THE PERFORMANCE CONSEQUENCES, AND MANIPULATION, OF CHALLENGE AND THREAT STATES

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CONTENTS

ABSTRACT

In the Theory of Challenge and Threat States in Athletes (TCTSA) it is proposed that on approach to motivated performance situations an individual can respond in a challenge state or a threat state. Challenge and threat states are marked by contrasting patterns of psychological, emotional, and cardiovascular (CV) responses. A challenge state is proposed to maintain or facilitate performance compared to a threat state. The aim of this thesis was to examine the relationships between competitive performance, and the psychological, emotional, and CV indices of challenge and threat states, and to examine the use of task instructions to manipulate challenge and threat states. Five quantitative studies were completed: three studies examined the relationships between challenge and threat states and performance using correlational methods, and two studies examined the manipulation of challenge and threat states using between-groups methods. Overall, challenge and threat CV reactivity were related to performance, and in particular, challenge CV reactivity was consistently related to superior performance compared to threat CV reactivity, in support of the TCTSA. In addition, task instructions were able to manipulate challenge and threat CV reactivity by employing the resource appraisals as posited in the TCTSA. To expand, challenge task instructions which promoted high self-efficacy, high perceived control, and a focus on approach goals, led to challenge CV reactivity, and threat task instructions which promoted low self-efficacy, low perceived control, and a focus on avoidance goals, led to threat CV reactivity. However, contrary to the TCTSA, self-reported psychological and emotional states were not related to CV reactivity or performance in the first three studies, and yielded no differences between challenge and threat conditions in the last two studies. Measurement flaws, response bias, and the notion of unconscious appraisal processes are discussed as explanations of the counter theoretical self-report findings. This thesis makes an original contribution to the field of stress and emotion, as it evidences the relationships

between CV responses to motivated performance situations and performance in a range of tasks and using a range of samples, and for the first time, uses the TCTSA as a framework for promoting a challenge state.

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PREFACE

This thesis includes published manuscripts, manuscripts currently under review, and book chapters. Data from this thesis has also been presented at UK conferences. The details of all outputs related to this thesis are as follows:

Articles

Turner, M. J., Jones, M. V., Sheffield, D., Barker, J. B., & Coffee, P. (under review). Manipulating cardiovascular indices of challenge and threat states while maintaining task importance. *Psychophysiology* (submitted May 2013).

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Turner, M. J., Jones, M. V., Sheffield, D., & Cross, S. L. (2012). Cardiovascular indices of challenge and threat states predict performance under stress in cognitive and motor tasks. *International Journal of Psychophysiology*, *86*, 48-57. doi:10.1016/j.ijpsycho.2012.08.004

Book Chapters

Turner, M. J., & Jones, M. V. (in prep). Stress, emotions and athletes' positive adaptation to sport: Contributes from a transactional perspective. In R, Gomes, R, Resende, and A, Albuquerque (Eds.). *Positive human functioning from a multidimensional perspective*. Nova Science.

Turner, M. J. (2013). Performing under pressure. In S. Cotterill and J. Barker (Eds.). *The psychology of cricket: Developing mental toughness*. Birmingham, UK: Bennion Kearney Limited.

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Conference Presentations

Turner, M. J., Jones, M. V., Sheffield, D., & Mosley, E. (2013). The manipulation of challenge and threat states while maintaining task importance: A physically demanding task. Presented at the Annual British Psychological Society Conference on 11th April 2013.

Turner, M. J., Jones, M. V., & Cross, S. (2012). The relationship between challenge and threat cardiovascular states and netball shooting performance. Presented at the Annual British Psychological Society Conference on 18th April 2012.

Turner, M. J., Jones, M. V., Sheffield, D., & Cross, S. (2012). Can cardiovascular indices of challenge and threat states predict performance under stress in a cognitive task? Poster Presented at the Annual British Psychological Society Conference on 19th April 2012.

Turner, M. J., Jones, M. V., & Cross, S. (2011). The relationship between challenge and threat cardiovascular states and netball shooting performance. Presented at the University of Birmingham Cardiovascular Stress Reactivity Conference on 8th June 2011.

N.B. As all of the studies in this thesis are either published or under review, each chapter has an extended literature review as would appear in an empirical article. Therefore some repetition may be present regarding the description and explanation of theory and research.

CHAPTER 1: LITERATURE REVIEW

1.1 Introduction

Stress is ubiquitous in human life, experienced in motivated performance situations where personal performance is of utmost importance (Seery, 2011), such as job interviews, exams, or sporting competition. As such, understanding how individuals manage stress through scientific endeavour is important. Typically, the term stress has been used to describe a variety of negative feelings and reactions in response to adverse or taxing situations, and has been used interchangeably in research to describe the causes *and* consequences of these negative feelings and reactions. In this thesis the terms 'stress' and 'stress response' are used to describe the psychological and physiological responses to a demand, and do not necessarily refer to negative experiences and responses. 'Stressors' is used to describe the demand or stimulus, and the term 'stressful' is used to identify situations that harbour these demands.

Largely, stress has been considered a hindrance to the quality of human life (Cox, 1978), but not all stress is negative. In this thesis the notion that stress can help or hinder human function is explored. Indeed a certain amount of stress is necessary for survival, for example events that are perceived to be positive, but are nonetheless psychological stressors, do not correlate with illness (Dienstbier, 1989; Thoits, 1983). In fact, stress can be viewed as an adaptive function (Franken, 1994), involving a complex relationship between cognition, neurological, and endocrinological functions. Specifically, stress reactions attempt to maximise an individual's energy expenditure/mobilisation, aiding the body in its attempt to meet demanding situations. Some people may experience adverse effects on health and or performance, while others may experience no effects on health and maintain or improve performance. In order to provide an empirical background for the studies within this thesis, the following literature review details how the concepts of challenge and threat emerged through scientific endeavour. This literature review begins by looking at the early studies of stress, after which the notion of adaptive and maladaptive cognitive and physiological stress is outlined. Then the recent theories that inform the studies in this thesis are detailed; specifically the Biopsychosocial Model of Challenge and Threat (Blascovich & Mendes, 2000) and the Theory of Challenge and Threat States in Athletes (Jones, Meijen, McCarthy, & Sheffield, 2009) are outlined.

1.2 Early Studies of Stress

The study of stress has its roots in the ancient Greek philosophers who explained the importance of perception on how humans interact with the external environment, and the effect this may have on the internal environment. For example, Protagaras (485-411BC) stated that "man is the measure of all things" (Hunt, 1993, p. 16) suggesting that each perception is true for each perceiver. Later on (460-362BC), Democritius put forth that we know nothing for certain, but only the changes produced in our body by the forces that impinge on it. Hippocrates (460-377BC) and Aristotle (384-322BC) both philosophised on the human body's requirement for internal balance, suggesting that perception determined brain function, which regulates the body's internal condition. Thus, a general understanding of how perception could determine healthy and unhealthy stress responses emerged.

Apart from the inaccurate postulation that the mind is located in the chest as this is where fear is felt (Lucretius, 94-51BC), the ancient Greek scholars recognised that the heart has a role to play in the interaction between the environment, mind, and body, an idea very much a part of current stress research. Epictetus (60-120AD) recognised that life's hardships are often determined by stimulus perception, and so one could simply change one's thoughts in order to shift the meaning of the stimulus to assuage emotional disturbance. Therefore psychological and physical health may be determined by the view which humans take of events. Epictetus' views on stress helped form the basis of Rational-Emotive Behaviour

Therapy (Ellis, 1957), the first cognitive behavioural therapy, employing the strategic alteration of thoughts and perceptions to promote psychological function and health.

The ancient Greek philosophers and scholars offered important theories linking perception to biological balance, which were later revisited and clarified in the 17th century. Confronting the mind-body relationship, Descartes (1637, trans 1960) put forth that the non-physical mind could influence the physical body, and the physical body could influence the non-physical mind (Doublet, 2000). The statement “I think therefore I am” is often used to illustrate Descartes’ idea that the only truth is of the self-conscious. Inspired by Descartes, future cognitive psychologists were to study how individuals build truth via perception and how this “truth” can impact people’s responses to the environment.

Also in the 17th century emerged an idea that would greatly influence the emergence of human stress study; Hooke’s Law (1705). Robert Hooke was interested in how man-made structures could withstand heavy loads without collapse, and introduced “load” (the demand placed on the structure), “stress” (the area affected by the demand), and “strain” (change that results from load and stress; Cox, 1978). Hooke’s Law then became used in the analogy that the body is machine-like and is therefore also subject to wear and tear. So into stress discourse emerged ideas that stress experienced in human life may have adverse implications, and that just like a machine, the body needs energy to help it withstand this stress. It follows that depending on the amount of energy demanded, and supplied, the body will perform well, poorly, or even stop, reflecting its machine-like nature (Doublet, 2000). As such, it was presumed that psychological dysfunction stems from depletion of nervous energy, nervous exhaustion, or a weakness of the nervous system, later posited by George Beard (1881).

