentional control (i.e., time to first fixation on goalkeeper, percentage viewing time on goalkeeper, percentage viewing time on goal, and quiet eye duration); and (3) NVB (i.e., submissive - dominant, unconfident - confident, on edge - composed, unfocused - focused, and inaccurate - accurate), during the first trial of the pressurised soccer penalty task. In addition, further simple linear regression analyses were conducted to determine if trial one cardiovascular response, attentional control (i.e., 1st fixation on goalkeeper and percentage viewing time on the goalkeeper), and task performance, predicted trial two challenge and threat states (i.e., DRES and/or CTI). Beta values of 0.10, 0.30, and 0.50 were interpreted as small, medium, and large effects, respectively (Cohen, 1992). A *p*-value of less than .05 was considered statistically significant (Field, 2013). All statistical analyses were conducted using IBM SPSS statistical program version 22.

Results

Task Engagement

The results showed that heart rate significantly increased from baseline by an average of 9.49 (SD = 4.78) beats per minute in trial one ($t(38) = 15.13$, $p < .001$), and by an average of 8.40 (SD = 3.16) beats per minute in trial two ($t(35) = 15.96$, $p < .001$). These findings confirm task engagement for both trials of the pressurised soccer penalty task, enabling further examination of challenge and threat states via DRES and CTI.

Trial One

Task performance.

The results revealed that both DRES ($R^2 = .11$, $\beta = .36$, $p = .021$, 95% CI [1.61, 18.24]), and CTI ($R^2 = .28$, $\beta = .55$, $p < .001$, 95% CI [10.14, 32.05]), significantly predicted task performance. These findings suggest that participants who evaluated the task as more of a challenge (i.e., coping resources match or outweigh task demands), and displayed a cardiovascular response more representative of a challenge state (i.e., increased HR and CO, and decreased TPR), performed better on the task (i.e., a more accurate soccer penalty kick) in comparison to those who evaluated the task as more of a threat, and exhibited a cardiovascular response more typical of a threat state.

Table 1

Means, standard deviations, and correlations for challenge and threat states and task performance variables.

	Mean	SD	DRES	CTI	Performance
DRES	1.57	2.07		.31	.36*
CTI	-0.34	1.51			.55**
Performance	77.31	57.75			

* Correlation is significant at .05 level (2-tailed). ** Correlation is significant at .01 level (2-tailed).

Attentional control.

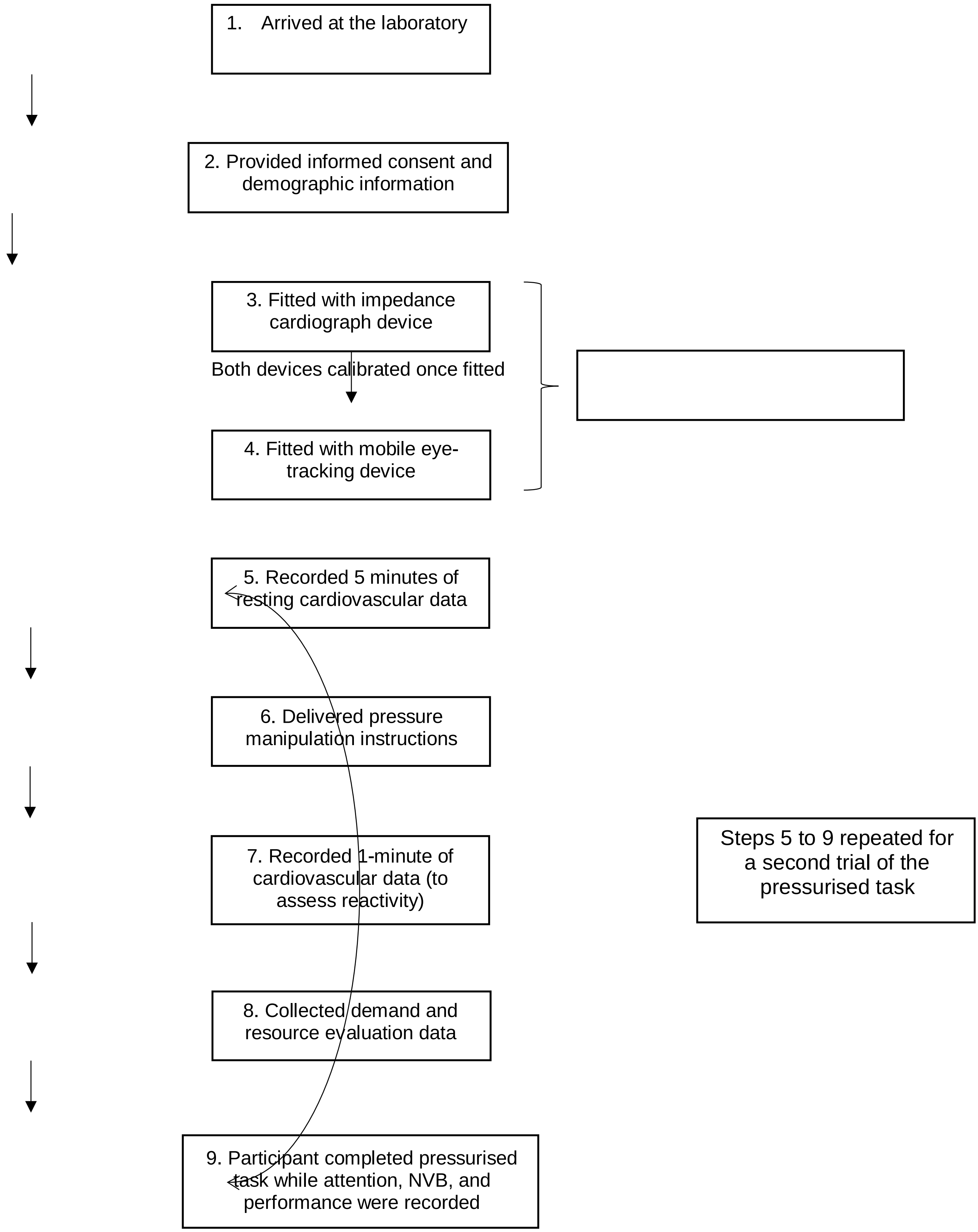
First fixation on goalkeeper. The results revealed that neither DRES (R^2 = -.02, β = .04, *p* = .786, 95% CI [-265.22, 347.98]), nor CTI (R^2 = -.03, β = .04, *p* = .820, 95% CI [-360.80, 452.47]), significantly predicted the time to first fixation on the goalkeeper.