Echoing the mechanistic rules put forth by Hooke and Beard, Claude Bernard (1859) suggested that the body’s internal fluid environment must be fairly constant in response to external changes; if not, illness and death would occur. Thus, the homeostatic principles discussed by Hippocrates now came to the fore, with Bernard suggesting that the human body has developed internal and continual compensatory reactions in response to external changes. Further, Bernard posited that external demands cause the overload of the nervous system leading to nervous exhaustion (including anxiety, fatigue, and irrational fears), with stress from the pressures of life now considered precursors to homeostatic imbalance (Howard & Scott, 1965). It was thought that the occurrence of stress was a sign that an individual had failed to adjust to modern life as it was in the 19th century (Abbott, 2001).

In summary, the psychological and biological concept of stress emerged through the ancient Greek philosophers and scholars, the psychological and mechanical postulations of 17th century scientists, and the merging of these views in the 19th century. Though the meaning of the word stress has altered somewhat over time, a common principle that has persevered through the ages is that perception of the environment influences bodily responses and functions, and that one's ability to regulate internal states is linked to one's ability to adjust to life stressors. Stress therefore was considered a reaction to perceived hardship manifested in illness due to internal bodily imbalance, and no-one furthered this homeostatic concept more assertively than Walter Cannon.

Cannon (1939) pioneered the psychosomatic approach to stress and his work is often cited as the instigation for the modern understanding of stress, as unlike those before him, his work was based on empirical research. It was Cannon that coined "homeostasis" to describe the relation of the automatic system to the self-regulation processes (Cannon, 1939), paying tribute to its Greek routes ("homeo" and "stasis" meaning "same" and "steady" in Greek). However, Cox (1978) suggested that a more fitting term would be "homeokinesis" given that Cannon did not imply that the internal condition was unchanging, and homeostasis is actually a dynamic process. Broadly, homeostasis is the body's ability to regulate its own consistency, particularly when threatened by change, employing corrective mechanisms to avert the demand and restore the body's internal environment to normal. For example, body temperature requires careful homeostatic control, with core body temperature maintained at 34.4–37.8 degrees Celsius despite environmental fluctuations (Sund-Levander, Forsberg, & Wahren, 2002). Others have suggested that if core body temperature is reduced to 35 degrees Celsius, hypothermia is a likely consequence, with an increase to 38.4 degrees Celsius likely to lead to hyperthermia and possible death (Marx, 2006).

In response to environmental stressors, every external event must be met with an internal reaction to maintain stability, a process operated through the sympathetic arm of the autonomic nervous system (ANS). That is, a person could survive without an ANS, but lacking the ability to execute homeostasis, would require constant and favourable external environments devoid of any stressors (Cox, 1978). By understanding the limits of homeostasis, an understanding of the limits beyond which stress overpowers the corrective mechanisms can be attained, thus explaining the evolutionary importance of homeostasis in order to cope with distressing external forces (Cannon, 1939). Two compensatory adjustments that are synonymous with Cannon's work are flight and fight responses, developed through evolution for rapid service in the battle for survival (Cannon, 1929). Flight represents fear (to run and escape), and fight represents anger (to be aggressive and attack), instinctively activated in the face of a threat to survival. These two responses account for the efficient mobilisation of mental and physical resources to meet demands through the ANS in conjunction with catecholamines (epinephrine and norepinephrine) secreted by the adrenal medulla. The body's needs in both flight and fight are similar (e.g., increased blood flow to the muscles, deepening respiration, pupil dilation), suggesting a typical bodily reaction to demands regardless of the relevance of the stimuli (Cannon, 1915).

Despite notable strengths, some elements of Cannon's work have been rendered too simplistic, for example Cannon did not posit what may determine which of the flight or fight responses would be elicited in a given situation, leading to the further development of the flight or fight concept during the 20th and 21st centuries (Bracha, Ralston, Matsukawa, Williams, & Bracha, 2004). In addition, the phrase "flight or fight" may mischaracterise the sequence of potential responses exhibited by mammals (Bracha et al., 2004). For example, the flight or fight response does not necessarily occur immediately. For an animal, a threat from another animal may be followed primarily by heightened awareness, allowing the animals to assess each other's behavioral signals. Based on this behavioral assessment, the fight or flight response might actually result in playing, mating, or nothing at all (e.g., kittens playing). However, even though the flight or fight concept was underdeveloped, Cannon's defined theory of homeostasis allowed the notion of stress to be possible (Doublet, 2000).

The physiological study of stress was pioneered by Cannon, but was contributed to most significantly by Hans Selye in the mid-20th century. Selye's work allowed the ideas behind the stress concept to be brought together as a workable theory in his General Adaption Syndrome (GAS), suggesting that physiological responses to noxious agents (stressors) are part of a co-ordinated pattern of protection initiated chemically, and non-specifically. That is, all stressors or demands deplete the finite adaptive energy of an organism, causing non-specific physiological reactions as an attempt to maintain a steady state (Selye, 1979), reflecting Cannon's homeostasis concept. Selye did not use the term stress in his early works due to semantic confusion present in literature with stress referring to the human response *and* the stimuli. Instead the terms nocuous or noxious were used to define a non-specific response to any type of change. Selye did eventually adopt the term stress, defining it as the effects of stressors on biologic responses and a condition within an organism in response to stressors (Selye, 1976).

With a disregard for cognitive psychology, Selye maintained that the stress response was exclusively chemical, even though stress occurred in circumstances where external demands could be considered physically harmless (e.g., exam taking), thus suggesting a cognitive mediator between stressor and stress. Criticism too was projected toward his notion that stress was a non-specific response, with research highlighting that different stressors have different effects on physiological functioning. For example, heat produces sweating and flushed skin, while cold produces shivering and erection of body hair. Indeed, if these specific responses were removed there would be few non-specific responses remaining (Doublet, 2000). In sum, it would seem that Selye understated the part psychology played in the cause of stress and overstated the non-specific nature of the stress responses.

Over time, the GAS was reconceptualised to include two distinct stress responses comprising the concepts of eustress and distress (Selye, 1976). Eustress was framed as stress that enhances human function (physical and mental), associated with positive emotions, and essentially meant good stress. Distress was framed as unhealthy, associated with negative emotions, and emerged when the demands of a situation exceeded the body's capacity to maintain homeostasis. Distress is associated with anxiety, and was considered a reaction to a situation that could not be resolved through coping or adaption. Selye still maintained that stress is a non-specific response and the body cannot distinguish between eustress and distress, thus both states could harm the individual. Selye never did formally recognise the part psychology plays in stress responses, apart from stating that "stressors, it should be noted, are not exclusively physical in nature" (Selye, 1982, p. 14). With the knowledge gleaned from contemporary research that the same event may produce a particular reaction in one individual and not in another (Cox, 1978), it is possible to see the inaccuracies of some of Selye's postulations regarding a non-specific stress response.

An individual that did recognise the role of psychology in stress was Harold Wolff, who proposed that stress is the result of the way a situation is perceived (reminiscent of the Ancient Greek views). Wolff's ideas indicated an interaction between the external and the internal environment in response to a demand. Wolff also realised that the human response to a perceived threat that was supposedly developed through evolution (e.g., Cannon, 1929), is inappropriate and can actually harm survival due to its adverse health implications (Wolff, 1953). More recently, this contention has been supported with the suggestion that human physiological responses are inappropriate for modern humans (Carruthers, 1981). Wolff concluded that the "common denominator in psychosomatic illness is the interpretation of an event as threatening" (Wolff, 1950; p. 1090), with the stress response providing an unsuitable protective and homeostatic function (Wolff, 1953). Wolff's most important contribution to the field of stress was the recognition that irrespective of its scale, the potential of a given event to evoke a protective reaction is dependent on its significance for the individual (Wolff, 1950; 1953). However, Wolff did not explain *why* individuals respond to symbolic stressors in the same inappropriate way as physical stressors, and did not detail the interaction between environment and organism that yields the stress response. This, it would seem, was the job of cognitive psychologists such as Richard Lazarus.