Percentage viewing time on goalkeeper. The results revealed that both DRES (R^2 = .14, β = .41, *p* = .012, 95% CI [0.16, 1.22]), and CTI (R^2 = .09, β = .34, *p* = .044, 95% CI [0.24, 1.58]), significantly predicted the percentage viewing time on the goalkeeper. These findings suggest that participants who evaluated the task as more of a challenge (i.e., coping resources match or outweigh task demands), and responded to the task with a cardiovascular response more representative of a challenge state (i.e., increased HR and CO, and decreased TPR), spent more time fixating on the goalkeeper compared to participants who evaluated the task as more of a threat, and exhibited a cardiovascular response more reflective of a threat state.

Percentage viewing time on goal. The results revealed that neither DRES (R^2 = -.02, β = -.07, *p* = .671, 95% CI [-0.86, 0.56]), nor CTI (R^2 = .08, β = .32, *p* = .059, 95% CI [-0.04, 2.08]), significantly predicted percentage viewing time on the goal. However, while nonsignificant, the result for CTI shows a potentially meaningful descriptive trend. More specifically, the trend suggests that participants who exhibited a cardiovascular response more typical of a challenge state (i.e., increased HR and CO, and decreased TPR), might have spent a greater percentage of time fixating on the goal compared to participants who displayed a cardiovascular response more indicative of a threat state. Indeed, while nonsignificant, the adjusted r-squared value equated to a correlation coefficient reflective of a medium effect size (Cohen, 1992).

Quiet eye duration. The results revealed that neither DRES (R^2 = -.02, β = -.10, *p* = .547, 95% CI [-17.17, 9.25]), nor CTI (R^2 = .07, β = .31, *p* = .066, 95% CI [-1.35, 40.16]) significantly predicted quiet eye duration. However, while nonsignificant, the result for CTI shows a potentially meaningful descriptive trend. More specifically, the trend suggests that participants who displayed a cardiovascular response more indicative of a challenge state (i.e., increased HR and CO, and decreased TPR), may have been more likely to experience longer quiet eye durations than participants who exhibited a cardiovascular response more reflective of a threat state. Indeed, while nonsignificant, the adjusted r-squared value equated to a correlation coefficient reflective of a medium effect size (Cohen,1992).

Figure 3. A schematic diagram representing the study protocol.



Trials One and Two

Cardiovascular response.

The results revealed that CTI before trial one did not significantly predict neither DRES (R^2 = -.01, β = .13, p = .456, 95% CI [-0.29, 0.64]), nor CTI before trial two (R^2 = .08, β = .33, p = .062, 95% CI [-0.02, 0.63]). However, while nonsignificant, the result for trial two CTI revealed a potentially meaningful descriptive trend. More specifically, this trend implied that participants who displayed a cardiovascular response more typical of a challenge state before trial one (i.e., increased HR and CO, and decreased TPR), may have been more likely to display a cardiovascular response more representative of a challenge state before trial two. Indeed, while nonsignificant, the adjusted r-squared value equated to a correlation coefficient reflective of a medium effect size (Cohen, 1992).

Attentional control.

First fixation on goalkeeper. The results revealed that time to first fixate on the goalkeeper in trial one did not significantly predict DRES (R^2 = -.03, β = .01, p = .936, 95% CI [0.00, 0.00]), or CTI (R^2 = -.01, β = .15, p = .410, 95% CI [0.00, 0.01]), before trial two.

Percentage viewing time on goalkeeper. The results revealed that percentage viewing time on the goalkeeper in trial one did not significantly predict DRES (R^2 = .02, β = .13, p = .446. 95% CI [-0.12, 0.27]), or CTI (R^2 = -.03, β = .07, p = .697, 95% CI [-0.12, 0.18]), before trial two.