1.3 Lazarus and Cognitive Appraisal

The theoretical and methodological developments leading up to the 1950's ensured the continued research and development of the stress concept. Cannon, Selye, and Wolff were primarily concerned with the effects of stress on health, and specifically why and how stress was produced in organisms. The notion that stress is determined by perceptions of demanding events opened up vast enquiry into the relationship between the environment and the individual at a psychological level for the first time. An individual whose work has greatly informed modern psychosocial perspectives in the study of stress was Richard Lazarus, whose work emerged in the 1950's. Initially, Lazarus proposed that stress occurs when a particular situation threatens the attainment of some goal, and more importantly, that stress does not necessarily lead to disruptive responses (Lazarus, Deese, & Osler, 1952). For example, Lazarus and Eriksen (1952) found that more stressful situations were associated with more variability in mental performance. That is, when faced with an important test, some people experienced a performance improvement, while others experienced a performance decline. Lazarus realised that there may be a critical point in the amount of stress beyond which performance disruption occurs, and this point was dependent upon previous experiences, and possible individual differences in motivational and cognitive variables that intervene between stressor and reaction (Lazarus & Eriksen, 1952). Moreover, performance disruption may be dependent on an individual's ability (or inability) to cope with stressful situations.

Through further exploration, Lazarus realised that whether a stimulus is perceived as a stressor or not is dependent on the nature of the cognitive appraisal an individual makes regarding the significance of that stimulus (Speisman, Lazarus, Mardkott, & Davison, 1964). In one study, using film as a medium for influencing cognitive appraisals, and skin resistance and heart rate as indicators of autonomic reactivity (i. e., stress), Lazarus and Alfert (1964) found that stress responses were attenuated when a film depicting primitive rituals (including footage of surgical procedure) was contextualised as harmless and benign in its introduction. Put another way, the meaning of an event determined the stress response, not the event alone.

Lazarus' formative experimental works informed his first conception of an appraisal theory (Lazarus, 1966). Although the appraisal concept was introduced into emotion research by Arnold (1960), Lazarus elaborated it with regard to stress (Lazarus, 1966; Lazarus & Launier, 1978). Lazarus proposed that the expectations an individual has with regard to the significance and outcome of an event, determines the experience of stress. Further, stress is produced, proliferated and mediated by a pattern of appraisals, determined by personal (e.g., motivational dispositions, goals, values, and generalised expectations) and situational factors (predictability, controllability and imminence of stressful event). In essence, Lazarus' theory explains individual differences in the quality, intensity, and duration of stress in environments where external demands are constant across individuals.

Lazarus' theory has had several revisions (Lazarus, 1991; Lazarus & Folkman, 1984; Lazarus & Launier, 1978). In the latest version, stress is considered a relational concept whereby stress refers to a relationship between an individual and an environment mediated by primary and secondary appraisals. Primary appraisal is concerned with whether something occurs that is relevant to the individual's well-being and comprises three components, goal relevance, type of ego involvement, and goal congruence. Goal relevance reflects the extent to which an encounter refers to issues about which the person cares. Type of ego involvement is concerned with self-esteem, moral values, and ego-identity. Goal congruence regards the extent to which an event proceeds in accordance with goals. Secondary appraisal is concerned with an individual's coping options in a given situation, and similar to primary appraisal, comprises three components; blame or credit, coping potential, and future expectations. Blame or credit is the appraisal of who is responsible for a certain event. Coping potential refers to the evaluation of one's ability to undertake behavioural and cognitive operations that will be beneficial for a relevant encounter. Future expectations concern the appraisal of the further course of an encounter with reference to goal congruence and incongruence.

Importantly, particular patterns of primary and secondary appraisal lead to different kinds of stress, namely harm, threat, and challenge (Lazarus & Folkman, 1984). Harm refers to psychological damage that has already occurred, whereas threat and challenge refer to future events relevant to the individual. Threat occurs with the anticipation of potentially imminent harm, and challenge occurs when an individual feels confident about mastering situational demands. For example, Lazarus (1991) maintained that for stress to be experienced, there must be some goal relevance to the encounter, goal incongruence must be high (e.g., personal goals thwarted), and ego-involvement must be concentrated on the protection of personal meaning against threats. Therefore, threat is experienced when secondary appraisal indicates that an individual's coping potential is not sufficient, thus deeming harm potentially imminent. Challenge is experienced when secondary appraisal indicates that an individual's coping potential is sufficient, thus deeming harm less likely.

The concepts of challenge and threat are appealing because they echo Cannon's fight or flight idea and Selye's eustress and distress theory, by suggesting two divergent stress responses, one adaptive and one maladaptive. Lazarus offers a theoretical explanation for the occurrence of challenge and threat that Cannon and Selye could not offer. While Lazarus' appraisals theory informed much psychology research in the mid to late 20th century, neuroendocrine research conducted separately from Lazarus, illuminated the variation in individuals' experiences of stress. To be clear, while Lazarus' cognitive appraisal ideas were being formulated, neuroendocrinologists were simultaneously formulating their own ideas about how individuals experience different stress responses.

1.4 The Psychophysiological Perspective

The notion that there are adaptive and maladaptive ways to respond to stressors is evidenced in neuroendocrine research. Some of Lazarus' research employed measurements of autonomic reactivity as an indicator of Sympathetic Nervous System (SNS) activation reflecting a stress response. Physiological measurements of psychological stress offers insights into the mechanisms through which health consequences emerge and performance is influenced. In particular, much attention has been given to the Sympathetic Adreno Medullary (SAM) and Pituitary Adreno Cortical (PAC) systems, given that researchers such as Walter Cannon and Hans Selye implicate the involvement of these systems in the stress response.

Numerous investigations led by Scandinavian researchers in the second half of the 20th century were dedicated to the roles of the SAM and PAC systems in the stress response.

Marianne Frankenhaeuser proposed that human biological equipment has undergone a much slower development than society, and that the ever increasing discrepancy between societal and biological development puts high demands on the human ability to adjust (Frankenhaeuser, 1981). In essence, echoing Wolff's (1953) views, the existential challenges humans have evolved with no longer exist (e.g., having to evade predators and cope with unpredictable and disastrous environmental changes). But although humans rarely have to endure such existential challenges, the human body has not compensated for this change in the living environment, with SAM and PAC systems activated in the face of relatively minor life challenges (e.g., motivated performance situations).

Utilising urine analysis developed by Professor von Euler (fluorimetric technique; von Euler & Lishajko, 1961), many investigations were undertaken to explore endocrine responses to various psychological stressors, and the impact on human functioning. Initial research discovered that when stress was induced in an individual, so too was catecholamine excretion measured in urine (e.g., epinephrine and norepinephrine; Frankenhaeuser & Patkai, 1965), with the amount of catecholamine excretion varying with the intensity of subjective emotional reactions (Frankenhaeuser & Kareby, 1962; Frankenhaeuser, Sterky, & Jarpe, 1962). Furthermore, individuals that exhibited high adrenaline excretion performed better in selective attention tasks than those with low adrenaline excretion (Frankenhaeuser, Mellis, Rissler, Bjorkvall, & Patkai, 1968). Interestingly, individuals who reported low stress levels but showed high adrenaline excretion performed better in the task, suggesting a mismatch between cognitive and physiological reactions to a stressor. In other words, the body experienced stress but the conscious mind did not, which may facilitate performance. This finding is similar to the postulations put forth in the catastrophe theory (Hardy, 1990) and the Multidimensional Anxiety Theory (MAT; Martens, Burton, Vealey, Bump, & Smith, 1990) which describe a covarying relationship between cognitive anxiety and physiological arousal.

In other words, an individual can experience high levels of one and low levels of the other, therefore physiological arousal is not always linked to high cognitive anxiety. Under conditions where arousal is high but cognitive anxiety is low, the performance of certain tasks may be undisrupted or even facilitated.

It was also found that there were two different responses to a given stressor that could be distinguished by the substance excreted in urine. In highly stressful situations, distressed individuals experienced negative emotions and excreted cortisol, while less distressed individuals experienced positive emotions and excreted catecholamines (Lundberg & Frankenhaeuser, 1980). This suggests that there are two systems determining emotional arousal, SAM activity, associated with catecholamines, and PAC activity, associated with cortisol, and that the presence of these hormones in urine is dependent on the level of cognitive stress experienced by the individual.