Task performance.

The results revealed that task performance on trial one significantly predicted DRES before trial two (R^2 = .14, β = .40, p = .009, 95% CI [0.01, 0.30]), implying that participants who took a more accurate penalty kick in trial one were more likely to evaluate trial two as more of a challenge (i.e., coping resources match or outweigh task demands). However, task performance on trial one did not significantly predict CTI before trial two (R^2 = -.01, β = .15, p = .405, 95% CI [-0.01, 0.01]).

Table 2

Means, standard deviations, and correlations for challenge and threat states and attentional control variables.

	Mean	SD	DRES	CTI	1st Fixation on Goalkeeper	% Viewing Time on Goalkeeper	% Viewing Time on Goal	Quiet Eye Duration
DRES	1.57	2.07		.31	.04	.41*	-.07	-.10
CTI	-0.34	1.51			.04	.34*	.32	.31
1st Fixation on Goalkeeper	5428.29	1987.26				.01	-.17	-.04
% Viewing Time on Goalkeeper	4.94	3.53					.09	.21
% Viewing Time on Goal	7.12	4.55						.30
Quiet Eye Duration	194.87	85.19						

* Correlation is significant at .05 level (2-tailed).
** Correlation is significant at .01 level (2-tailed).

Table 3

Means, standard deviations, and correlations for challenge and threat states and NVB variables.

	Mean	SD	DRES	CTI	Submissive – Dominant	Unconfident – Confident	On Edge – Composed	Unfocused – Focused	Inaccurate – Accurate
DRES	1.57	2.07		.31	.33*	.38*	.44*	.28	.32*
CTI	-0.34	1.51			.18	.14	.28	-.01	.03
Submissive – Dominant	6.71	0.99				.98**	.88**	.84**	.88**
Unconfident – Confident	6.87	1.11					.92**	.88**	.93**
On Edge – Composed	6.73	1.07						.90**	.92**
Unfocused – Focused	7.12	1.00							.94**
Inaccurate – Accurate	6.80	1.02							

* Correlation is significant at .05 level (2-tailed).
** Correlation is significant at .01 level (2-tailed).

Trial One

Nonverbal behaviour.

Submissive – Dominant. The results revealed that DRES significantly predicted submissive - dominant NVB (R^2 = .09, β = .33, p = .031, 95% CI [0.02, 0.31]), suggesting that participants who evaluated the task as more of a challenge (i.e., coping resources match or outweigh task demands) were perceived as relatively more dominant than participants who evaluated the task as more of a threat. However, CTI did not significantly predict submissive - dominant NVB ($R^{2\,=}$ .01, β = .18, p = .292, 95% CI [-0.10, 0.32]).

Unconfident – Confident. The results revealed that DRES significantly predicted unconfident - confident NVB (R^2 = .13, β = .38, p = .012, 95% CI [0.05, 0.36]), implying that participants who judged the task as more of a challenge (i.e., coping resources outweigh task demands) were deemed more confident than participants who judged the task as more of a threat. In contrast, CTI did not significantly predict unconfident - confident NVB (R^2 = -.01, β = .14, p = .399, 95% CI [-0.14, 0.34]).

On Edge – Composed. The results revealed that DRES significantly predicted on edge - composed NVB (R^2 = .17, β = .44, p = .004, 95% CI [0.08, 0.37]), suggesting that participants who evaluated the task as more of a challenge (i.e., coping resources match or outweigh task demands), were thought to appear more composed than participants who evaluated the task as more of a threat. However, CTI did not significantly predict on edge - composed NVB (R^2 = .05, β = .28, p = .085, 95% CI [-0.03, 0.42]). While nonsignificant, the result for CTI revealed a potentially meaningful descriptive trend. More specifically, the trend implied that participants who displayed a cardiovascular response more typical of a challenge state (i.e., increased HR and CO, and decreased TPR), may have been perceived as more composed than participants who displayed a cardiovascular response more typical of a threat state. Indeed, while nonsignificant, the adjusted r-squared value equated to a correlation coefficient reflective of a medium effect size (Cohen, 1992).

Unfocused – Focused. The results revealed that DRES did not significantly predict unfocused - focused NVB (R^2 = .06, β = .28, p = .075, 95% CI [-0.02, 0.29]). While nonsignificant, the result for DRES revealed a potentially meaningful descriptive trend. More specifically, this trend implied that participants who evaluated the task as more of a challenge (i.e., coping resources match or outweigh task demands), may have been perceived to be more focused than participants who evaluated the task as more of a threat. Indeed, while nonsignificant, the adjusted r-squared value equated to a correlation coefficient reflective of a medium effect size (Cohen, 1992). However, CTI did not significantly predict unfocused - focused NVB (R^2 = -.03, β = -.01, *p* = .941, 95% CI [-0.23, 0.21]).

Inaccurate – Accurate. The results revealed that DRES significantly predicted inaccurate - accurate ratings from NVB (R^2 = .08, β = .32, *p* = .045, 95% CI [0.00, 0.33]), suggesting that participants who judged the task as more of a challenge (i.e., coping resources match or outweigh task demands), were deemed more likely to take an accurate penalty than participants who judged the task as more of a threat. However, CTI did not significantly predict inaccurate - accurate ratings from NVB (R^2 = -.03, β = .03, *p* = .843, 95% CI [-0.21, 0.25]).

Discussion

It has been shown that during the performance of a stressful task, evaluating the task as more of a challenge (i.e., coping resources match or outweigh task demands), and displaying a cardiovascular response more representative of a challenge state (i.e., increased HR and CO, and decreased TPR), leads to improved task performance (e.g., Moore et al., 2012; Vine et al., 2015). Furthermore, contemporary theories suggest that challenge and threat states primarily influence performance via their effects on attentional control (e.g., Integrated Framework of Stress, Attention, and Visuomotor Performance; Vine et al., 2016). More specifically, a challenge state is reported to be followed by a balance of two attentional systems (i.e., goal-directed and stimulus-driven), allowing for optimal information pick up from the most pertinent task-relevant cues and therefore, optimal performance. Alternatively, a threat state is said to be followed by over activation of the stimulus-driven attentional system, which disrupts information pick-up from task-relevant cues, and increases distractibility by task-irrelevant and potentially threatening stimuli, resulting in poorer performance (Vine et al., 2016). The results here offer partial support for hypothesis one. More specifically, participants who evaluated the task as more of a challenge (i.e., coping resources match or outweigh task demands), and displayed a cardiovascular response more representative of a challenge state (i.e., increased HR and CO, and decreased TPR), performed better on the pressurised soccer penalty task. Also, the results show promising signs for a number of the integrated frameworks predictions (Vine et al., 2016). Indeed, while nonsignificant, the present thesis shows that a relationship may exist between challenge and threat states, percentage viewing time on the goal, and quiet eye duration. Finally, while the present thesis found that challenge and threat states influenced percentage viewing time on the goalkeeper, this finding was not in the hypothesised direction.

In addition, this framework suggests that during this process three feedback loops are present, with cardiovascular responses, attentional control, and task performance proposed to influence the likelihood of challenge and threat states in response to subsequent tasks of a similar nature (Vine et al., 2016). However, since its publication, to date, no research has examined the predictions of the integrated framework, thus, the present thesis offered the first empirical test, enabling the framework to be developed and refined. The results of the present thesis once again offer only partial support for hypothesis two. More specifically, while nonsignificant, cardiovascular response before trial one shows a potential relationship with the cardiovascular response experienced before trial two. Additionally, task performance in trial one significantly predicted DRES before trial two. Regarding the other predictions made concerning the integrated frameworks feedback loops, the present thesis was not able to offer any support.

Finally, while previous research in social psychology has linked challenge and threat states with distinct NVBs (e.g., Mendes et al., 2007; Weisbuch et al., 2009), to date, no literature has studied this relationship in sport. This is surprising given that research has found NVB to have a significant effect on impression formation in sport (e.g., Furley & Dicks, 2012; Furley & Schweizer, 2016; Greenlees et al., 2008). Thus, the present thesis also assessed whether challenge and threat states could be used as a predictor of NVB, offering a possible new method of identifying whether athletes are experiencing a challenge or threat state in real-world settings. The results here again offer partial support for hypothesis three. A number of NVB variables were successfully predicted by the DRES (i.e., submissive – dominant, unconfident – confident, on edge – composed, and inaccurate – accurate). However, CTI was not a significant predictor of any of the NVB variables.

Challenge and Threat States and Performance

Consistent with the predictions of the BPSM (Blascovich, 2008a), the present thesis revealed that both subjective (i.e., DRES), and objective (i.e., CTI) measures of challenge and threat states successfully predicted performance during the pressurised soccer penalty task, equating to medium and large effect sizes, respectively. More specifically, participants who evaluated the stressful task as more of a challenge (i.e., personal coping resources match or outweigh task demands), and displayed cardiovascular responses more typical of a challenge state (i.e., increased HR and CO, and decreased TPR), performed more accurately during the task, placing their penalty kicks further from the goalkeeper into the corner of the goal in comparison to participants who evaluated the task as more of a threat (i.e., task demands outweigh personal coping resources), and exhibited a cardiovascular response more reflective of a threat state (i.e., increased HR, little change or decreased CO, and little change or increased TPR). These findings support hypotheses, and are consistent with the growing research that suggests a challenge state is necessary for optimal performance under pressure, while a threat state might be suboptimal (e.g., Blascovich et al., 2004; Moore et al., 2013; Turner et al., 2013). For example, Turner and colleagues (2012) found that netball players who exhibited a cardiovascular response more typical of a challenge state, performed more successfully during a netball shooting task compared to those who displayed a cardiovascular response more typical of a threat state (Turner et al., 2012). Despite this research, to date, limited research has explored the mechanisms (e.g., attentional) underlying the beneficial effects of a challenge state (Vine et al., 2016).