Further clarifying the roles of SAM and PAC activity in the stress response, it was found that the relationship between cortisol and catecholamines was such that increases in catecholamines was met with decreases in cortisol, suggesting the dominance of SAM over PAC in certain stressful situations, particularly in situations permitting controllable and self-paced performances (Frankenhaeuser, Lundberg, & Forsman, 1980). In fact, it was suggested that heightened catecholamine levels reflect the challenge to perform well, and that a lowering in cortisol levels reflects the perceptions of being in control. This conclusion fits the model proposed by Henry and Stephens (1977) suggesting SAM activation and PAC deactivation in response to a controllable situation. In short, Frankenhaeuser's research identified that SAM activation, accompanied by catecholamine excretion, represented an adaptive response to stressors, while PAC activation, accompanied by cortisol excretion, represented a maladaptive response to stressors. In effect, two distinct stress responses, adaptive and maladaptive, had emerged within psychological research (e.g., Lazarus) and neuroendocrine research (e.g., Frankenhauser) separately.

An individual who further distinguished the two emerging psychophysiological stress responses, with particular reference to psychological causation, was Holger Ursin, who undertook an extensive investigation of behavioural and physiological parameters following repeated exposure to a highly demanding situation (e.g., Ursin, Baade, & Levine, 1978). Similar to Frankenhauser, Ursin et al. regarded the psychological evaluation of an event to be of utmost importance in the activation of the physiological stress responses, and thus set out to explore subjective psychological and objective physiological responses to stressful situations.

Blood and urine samples were collected from a large number of parachute trainees in the Norwegian Military prior to and after training drills of increasing fear provocation. For example, initially the trainees jumped from a 12m-high mock tower and slid down a long steel wire, a task that is highly fear provoking for the first several jumps (according to the officials and prior trainees). Then, as training progressed, more threat provoking training tasks were undertaken, leading ultimately to an airplane jump. Ursin et al. examined how the repeated exposure to threatening situations developed adaption in participants, and whether varying levels of affective disturbances identified throughout the training process, via fear self-rating data, had an effect on SAM and PAC activation. The fear ratings declined as training progressed, with plasma (blood) cortisol and urine catecholamines increasing from the basal level most significantly at the beginning of the training process, then less significantly as training progressed. Interestingly, catecholamine levels after the jumps were higher than before the jumps (though the level of increase diminished with time). Even fairly experienced jumpers (who had made it to the later stages of the training process), had this short-lasting sympathetic activation at the time of the jump, perhaps accounting for the "adrenaline rush" individuals often report in demanding situations.

Ursin et al. highlighted many associations between the psychological and physiological data. For example, all physiological variables demonstrated a significantly high level when fear level was high, with performance improving as fear diminished. Also, upon repeated exposure, all variables, except heart rate, followed the pattern that is referred to as the coping effect, signified by a reduction in activation. This indicated that the situation alone did not stimulate activation, but the subjective evaluation of it. Additionally, two consistent factors emerged through the data; the catecholamine factor and the cortisol factor. The major distinguishing feature between the two factors was that the catecholamine factor was clearly positively associated with successful performance, and the cortisol factor was associated with defence mechanisms and poor performance throughout the training program. Therefore, as well as a better understanding of the coping process, two distinct branches of the stress response were identified, one driven by PAC activation, and one by SAM activation, that are related to performance in highly stressful situations. Again, the two pattern stress response emerges in these data, supporting previous postulations and research findings (e.g., Frankenhauser et al., 1980).

A further acknowledgment of the two pattern stress response appeared in an exploration of past psychophysiological research findings by Williams (1986). The two emerging patterns are most notably distinguished by differential vascular reactivity in skeletal muscle circulatory networks, with 'pattern 1' responses associated with vasodilation and 'pattern 2' with vasoconstriction. Skeletal muscle circulation is of particular interest in stress research because it is the only vascular bed that has neural and neuroendocrine mechanisms that permit both active vasodilation and active vasoconstriction, thus allowing the assessment of both stress response patterns (Williams, 1986). In research, active vasodilation is characteristic of an appropriate fight or flight response, which in animals is accompanied by the stimulation of the “defence” area of the hypothalamus (Roberts & Nagle, 1996). In parallel, research provides evidence for the vasoconstrictive element of the pattern 2 response. For example, increased forearm vascular resistance (FVR) was found in participants undertaking a sensory intake test (passive coping required), compared to vasodilation in a mental arithmetic test (Wolthuis, Froelicher, Fischeret, & Triebwasser, 1977). Broadly, it appears that skeletal muscle vasoconstriction was partly triggered by the intake of threatening stimuli. For example, during a personal interview, FVR fell in participants who avoided attending to the interviewer, whereas those who attended closely to the interviewer showed an increase in FVR (Williams, Bittker, Buchsbaum, & Wynne, 1975; Bittker, Buchsbaum, Williams, & Wynne, 1975). Bittker et al. (1975) suggested that high attenders of stressful and often emotionally charged situations experience a high stress response as they are picking up more numerous threatening stimuli than the low attenders.

To summarise Williams’ assertions, pattern 1 vascular reactivity occurs in response to active coping tasks such as mental arithmetic tests, and tasks involving shock avoidance and/or uncontrollable aversive stimuli (Alpert et al., 1982). Pattern 2 vascular reactivity occurs in response to passive coping tasks such as sensory intake, alert immobility, and vigilant observation.

There is evidence from animal research that could explain the neurological mechanisms of the two pattern stress responses reported by Williams (1986). For example, stimulation of the basal amygdala results in motoric behaviour typical of pattern 1 (e.g., vasodilation, increased aortic blood flow) responses in animals (alert). But stimulation of the central amygdala produces a pressor response associated with increased peripheral vascular resistance akin to pattern 2 reactivity (Riopel, Taylor, & Hohn, 1979). Further, in the pattern 2 response, the animal is activated and alert, but adopts behaviours that indicate an attack reaction. At a mechanistic level, the Locus ceruleus supplies most of the noradrenergic innervations to the entire cerebral cortex and hypothalamus, thus facilitating norepinephrine release as in pattern 2. Locus ceruleus - noradrenergic activity has been observed when surveillance of environmental stimuli is suddenly and dramatically increased (Godfrey, Nelson, Schrier, Breuer, & Ransom, 1975). Thus, the Locus ceruleus - noradrenergic system likely plays a part in mediating the motoric and physiological manifestations of a pattern 2 response, when that pattern is elicited by environmental stimuli (i.e., stressors; Williams, 1986).

In short, Williams provided further evidence and support for the notion of a two pattern stress response, with vascular reactivity central to his postulations. Following Williams, Richard Dienstbier (1989) developed the two patterned psychophysiological stress response idea further, taking a more theory-driven approach toward explaining the cognitive elements of stress reactivity by drawing on Lazarus' (Lazarus & Folkman, 1984) appraisal theory.

Drawing from the Scandinavian research, Williams' (1986) ideas, and Lazarus' (Lazarus and Folkman, 1984) work, Dienstbier (1989, 1992) highlighted that arousal caused by a stressful situation is not always negative and depends on cognitive appraisal. Dienstbier distinguished between challenge and threat responses, referring to two distinct responses to a stressor characterised by cognitive appraisal and associated neuroendocrine activity. Specifically, an individual's ability to cope is associated with the system through which arousal is elicited. Broadly, SAM activity accompanied by catecholamine release is associated with positive secondary appraisal and positive emotions, representing a challenge response. Therefore, arousal is adaptive if coping resources sufficiently outweigh situational demands. Conversely, PAC activity accompanied by cortisol release represents insufficient coping resources and therefore suggests maladaptive arousal, or a threat response. To explain, in a threat response to an acute stressor (e.g., imminent sporting competition) it is not that cortisol directly disrupts performance, rather that PAC activity tempers the positive effects of SAM activity. Further, SAM activation is correlated with successful performance, and PAC activation is correlated with unsuccessful performance in research utilising a variety of tasks ranging from the lab to the field (Dienstbier, 1989, 1992).

Dienstbier considered the challenge response to be a “toughened” response, where the energy (glucose) needed for successful performance is released into the blood, and can reach the brain efficiently due to decreased vascular resistance and enhanced blood flow (e.g., Williams, 1986). The awareness of this capability in a challenge response enhances potential coping thus leading to a challenge cognitive appraisal (Dienstbier, 1989, 1992). Therefore, arousal contributes to secondary appraisal, as proposed by Lazarus (1966), thus influencing coping potential. To summarise, a challenge response (toughened) is associated with increased catecholamines, decreased vascular resistance, positive emotions, and successful performance, compared to a threat response, which is associated with increased cortisol, negative emotions, and unsuccessful performance.