Interestingly, while both DRES and CTI were significant predictors of performance under pressure, the two measures were not significantly related (i.e., DRES did not predict CTI nor did CTI predict DRES). This is interesting given that the BPSM suggests that a challenge evaluation is always followed by a challenge cardiovascular response, and a threat evaluation is always followed by a threat cardiovascular response (Blascovich, 2008a). Also, it appears that research in the area typically does not report the relationship between DRES and CTI. More specifically, in a recent systematic review Hase and colleagues (2018) found that, of all the studies that computed DRES and CTI, only three studies reported the relationship between the two measures. Moreover, of these studies two (i.e., Moore et al., 2017; Turner et al., 2013), found no significant relationship between the indices, while one (i.e., Vine et al., 2013), reported a significant relationship during the baseline test, but not the pressurised test. These findings suggest that more work is needed that examines the relationship between DRES and CTI.

Challenge and Threat States and Attentional Control

Congruent with some propositions of the integrated framework of stress, attention, and visuomotor performance (Vine et al., 2016), the present thesis revealed that challenge and threat states may be associated with a number of attentional control variables (e.g., percentage viewing time on goalkeeper, percentage viewing time on goal, and quiet eye duration). Initially, the present thesis suggests that the objective measure of challenge and threat states (i.e., CTI) was marginally related to percentage viewing time on the goal and quiet eye duration. More specifically, cardiovascular responses more typical of a challenge state (i.e., increased HR and CO, and decreased TPR), were marginally associated with a greater percentage of time fixating on the goal and longer quiet eye durations when compared to cardiovascular responses more akin to a threat state (i.e., increased HR, little change or decreased CO, and little change or increased TPR). However, while these results equated to medium effect sizes (Cohen, 1992), they should be interpreted with caution as they were not statistically significant. These nonsignificant trends support previous research has also linked a challenge state to longer quiet eye durations (e.g., Moore et al., 2012; 2013). Taken together, these findings offer partial support for the predictions of the integrated framework in that, a challenge state may correspond to optimal goal-directed attention (Vine et al., 2016), as evidenced by the marginally greater attention paid to task-relevant cues (i.e., the goal), and the marginally longer quiet eye durations. Indeed, longer quiet eye durations have been linked to improved performance by lengthening the critical period of information processing prior to performance (Vine et al., 2014).

Contrary to hypotheses, and the suggestions of the integrated framework (Vine et al., 2016), neither subjective (i.e., DRES) or objective (i.e., CTI) measures of challenge and threat states significantly predicted the time to first fixation on the goalkeeper. The integrated framework suggests that an individual experiencing a threat state will direct gaze towards negative and potentially threatening stimuli (i.e., the goalkeeper) quicker than an individual experiencing a challenge state (Vine et al., 2016). Thus, the present results offer no support for this proposition. However, as predicted, both subjective (i.e., DRES) and objective (i.e., CTI) measures of challenge and threat states significantly predicted the percentage viewing time on the goalkeeper. Interestingly though, this finding was not in the predicted direction. Indeed, evaluating the task as more of a challenge (i.e., coping resources match or outweigh task demands), and displaying a cardiovascular response more typical of a challenge state (i.e., increased HR and CO, and decreased TPR), was associated with a greater amount of time spent fixating the goalkeeper. This result also contrasts the predictions of the integrated framework (Vine et al., 2016), which suggests that a threat state should correspond to increased time spent fixating on negative and potentially threatening cues (i.e., the goalkeeper). However, there are a number of possible explanations for these mixed findings.

First, previous research has found that soccer players commonly use a 'keeper dependent' strategy during soccer penalties, which involves directing gaze to the goalkeeper's movement before deciding the striking direction (Kuhn, 1988; Wood & Wilson, 2010). It is, therefore, typical for soccer players to direct gaze toward the goalkeeper as part of their normal routine. Thus, the longer fixations directed towards the goalkeeper during a challenge state might actually reflect superior goal-directed attentional control, with players in a challenge state able to execute their typical routine and attend to an important task-relevant cue (i.e., the goalkeeper) when preparing to perform the soccer penalty. Second, the gaze pattern associated with a challenge state might reflect balanced goal-directed and stimulus-driven attentional control. Indeed, individuals experiencing a challenge state were able to spend longer fixating on the threatening, but task-relevant, stimuli (i.e., goalkeeper) using the stimulus-driven system, while also spending longer fixating on other task-relevant stimuli (i.e., the goal) using the goal-directed system. Third, prolonged eye contact is considered a way of attempting to appear dominant to an opponent (e.g., Furley et al., 2012a; Greenlees et al., 2005), and could therefore have been used by participants in a challenge state to increase the likelihood of being perceived as confident and competent by the goalkeeper. Finally, participants in a challenge state might have maintained eye contact with the goalkeeper to avoid alerting the goalkeeper to the intended striking direction, a strategy aimed at increasing the likelihood of a successful penalty by giving the goalkeeper less visual information they can utilise to anticipate shot direction (Wood et al., 2017).

Regarding the first of the three feedback loops proposed by the integrated framework (Vine et al., 2016), the present thesis found that the cardiovascular response (i.e., CTI) exhibited before trial one did not significantly predict demand and resource evaluations (i.e., DRES) before trial two. This finding contradicts hypotheses, and the predictions of the integrated framework (Vine et al., 2016), which suggests that an individual who experiences a cardiovascular response more akin to a threat state (i.e., increased HR, little change or decreased CO, and little change or increased TPR), is more likely to evaluate future tasks as a threat (i.e., task demands outweigh coping resources). Additionally, the cardiovascular response (i.e., CTI) displayed before trial one did not significantly predicted the cardiovascular response (i.e., CTI) exhibited before trial two. However, while this result equated to a medium effect size (Cohen, 1992), they should be interpreted with caution as they were not statistically significant. This nonsignificant trend suggests that, participants who reacted to trial one with a cardiovascular response more akin to a threat state may have been more likely to react to trial two with a cardiovascular pattern more consistent with a threat state (i.e., increased HR, little change or decreased CO, and little change or increased TPR). Taken together, the results offer only partial support for this prediction of the integrated framework (Vine et al., 2016), and suggest that further research is warranted. While speculative, the lack of an association between trial one cardiovascular responses and trial two demand and resource evaluations might be due to social desirability bias, with participants wanting to appear more confident than they truly are before the second trial (as indicated by the cardiovascular response). Interestingly, the relationship between trial one and trial two cardiovascular responses suggests that challenge and threat states might be relatively stable over time and across tasks, a notion that has received limited attention to date and needs further examination (Power & Hill, 2010).

In terms of the second of the three feedback loops proposed by the integrated framework (Vine et al., 2016), the present thesis found that neither the time to first fixation on the goalkeeper or the percentage of time spent fixating the goalkeeper in trial one predicted subjective (i.e., DRES) or objective (i.e., CTI) measures of challenge and threat states before trial two. These findings contradict hypotheses and the predictions of the integrated framework (Vine et al., 2016), which suggests that an individual who fixates on negative and potentially threatening stimuli (e.g., the goalkeeper) earlier and for longer is more likely to respond to subsequent tasks with a threat state. However, as noted above, research has highlighted that it is commonplace for soccer players to focus on the goalkeeper when preparing to take soccer penalty kicks (i.e., 'keeper-dependent' strategy; Wood & Wilson, 2010; Wood et al., 2017). Therefore, these unexpected findings may be the result of the goalkeeper being used as a task-relevant cue, rather than being seen as a negative and potentially threatening stimulus. Regardless, it is clear that this particular feedback loop needs further examination in the future.

With regards to the third and final feedback loop proposed by the integrated framework (Vine et al., 2016), the present thesis found that task performance on trial one significantly predicted the subjective measure of challenge and threat states (i.e., DRES) before trial two. More specifically, an individual who achieved a more accurate penalty in trial one, was more likely to evaluate trial two as more of a challenge (i.e., coping resources match or outweigh task demands), compared to an individual who took a less accurate penalty in trial one. This result was congruent with hypotheses and the prediction of the integrated framework (Vine et al., 2016). Moreover, this finding is consistent with the limited research on the reciprocal relationship between challenge and threat states and performance to date, which has showed that good performance led participants to reappraise a mental arithmetic task as more of a challenge (e.g., Quigley et al., 2002). However, contrary to hypotheses, and the predictions of the integrated framework (Vine et al., 2016), task performance on trial one did not significantly predict the objective measure of challenge and threat states (i.e., CTI) before trial two. Previous research has reported that repeated exposure to a task has a dampening effect on cardiovascular responses (Kelsey et al., 1999), therefore, this unexpected result might be attributable to participants performing the same task for a second time, attenuating cardiovascular reactivity, as evidenced by the reduction in HR reactivity between the first and second trials on the soccer penalty task.

Challenge and Threat States and Nonverbal Behaviour

As hypothesised, the subjective measure of challenge and threat states (i.e., DRES) significantly predicted a number of NVB variables. More specifically, individuals who evaluated the pressurised task as more of a challenge (i.e., coping resources match or outweigh task demands), were perceived to be significantly more dominant, confident, composed, and more likely to take an accurate soccer penalty from their NVB in comparison to those who evaluated the task as more of a threat. The aforementioned findings may be used to extend previous research into the role of NVB in sport (e.g., Furley et al., 2012a; Furley & Schweizer, 2016). Indeed, while research notes that an individual displaying positive or dominant NVB (i.e., erect posture, shoulders back, chest out, chin up, and prolonged eye-contact) is more likely to be perceived positively (i.e., more confident, composed, focused, and competent) than an individual displaying negative or submissive NVB (i.e., slouched posture, shoulders hanging in front, chin down, and maintain eye-contact at the ground; Furley & Dicks, 2012; Greenlees et al., 2005), no studies have examined what factors can lead to the display of positive or negative NVB. The present research suggests that evaluating a stressful task as more of a challenge might lead to an individual displaying more dominant NVB, which then leads to them being perceived more positively. In contrast, evaluating a stressful task as more of a threat may be linked to displays of submissive NVB and being perceived more negatively. Indeed, displaying submissive NVB has been linked to increases in opponent confidence (Furley et al., 2012a; Furley & Schweizer, 2014). For example, Furley and colleagues (2012a) found that goalkeepers felt more capable of saving the penalty of an outfield soccer player who displayed submissive NVB (Furley et al., 2012a). However, while a couple of these results equated to medium effect sizes (i.e., on edge – composed, and unfocused – focused; Cohen 1992), they should be interpreted with caution as they were not statistically significant.