Many research studies have supported Dienstbier’s assertion that cortisol release may be a key indicator of poor coping and subsequent performance disruption. Indeed, since the studies conducted in the 1970’s and 1980’s implicated cortisol as part of the stress response, further research has elucidated the mechanisms through which stress elicits the cortisol response, the part cognitive appraisal might play, and how this may implicate performance. Dickerson and Kemeny (2004) discuss the mechanisms in detail using a vast array of research findings (e.g., Feldman, Conforti, & Weidenfeld, 1995; Lovallo, 1997; Lovallo & Thomas, 2000; Sapolsky, Romero, & Munck, 2000). First, information about the stressor (e.g., motivated, evaluative, and uncontrollable performance situation) is gathered via the cerebral cortex. Second, the thalamus and frontal lobes (e.g., prefrontal cortex) integrate the information received and appraise the significance of the stimuli, which leads to an emotional response through connections from the prefrontal cortex to the limbic system (e.g., amygdala and hippocampus). Third, limbic structures connected to the hypothalamus serve as primary pathway for activating the PAC axis, instigated by hypothalamic release of corticotrophin releasing hormone (CRH). This stimulates the anterior pituitary to secrete adrenocorticotropin hormone (ACTH), which triggers the adrenal cortex to release cortisol into the blood stream. Coupled with SAM activation (via epinephrine) stimulating the heart to pump more rapidly, this mechanism offers an effective way of delivering energy to the muscles thus enabling efficient coping in stressful situations (Cacioppo et al., 2000; Denson, Spanovic, & Miller, 2009).

Of particular importance, Dickerson and Kemeny (2004) highlighted that while PAC and subsequent cortisol release can be necessary for energy mobilisation as part of an adaptive response to reduce the threat of a stressor in motivated performance situations, it is associated with a host of adverse health consequences with sustained activation including a suppressed immune system, diabetes, hypertension, and memory inhibition, thus justifying its status as a maladaptive stress response. Other research has indicated that the relationship between PAC activation and cortisol, and its deleterious influence on performance, is a consistent finding (Buchanan, Tranel, & Adolphs, 2006). For example, elevated cortisol responses to stressful events are associated with performance impairments on tasks of memory, attention, decision making, and clinical performance (Harvey, Nathens, Bandiera, & LeBlanc, 2010). Additionally, participants showing a significant increase in cortisol in urine from base levels performed worse in a mental task (1 hour test including verbal memory, concept shifting, and divided attention elements) than those with a lower cortisol response (Bohnen, Houx, Nicolson, Jolles, 1990). Unfortunately, no self-report measures of stress were acquired therefore the psychological correlates behind the findings cannot be distinguished.

In response to a public speaking task, it was found that working memory was impaired in participants who showed increased salivary cortisol and reported feeling stressed (Buchanan et al., 2006). But participants who reported feeling stressed without displaying increased cortisol did not show impaired working memory, which supports previous findings that SAM and PAC activity, rather than just SAM activity, reduces working memory (Elzinga & Roelufs, 2005).

Cortisol is associated with performance disruption particularly in cognitive tasks. A recent study found that participants exhibiting increased cortisol performed worse on a maths test only when they had high math-anxiety (Mattarella-Micke, Mateo, Kozak, Foster, & Beilock, 2011). In contrast, participants with low math-anxiety performed better when cortisol increased. In line with a vast body of research explaining the influence of stress on working memory and subsequent performance (e.g., Beilock & Gray, 2007), Mattarella-Micke et al. suggested that the interaction between anxiety and cortisol causes this effect, not cortisol and anxiety alone. These findings echo the MAT (Martens et al., 1990) and the catastrophe theory (Hardy, 1990), and support previous research (e.g., Frankenhauser, 1980; Ursin et al., 1978). In short, it is not hormonal activation causing performance disruption alone, it is the relationship between hormonal activation and perceived stress.

With regards to type of stressor, a number of properties have been linked to increased cortisol levels. For example, unfamiliarity, uncontrollability of the environment, danger to esteem, threat to central goals (Dickerson & Kemeny, 2004), level of demand, novelty, and duration (Kemeny, 2003) have all been shown to elicit increased cortisol reactivity. As purported by Lazarus, it is the appraisal of the situation that, in part, determines the stress response, and therefore must in part determine the cortisol response. For instance, research has indicated that cortisol release is associated with a cognitive appraisal of threat (Kemeny, 2003). Harvey et al. showed that, in a high stress situation, validated by high subjective stress scores, there was a significant positive correlation between salivary cortisol level and threat appraisal, indicative of PAC activation. Similarly in an evaluative task (speech in front of audience), a threat appraisal led to stronger cortisol responses in participants who reported typically experiencing strong emotional, cognitive, and autonomic responses to social evaluation (Scholtz, Hammerfeld, Ehlert, & Gaab, 2011). Additionally, research has indicated that during acutely stressful occurrences, cortisol reactivity can be increased or attenuated depending on the appraisals elicited in specific situations (Denson et al., 2009).

At this point, it is perhaps worthwhile reflecting on the recurring themes that have emerged through research, particularly research done in the latter half of the 20th century. Most pertinently, two stress responses have emerged within psychology and neuroendocrine literature echoing the fight and flight response proposed by Cannon (1939) and the eustress and distress concept conceived by Selye (1976). Whether the two responses have been described as patterns (e.g., Williams, 1986) or factors (e.g., Ursin et al., 1978), there is a consensus that increased SAM activity accompanied by catecholamine release and reduced vascular resistance, is associated with positive emotion and enhanced performance. In parallel, increased PAC activity accompanied by cortisol and increased vascular resistance, is associated with negative emotions and reduced performance (e.g., Frankenhaeuser & Patkai, 1965; Ursin et al., 1978; Williams, 1986). Further, cognitive appraisal (Lazarus, 1966) has offered an explanation of how the two distinct responses may occur in reaction to stressors, with challenge appraisals leading to SAM activity and threat appraisal leading to SAM and PAC activity (Dienstbier, 1989). The research from psychology and neuroendocrinology has been combined in an integrative, interdisciplinary approach in the understanding of the human stress response. In the next section, the BioPsychoSocial (BPS) model of challenge and threat (Blascovich and Mendes, 2000; Blascovich & Tomaka, 1996) is discussed.

1.5 The BioPsychoSocial (BPS) Model of Challenge and Threat

The BPS model of challenge and threat (Blascovich and Mendes, 2000; Blascovich & Tomaka, 1996) builds on Lazarus and Folkman's (1984) work and is informed by the work of Obrist (1981) and Dienstbier (1989) in proposing a dichotomy in the way humans respond to stress. In the BPS model a challenge state is experienced when sufficient, or nearly sufficient, resources to meet the demands of a situation are perceived, whereas a threat state is experienced when insufficient resources to meet the demands of a situation are perceived (Blascovich & Mendes, 2000; Blascovich & Tomaka, 1996). Demand appraisals comprise perceptions of danger, uncertainty, and required effort in a situation, and resource appraisals relate to perceived ability to cope with the demands of a situation and include skills, knowledge, abilities, dispositional factors, and external support available to a person (Blascovich, Mendes, Tomaka, Salomon, & Seery, 2003). These demand and resource appraisals are reflected in two distinct patterns of CV reactivity that distinguish challenge and threat.

In the BPS model it is proposed that in motivated performance situations challenge is accompanied by increased SAM activity accompanied by catecholamine release (epinephrine and norepinephrine). The physiological response exhibited in challenge is indexed by changes from resting baseline (reactivity) in four CV variables; increased heart rate (HR; heart beats per minute[bpm]) and cardiac output (CO; litres of blood pumped from the heart per minute[l/min]), attenuated preejection period (PEP; time interval from beginning of electrical stimulation of the ventricles to the opening of the aortic valve[ms]), and decreased total peripheral resistance (TPR; sum of the resistance of all peripheral vasculature in the systemic circulation[dyn.s.cm^{-5}]). Increased HR and attenuation of PEP from baseline indicate motivation to engage in the task (e.g., Obrist, 1981). A challenge response is proposed to promote efficient energy use through increased blood flow to the brain and muscles, higher blood glucose levels (fuel for the nervous system) and an increase in free fatty acids that can be used by muscles as fuel (e.g., Dienstbier, 1989).

A threat state is similarly marked by increased SAM activity, but is also characterised by increased PAC activity accompanied by cortisol release. A threat state is also evidenced by changes from resting baseline in four CV variables, increased HR and attenuated PEP, but with a minimal change, stabilisation, or small decrease in CO, and an increase or stabilisation in TPR. Consequently, in a threat state PAC activity tempers SAM activity therefore the mobilisation of energy is less efficient than in a challenge state as blood flow (and therefore glucose) to the brain and muscles is restricted (e.g., Dienstbier, 1989). In short, both challenge and threat states are indexed by increased HR and decreased PEP reactivity, which are indicators of motivated performance. In a challenge state, the proposed underlying SAM activation is fast-acting and represents the efficient mobilisation of energy for action, reflected by increased CO and decreased TPR reactivity. A threat state reflects PAC (and SAM) activation and is considered a “distress system” reflected by decreased or stable CO and increased TPR reactivity (Blascovich & Mendes, 2000). A threat state is considered maladaptive in modern motivated performance situations (e.g., interviews, exams, sports competitions), but may have served an adaptive function early in human history, for example by allowing energy production over long periods of time in order to cope with especially demanding circumstances (e.g., evading and escaping predators or natural disasters). In sum, increased HR and attenuation of PEP from baseline indicate motivation to engage in the task while changes from baseline in CO and TPR are the key indices of challenge and threat (Blascovich & Tomaka, 1996; Seery, 2011).