The findings of the present thesis could potentially extend existing knowledge regarding the effects of challenge and threat states on NVB (e.g., Mendes et al., 2007; Weisbuch et al., 2009). For example, O'Connor and colleagues (2010) found that would-be negotiators who appraised a stressful negotiation task as more of a threat (i.e., task demands outweigh coping resources) were perceived to be more passive and less likely to resort to tough-tactics (O'Connor et al., 2010). In contrast, would-be negotiators who evaluated the task as more of a challenge (i.e., coping resources match or outweigh task demands) were noted to be more active and competitive during the task. Indeed, the present thesis supports the findings of previous research and highlights that challenge and threat evaluations might impact subsequent displays of NVB. However, unexpectedly, the objective measure of challenge and threat states (i.e., CTI) did not significantly predict any of the NVB variables. Previous research offers a potential explanation. For example, Weisbuch and colleagues (2009) reported that participants who responded to a stressful speech task with a cardiovascular response more reflective of a threat state attempted to mask a lack of ability (i.e., low vocal confidence), by attempting to appear more confident (i.e., high facial confidence; Weisbuch et al., 2009). The NVB findings in the present thesis may offer further support for this notion. For example, the soccer players might have attempted to mask inability or low confidence by indicating to the researcher, via self-report, that they viewed the task as more of a challenge, and might have continued to create this false impression by displaying NVB associated with higher competence and confidence (i.e., chest out, head high, etc.). Thus, while self-report measures and NVB are more susceptible to bias, objective measures (i.e., HR, CO, and TPR) offer a less biased assessment of challenge and threat states. However, it should be noted that both measures were able to accurately predict performance on the soccer penalty task.

Implications

The findings of the present thesis have a number of important implications. From a theoretical perspective, the findings support the BPSM of challenge and threat states (Blascovich, 2008a) as an important model for explaining performance variability under pressure. Additionally, the findings offer some support for the predictions of the integrated framework of stress, attention, and visuomotor performance (Vine et al., 2016). More specifically, the attentional control results suggest that a challenge state might be linked with superior utilisation of the goal-directed attentional system, evidenced by marginally longer quiet eye durations and increased focus on task-relevant stimuli (i.e., the goal and goalkeeper). However, the results did not fully support the predictions of the integrated framework (Vine et al., 2016). Indeed, the findings raise questions as to whether a threat state is linked to increased distractibility by negative or potentially threatening cues, given that challenge and threat states were not associated with the time to first fixate on the goalkeeper, and a challenge state was linked with more time fixating on the goalkeeper than a threat state. Finally, while the present findings offer partial support for the idea that prior performance and cardiovascular responses may influence challenge and threat states before subsequent tasks, attention to negative or threatening cues does not appear to influence future challenge and threat states. Clearly further research is needed to examine the predictions of the integrated framework (Vine et al., 2016).

From an applied perspective, the present thesis supports previous research in that, a challenge state was associated with better sports performance under pressure (e.g., Moore et al., 2013; Turner et al., 2013). This result suggests that athletes should be encouraged to respond to stress with a challenge state, as it is more likely to yield positive outcomes. Previous research has shown that a number of cheap and effective methods exist for promoting a challenge state (e.g., arousal reappraisal, Moore et al., 2015; imagery, Williams & Cumming, 2012). For example, Williams and colleagues (2012) found that participants who were administered a challenge imagery script before a competitive dart-throwing task evaluated the task as more of a challenge (i.e., coping resources match or outweigh task demands), felt more in control, and were more likely to believe they would perform well on the task (Williams & Cumming, 2012). In addition, the findings of the present thesis offer a potential new method of identifying athletes who are experiencing a threat state and who might benefit from intervention. More specifically, using self-report or cardiovascular measures to screen for challenge and threat states in real world situations is problematic owing to issues around the timing of the administration of the self-report items and the portability of the recording equipment. The results of this thesis suggests that individuals experiencing a threat state will likely display NVB characterised by slouched posture, shoulders hanging in front, chin down, and eye contact directed at the ground. Therefore, if a coach or fellow athlete spots an individual displaying this type of NVB, they can act upon this information by either removing them from that particular situation, as they are less likely to perform the task successfully, or intervening with them to foster a challenge state.

Limitations and Future Research

The present thesis is not without its limitations, however, these limitations offer potential avenues for future research. First, certain cardiovascular measures omitted by the present thesis may be considered a limitation. More specifically, the lack of attention paid to particular physiological markers (i.e., blood pressure, stroke volume, catecholamines, and cortisol), by the BPSM is a potential limitation. Indeed, research criticising the BPSM has acknowledged that the model does not offer a comprehensive enough analysis of the cardiovascular markers of challenge and threat states. For example, while TPR and blood pressure are considered by some to be synonymous (i.e., Wright & Kirby, 2003), the BPSM does not discuss blood pressure as an impactful variable. Future research should consider other cardiovascular measures (i.e., blood pressure, stroke volume, catecholamines, and cortisol) as extra cardiovascular measures of challenge and threat states. Additionally, critics of the BPSM suggest heart rate should allow one to distinguish between challenge and threat states rather than merely represent task engagement (Wright & Kirby, 2003). Therefore, future research should strive to examine alternate ways of measuring task engagement under pressure. Second, the sample had limited female participants and was restricted to experienced University-level soccer players. Future research should therefore aim to replicate the findings of the present thesis with more female participants and/or elite athletes (e.g., professional soccer players) to see if the relationships observed in this thesis still emerge. Indeed, to date, little research in the challenge and threat literature has been conducted with a female or elite sample (see Turner et al., 2013 for a possible exception). Third, the present thesis examined the relationship between challenge and threat states and performance over a limited number of trials (i.e., a single soccer penalty kick). While the findings of the thesis support previous research, future research should increase the number of trials performed by participants in order to improve validity and reliability. Indeed, an average performance score taken across multiple trials might have provided a more accurate reflection of soccer penalty ability. However, the present thesis decided to use a single-trial design in order to enhance psychological pressure and ecological validity, as soccer players' only get one opportunity to score a soccer penalty in real competition. Fourth, when determining performance scores (i.e., kick accuracy in cm), the present thesis did not consider difference in kick elevation. Moreover, a kick that was placed in a top corner did not score any better than a kick placed into a bottom corner, despite the idea that top corner shots may be trickier. Therefore, future research should endeavour to adapt the measure of performance used here to offer greater reward for more difficult shots. Finally, it is unclear exactly which cues (i.e., body movements, facial expressions) allowed observers to identify certain participants as dominant, confident, composed, focused, or competent. Therefore, future research could apply existing coding schemes from other domains, like the Facial Action Coding System

(Ekman & Friesen, 1978), or the Body Action and Posture Coding System (Dael, Mortillaro, & Scherer, 2012).

Conclusion

To conclude, the present thesis offered the first empirical test of the predictions of the integrated framework of stress, attention, and visuomotor performance (Vine et al., 2016), which purports that challenge and threat states influence task performance via their effect on attentional control. Additionally, the present thesis was the first to explore the effects of challenge and threat states on NVB in a sporting context. The present thesis found that a challenge state was associated with better performance. Additionally, challenge state may be associated with longer quiet eye durations, and a greater amount of time spent fixating task-relevant cues (i.e., the goal and goalkeeper), indicating superior goal-directed attentional control. Additionally, the present thesis found that poorer task performance and a cardiovascular response more akin to a threat state were associated with responding to a subsequent task with a threat state. Finally, the present thesis found that a challenge state was associated with more positive NVB including more dominant, confident, and composed body language. These findings offer applied practitioners a potential new method of identifying athletes who are experiencing a threat state in a real-world setting. Overall, the results of this thesis suggest that in order to perform optimally under pressure, an athlete must adopt a challenge state.

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Appendix

Pressure Manipulation Instructions – Trial 1

The rest period is now over. In a few moments you will be asked to take a soccer penalty kick. Your score on the penalty kick will be measured in terms of distance from the centre of the goal in centimetres. Your performance on this task is the most important part of the study, and you must do your best to take the most accurate penalty you can. Do you have any questions?

The accuracy of your penalty is key as it will be placed onto a leader board. The leader board will then be sent via email to all those who took part in the study, including participants, researchers, and lecturers. It will also be displayed in the Link corridor. The 5 most accurate participants will be entered into a draw to win a £50 gift voucher, while the 5 least accurate participants will be interviewed at length by myself about their poor performance. Finally, your penalty will be recorded via a digital video camera and the video will be analysed by an expert in soccer penalty taking.

With this information in mind, please take another minute to sit and think about the upcoming soccer penalty task.

Pressure Manipulation Instructions – Trial 2

The rest period is now over. In a few moments you will be asked to take a second soccer penalty kick. Like the first, your score on the penalty kick will be measured in terms of distance from the centre of the goal in centimetres. Your performance on this task is important and will be combined with your performance on your last penalty, so you must take the most accurate penalty you can. Do you have any questions?

Again, the accuracy of your penalty is key as it will be combined with your previous performance and placed onto a leader board. The leader board will then be sent via email to all those who took part in the study, including participants, researchers, and lecturers. It will also be displayed in the Link corridor. The 5 most accurate participants across the two penalties will be entered into a draw to win a £50 gift voucher, while the 5 least accurate participants across the two penalties will be interviewed at length by myself about their poor performance. Finally, this penalty will also be recorded via a digital video camera and the video will be analysed by an expert in soccer penalty taking.

With this information in mind, please take another minute to sit and think about the upcoming soccer penalty task.