In constructing the BPS model of arousal regulation, the work of Blascovich and Katkin (1993) was of great significance, along with many other prominent researchers at this time (e.g., Saab & Schneiderman, 1993; Manuck, Kamarck, Kasprowicz, & Waldstein, 1993; Sherwood, 1993). These works clarified the theoretical and methodological implications of measuring two divergent stress responses, by advocating the use of impedance cardiography. Impedance cardiography has been used frequently by psychophysiologists to monitor the mechanical functions of the CV system (Sherwood, Allen, Fahrenberg, Kelsey, Lovallo, & van Doornen, 1990) and is considered a non-invasive and unobtrusive method of measuring CO and TPR. Stroke volume (SV) is the actual parameter obtained via impedance cardiography, which measures thoracic electrical impedance changes, with CO a product of SV and HR (CO = SV x HR), and TPR derived from mean arterial pressure (MAP; average blood pressure) and CO (TPR = [MAP/CO] x 80).

Blascovich and Katkin (1993) asserted the importance of using continuous methods, such as impedance cardiography, to measure vascular reactivity as well as cardiac reactivity, to assess stress responses. Indeed, Manuck et al. (1993) suggested that blood pressure (BP) alone cannot accurately measure the human stress response. For example, in one study a participant showed a marked acceleration in heart rate, attenuated PEP and a substantial rise in CO, compared to another participant, who showed an increase in peripheral resistance, though both experienced increased BP. Thus, similar BP changes were achieved through different mechanisms (Manuck, Kasprowicz, & Muldoon, 1990). Additionally, in response to a stressor, some individuals may experience increased CO, reduced PEP, and a reduction in TPR while others may experience reduced CO, increased PEP, and increased in TPR (Kasprowicz, Manuck, Malkoff, & Krantz, 1990). Thus, using impedance cardiography to measure all of these aspects is necessary when determining stress responses.

In further support of impedance cardiography, Saab and Schneiderman (1993) refer to previous research using this method, and conclude that it can indeed measure the two distinct stress responses found in previous research, which they refer to as patterns. It has been elucidated that pattern 1-type reactions (defensive reactions or striving) comprise skeletal muscle vasodilation, BP increases due to elevated CO, and increased HR (via increased β1-adrenergic activity and decreased vagal tone). Pattern 2-type reactions (vigilance) comprise skeletal muscle vasoconstriction, BP increases due to elevated TPR, decreased CO, and attenuated HR (via increased α-adrenergic activity and increased vagal tone). Situations that involve active coping, mental work, or defence behaviour evoke pattern 1, and vigilance, inhibitory coping, or passive avoidance evoke pattern 2.

Sherwood (1993) makes an important distinction between the two patterns discussed by Saab and Schneiderman (1993), and Cannon's (1939) fight or flight responses. Rather than fight or flight representing one of either the pattern 1 or 2 responses, Sherwood (1993) contends that a pattern 1 response in active coping situations represents the fight or flight response. Conversely, the pattern 2 response is more representative of a distress response, not permitting successful escape or approach behaviour in response to a stressor. Further, and similar to Selye's eustress and distress concept, Sherwood (1993) suggested that pattern 1 and pattern 2 responses signify two possible adrenergic responses to a stressor, with pattern 2 leading to adverse health implications thus further reflecting its association with maladaptive coping. These contentions are an extension of Obrist's (1981) ideas about the psychophysiological relationship between stressor and CV responses.

Obrist (1981) suggested that in the face of a stressor, an individual can either actively cope (leading to energy mobilization and task engagement), or passively cope (leading to helplessness). CV activity (myocardium excitation) is evoked by active coping, but echoing Selye's (1979) ideas, this may lead to disease through unnecessarily exacerbated energy production. Also, because the diseases synonymous with mobilisation (e.g., hypertension) do not usually materialise until later life, the genetic material that partially drives this maladaptive response will have already been vested in the next generation (via sexual reproduction). Thus, the stress response may be a vestige which has endured through the course of evolution, with the developing civilisation highlighting its pathology due to the action that would mitigate its pathological consequences not being taken (e.g., not expending energy through physical action synonymous with the fight or flight response). The idea that societal evolution has caused humans to adopt inappropriate stress responses was also suggested by Frankenhauser (1981), and helps to explain why humans experience such drastic physiological reactions to often minor stressors (e.g., fear of harmless spiders).

Collectively then, Blascovich and Katkin (1993), and colleagues (Saab & Schneiderman, 1993; Manuck et al., 1993; Sherwood, 1993) support the two distinct stress response concepts, but also identified BP, CO, TPR, and PEP, as measured using impedance cardiography, as the key indicators of each response. The psychological correlates for each response were not discussed until the BPS model of arousal regulation (Blascovich & Tomaka, 1996) that for the first time integrated CV, endocrine, and psychological research to form a coherent model.

1.6 Validating the BPS Model of Arousal Regulation

It has hitherto been established that CV reactivity in motivated performance situations reflects adaptive (challenge) and maladaptive (threat) processes indexed in part by TPR and CO. The BPS model (Blascovich & Tomaka, 1996) asserts that both responses, accompanied by arousal, are initiated by the perception and cognitive appraisal of a goal relevant situation (e.g., perceived consequences for well-being; Lazarus, 1991). Thus, the two patterns of physiological arousal are dependent on situational demands and appraisal outcomes. Drawing on Lazarus' cognitive appraisal theory and Dienstbier's psychophysiological postulations, if the demands of a situation are perceived as too much for the individual to cope with, then the situation is appraised as a threat. Conversely, if an individual's perceived coping resources are sufficient enough to cope compared to the demands of a situation, the situation is appraised as a challenge. The concepts of challenge and threat therefore represent two divergent appraisals that determine the two distinct physiological stress responses.

Although the BPS draws heavily on Lazarus' ideas, Blascovich and Tomaka (1996) assert that challenge and threat cannot be determined via primary appraisal alone, but must also involve consideration of secondary appraisal coping resources and abilities. Indeed, Lazarus and Folkman (1984) include goal relevance within the notion of primary appraisal but Blascovich and Tomaka (1996) do not. In the BPS model it is highlighted that passive situations (e.g., spectator watching favourite team against a rival team) limit the range and relevance of secondary appraisal compared to motivated performance situations (e.g., an athlete performing against the rival team) due to differences in behavioural and cognitive demands for action (Blascovich & Tomaka, 1996). So, although both the spectator and the athlete perceive the situation as potentially threatening for well-being, their behaviour and courses of action in order to cope are completely different (e.g., passive vs. active), thus the emergence of challenge and threat is also dependent on secondary appraisal. Additionally, the BPS model includes self-efficacy and perceived control as part of the appraisal process, with individuals exhibiting high levels in both more likely to make challenge appraisals in motivated performance situations, reflecting their perceived ability to cope (Blascovich & Tomaka, 1996).

As already mentioned, a key aspect of the BPS model is the acknowledgment of two distinguishable patterns of physiological arousal following appraisal, differentiated autonomically via myocardial and vascular responses (e.g., Blascovish & Katkin, 1993; Dienstbier, 1989; Obrist, 1981). There are two autonomic responses available on approach to motivated performance situations, one driven by increased SAM activity, and one driven by increase PAC activity (see Dienstbier, 1989; Manuck et al., 1993). Increased SAM activity results from positive cognitive appraisals and is associated with increased cardiac performance and *decreased* vascular resistance; a challenge state. Increased PAC activity results from negative cognitive appraisals and is associated with increased cardiac performance but *increased* vascular resistance; a threat state. Blascovich and Tomaka (1996) suggest that SAM activity is indeed an effort system mobilising energy for coping as put forth by Cannon (fight or flight), and that PAC activity is indeed a distress system as posited by Selye.

Following cognitive appraisal, which can occur consciously or unconsciously (Blascovich & Mendes, 2000), physiological arousal occurs, accompanied by specific mechanisms by which the two distinct CV patterns emerge. SAM activation, associated with challenge, represents sympathetic neural stimulation of the heart that increases cardiac performance via the release of epinephrine and norepinephrine by the adrenal-medullary, causing vasodilatation in large skeletal muscle beds and bronchi thus decreasing vascular resistance. PAC activation, associated with threat, is accompanied by sympathetic neural stimulation, but inhibits epinephrine and norepinephrine release from the adrenal-medulla, thus increasing CO without a decrease in vascular resistance. In addition, the inhibitory effects of PAC activity reflects anxiety and uncertainty of one's coping options, and is linked to neurophysiological research illustrating a link between anxiety and brain centres that control PAC activity (e.g., Gray, 1982; McNaughton, 1993).

Using the hypothesised CV responses that accompany SAM and PAC activation following cognitive appraisal, researchers have tested the validity of the BPS model. Initially, using skin conductance response (SCR; reflecting Sympathetic Nervous System activation separate to the cardiac system), heart rate (HR), and pulse transit time (PTT), it was found that cognitive appraisals predicted subjective and physiological (objective) reactions to an active coping stressor (mental arithmetic; Tomaka, Blascovich, Kelsey, & Leitten, 1993). Specifically, challenge appraisals were related to increased physiological reactivity compared to threat appraisals.

In a further set of experiments, threat appraisals were associated with high subjective stress, low effort and performance in an active coping task (mental arithmetic) compared to challenge appraisals. In addition, challenge appraisals were associated with increased cardiac activity (PEP, CO, and HR), and decreased vascular reactivity (TPR) compared to threat appraisals. Tomaka et al. (1993) concluded that threat appraisals relate positively to stress during an active coping task accompanied by low cardiac reactivity and increased TPR reactivity, with challenge appraisals accompanied by increased cardiac reactivity and decreased TPR reactivity.

Further validation came from Tomaka, Palacios, and Lovegrove (1995), who manipulated appraisals via task instructions to test the predictive capabilities of challenge and threat appraisals. Prior to a mental arithmetic task (i.e., motivated performance situation), participants were given either challenge instructions (e.g., try your best), or threat instructions (e.g., your performance will be evaluated). As hypothesised, challenge instructions led to challenge appraisals accompanying low self-reported stress, enhanced cardiac reactivity, and decreased TPR reactivity. In contrast, when challenge and threat physiological responses were stimulated in participants using exercise (challenge) and cold/warm pressers (threat), (Blascovich, Kibler, Ernst, Tomaka, & Vargas, 1994), results showed no differences in cognitive appraisal. Therefore the causal direction of cognition to physiological responses found previously (e.g., Tomaka et al., 1993) was validated.

In sum, the results of initial studies validate central ideas proposed in the BPS model that prior to non-metabolically demanding motivated performances; challenge appraisals lead to adaptive physiological responses thus promoting successful coping, and threat appraisals lead to maladaptive physiological responses thus inhibiting successful coping. Importantly, the validational research provides initial support for the idea that CV responsiveness is a function of challenge and threat appraisals. The implications of these early findings are that it is possible to obtain subjective *and* objective measurements of challenge and threat responses, using self-report measures accompanied by impedance cardiography, to determine individual responses to motivated performance situations.

Since its inception, a wealth of research has used the BPS model as a framework for explaining determinants of and responses to stress. With the BPS model functioning as a validated and testable model, Blascovich and many others sought to further explore its applicability in an array of contexts. The next section of this chapter will discuss the extensive and diverse research that has been conducted using the BPS model as a framework.

1.7 BPS Model Research Studies

1.7.1 Individual Differences

Individual difference research has explored topics such as just world beliefs, assertiveness, self-esteem, defensive pessimism, and basic psychological needs satisfaction in relation to the BPS model. In one study individuals with high just world beliefs (e.g., perception that hard work and effort will be rewarded) reported higher challenge appraisals, exhibit higher CO, HR, PEP reactivity, and lower TPR reactivity, and performed better in an arithmetic task than individuals with low just world beliefs (Tomaka & Blascovich, 1994). Individuals with high just world beliefs are predisposed to experience stressful situations as challenging, with individuals reporting low just world beliefs predisposed to experience stressful situations as threatening. In another study, the relationship between assertiveness, challenge and threat responses, and performance in a stressful task (impromptu video-taped speech to a male lab assistant) were examined (Tomaka, Palacios, Schneider, Colotia, Concha, & Herrald, 1999). Results showed that high assertive females displayed higher PEP reactivity, maintained CO and stroke volume (SV), and lower TPR reactivity than low assertive females, indicative of a challenge state. In addition, high assertive women cognitively appraised the task as less demanding than low assertive women, felt they had more control, and also gave better speeches.

Self-esteem has been assessed in relation to challenge and threat states and manipulated performance feedback (failure; positive and encouraging vs. success; negative and non-encouraging; Seery, Blascovich, Weisbuch, & Vick, 2004). Results indicated that after a word association task (Remote Associates Test; RAT), failure feedback given to participants with unstable high self-esteem, and also those with stable low self-esteem, exhibited threat CV responses when approaching a second task. In addition, participants with unstable high self-esteem exhibited challenge CV responses after success feedback. It was concluded that individuals with unstable high self-esteem possess underlying self-doubt, and that this can be illustrated via the physiological indices of challenge and threat.

Similarly using the RAT, individual dispositions of defensive pessimism were examined in relation to challenge and threat CV responses, and task performance strategies (Seery, West, Weisbuch, & Blascovich, 2008). Results showed that defensive pessimists exhibited threat CV reactivity after imagining negative outcomes, and adopted a task strategy where they answered a higher percentage of attempted questions correctly compared to positive and relaxation imagery groups. Therefore, defensive pessimists were less likely to guess when threatened, answering only when confident in their response, thus minimizing the chances of answering incorrectly. Therefore defensive pessimists often succeed in the real world due to negative reflection serving to motivate their task preparation, such as studying for an exam. This illustrates how a threat response may be useful in some situations.

In a more recent study involving dancers (Quested, Bosch, Burns, Cumming, Ntoumanis, & Duda, 2011), trait basic psychological needs satisfaction (e.g., feelings of autonomy, competence, and relatedness; Deci & Ryan, 2000) data were collected to examine its influence on PAC activation indicated via salivary cortisol reactivity, challenge and threat appraisals, and anxiety, in relation to a solo performance in front of judges. Results indicated that low basic psychological needs satisfaction was related to higher threat appraisal, lower challenge appraisal, higher cortisol reactivity (associated with PAC activation), and higher anxiety intensity (somatic and cognitive), compared to high basic psychological needs satisfaction. Therefore, when approaching a stressful event, higher basic psychological needs satisfaction predicts more adaptive psychophysiological reactions associated with challenge.

In summary, individual difference research has shown that certain dispositions (just world beliefs, assertiveness, self-esteem, defensive pessimism, basic psychological needs satisfaction) are related to challenge and threat states in motivated performance situations. However, although there is evidence that challenge and threat appraisals can be influenced by dispositions, the majority of research regarding the BPS model has focused on stress reactions in social interactions.

1.7.2 Social Interactions

Social interaction research has explored social comparisons (e.g., Mendes, Blascovich, Major, & Seery, 2001), stigmatized partners of perceivers (e.g., Blascovich, Mendes, Hunter, Lickel, & Kowai-Bell, 2001), mixed/same-sex emotional interactions and rejection/acceptance situations (e.g., Mendes, Reis, Seery, & Blascovich, 2003; Townsend, Major, Gangi, & Mendes, 2011), and mixed/same race rejection/acceptance situations (e.g., Jamieson, Koslov, Nock, & Mendes, 2012; Mendes, Blascovich, Lickel, & Hunter, 2002; Mendes, Major, McCoy, & Blascovich, 2008). In one study Mendes et al. (2001) found that upward social comparisons (e.g., participants told that they performed worse than their experimental partner in a word finding task) resulted in a CV threat pattern, along with larger demands/resources ratios (lower evaluation of resources compared to demands) and increased negative affect. In contrast, downward comparisons (e.g., participants told that they performed better than their experimental partner in a word finding task) resulted in a CV challenge pattern, along with smaller demands/resources ratios (higher evaluation of resources compared to demands) and increased positive affect. In other studies it has been found that when interacting with stigmatised others (e.g., by physical, racial, and socially constructed stigmas) individuals exhibited CV patterns associated with threat and performed more poorly (in a cooperative word finding task) than participants interacting with non-stigmatized others (Blascovich et al., 2001; Mendes et al., 2002). Furthermore, it has been found that individuals paired with counterstereotypical partners (e.g., Asians with southern American accents) displayed CV responses consistent with threat, performed worse in a word finding task, and rated their partners less positively, compared to those paired with stereotypical partners (e.g., Asians with local accents; Mendes, Blascovich, Hunter, Lickel, & Jost, 2007). It is suggested that the unfamiliarity of the interaction with counterstereotypical partners functioned to increase uncertainty about the situation (demand appraisal), thus promoting a threat response.

Further, Mendes et al. (2003) found that, during emotional *interaction* (participants asked to talk about their very deepest thoughts and feelings from the outset) with empathetically responsive strangers of the same sex, challenge reactivity was elicited, but during emotional *suppression* (participants told to hold back their thoughts and feelings till a later date) threat reactivity was evoked (compared to control groups). In contrast, in opposite-sex interactions, it was emotional expression that engendered threat reactivity. Comparably, it has also been found that women performing in a gender-biased maths test (test historically produces gender differences) exhibited threat CV responses, while men performing in the same test exhibited challenge CV responses (Vick, Seery, Blascovich, & Weisbuch, 2008). It is suggested that for women, the gender-biased test represented a negative stereotype situation that would therefore diminish resource evaluations compared to demands. Conversely, for men the gender-biased test represented a positive stereotype situation that would enhance resource evaluations compared to demands. On the contrary, women performing in the gender-fair condition (test historically does not produced gender differences), exhibited challenge CV reactivity, whereas men exhibited CV threat reactivity. Ergo, removing the stereotypic element of the test also removed the assumption that men should outperform women, reversing the resource and demand evaluations made in the gender-biased condition by women and men. A more recent study examined women's neuroendocrine responses associated with sexism (Townsend et al., 2011) in relation to merit based rejection vs. sexist based rejection. Female participants completed a bogus questionnaire from which their scores were reviewed by a male interviewer who provided feedback to the participant based either on their questionnaire score, or their sex. Prior to the study the participants completed a 'chronic perceptions of sexism' questionnaire, and after the interview salivary cortisol was collected to indicate PAC activity alongside self-reported stress. Results showed that only when women were interviewed by a man who had previously given sexist feedback was chronic perceptions of sexism associated with higher cortisol, indicating PAC activity associated with a threat state. Interestingly, self-reported stress was unrelated to cortisol.

Within an interracial social context, Mendes et al. (2008) found that *interracial* social rejection (individual is deliberately excluded from a social interaction via negative evaluation) led to a CV response indicative of challenge, better performance in a word finding task, and more self-reported (non-verbal) displays of anger. Conversely, *intraracial* social rejection led to a CV pattern indicative of threat and impaired performance, though no significant negative emotions were found. Further, intraracial social acceptance (via positive evaluation) led to challenge CV responses, better performance, and more positive emotions than receiving positive evaluation from a different race partner (interracial), in white participants only. In contrast, black participants exhibited CV responses consistent with threat, performed less well, and showed less positive emotion, when positively evaluated by white partners (interracial). The results illustrate the differential physiological, emotional, and behavioural implications of social rejection and acceptance depending on racial context. More recently, Jamieson et al. (2012) explored the effects of same and different race rejection on participants' CV reactivity, cortisol reactivity, affect, and risk-taking (in a card task). Black and white participants were asked to prepare and deliver a speech throughout which they received rejecting feedback from either same or different race confederates. Baseline CV and cortisol measures were attained, and after the speech cortisol was collected again and participants completed the Columbia card task assessing risk-taking. The results revealed that participants rejected by same-race confederates exhibited higher threat CV reactivity, higher cortisol reactivity, greater levels of shame (affect), and less risk-taking in the card task. The CV and cortisol reactivity findings illustrate the underlying mechanisms through which a threat state is potentially elicited, as increased TPR, decreased/stable CO, and increased cortisol reactivity are all associated with PAC activation linked to a threat state. However, in the study CV reactivity and cortisol reactivity are not analysed at a correlational level therefore it is not possible to state that CV reactivity and cortisol were related.

In another study, Scheepers (2009) examined the role of social identity in challenge and threat and found that members of a low-status group (told that they performed worse than another group in a number counting task) displayed a physiological threat pattern when the status was stable (e.g., informed that a previous number counting task is a good predictor of performance in a subsequent letter counting task), but that threat turned to challenge when status differences became unstable (e.g., informed that the two previous cognitive tasks were a poor predictor of performance in a word searching task). Conversely, members in the high status group (told that they performed better than another group in a number counting task) were threatened when the status was unstable, but not when the status was stable. These findings suggest that when part of a group, individual challenge and threat responses are determined by group status, and the stability, or indeed instability, of that group's status. This has implications for teams operating in an achievement setting, where emphasising successful past performance in order to promote future success may be important.

Social identity and challenge and threat responses have also been examined alongside group affirmation (Derks, Scheepers, van Laar, & Ellemers, 2011). In this study, female participants were told that the goal of the study was to assess the parking performance of men and women. To manipulate affirmation, the participants were either told that they had been selected for a future study due to their personal high performance in a previous task (self-affirmation), or told that they were selected due to the high performance of women found in previous studies (group-affirmation). Results indicated that self-affirmation led to CV patterns of challenge in less socially identified members of devalued groups. This suggests that self-affirmation promotes coping even when the identified group is negatively stereotyped, when the individual has low identification with that group. Conversely, highly identified women in the self-affirmation condition exhibited CV patterns of threat, indicating that even when the participants were self-affirmed, they displayed low coping due to their level of identification with the group. It was concluded that participants with concern for their social identity suffered from the negative stereotypes about their group, regardless of personal identity, leading to a threat state.

More recently, CV reactivity was measured in response to a naturalistic stressor, that of an actual student classroom presentation (Zanstra, Johnston, & Rasbash, 2010).

Interestingly, data were collected before, during and after the speech. In line with the BPS model, increased challenge appraisals were associated with decreased TPR and increased CO (challenge state), with increased threat appraisal associated with increased TPR and decrease CO (threat state). These relationships emerged only in the anticipation period prior to the task, thus validating the common approach within challenge and threat research of assessing CV reactivity in the preparation period of a task. Also, this study illustrates the relationship between cognitive appraisals and CV reactivity in an ecologically valid context, instead of a laboratory task where motivated performance is typically created superficially.

In summary, ample research has explored the influence of social contexts on the stress responses and performance using the BPS model as a guiding framework. Among the findings, it is clear that motivated performance situations (collaborative or individual task performance) within social contexts can either lead to challenge or threat responses depending on the manipulation of key socially meaningful variables (e.g., rejection vs. acceptance, upward vs. downward social comparison, emotional interaction vs. suppression, unstable group status vs. stable group status, high group identity vs. low group identity, and self vs. group affirmation). Thus, it may be possible to predict how individuals will react in certain social contexts, and specifically how individuals within the contexts may cope in motivated performance situations.

1.7.3 Manipulating Challenge and Threat States

Previous research has validated a causal direction from challenge and threat appraisals to challenge and threat CV reactivity (Blascovich et al., 1994; Tomaka et al., 1993; Tomaka et al., 1995). This suggests that, in order to manipulate challenge and threat CV states, presumably cognitive appraisals need first be manipulated. There is a consistent body of research demonstrating that modifying perceptions can alter psychophysiological responses to potentially stressful stimuli (e.g., Allred & Smith, 1989; Holmes & Houston, 1974; Koriat, Melkman, Averill, & Lazarus, 1972; Nisbett & Schachter, 1966; Speisman. et al., 1964) and specifically that it is possible to modify perceptions of challenge and threat (e.g., Hemenover & Dienstbier, 1996; Taylor & Scogin, 1992).

One way research has attempted to manipulate challenge and threat appraisals is by using instructional sets. For example, challenge task instructions focusing on potential reward for successful performance, and threat task instructions focusing on potential loss for unsuccessful performance have been shown to lead to challenge and threat appraisals respectively (Hemenover & Dienstbier, 1996; Taylor & Scogin, 1992). In other studies, modifying the perceived importance of an upcoming task has been shown to manipulate challenge and threat appraisals. In one study (Alter, Aronson, Darley, Rodriguez, & Ruble, 2010) participants in a threat condition were instructed that an upcoming maths test would “show how good [they] were” and that “it would be able to measure [their] ability at solving math problems” (p. 167). In contrast, participants in a challenge condition were instructed that they “would learn a lot of new things” and that “working on these problems might be a big help in school because it sharpens the mind” (p. 167). Participants appraised the test (measured on a 7-point likert scale where 1 = *challenging* and 7 = *threatening*) in line with the instructions, and furthermore participants in the challenge condition performed better than those in the threat condition. In four studies Feinberg and Aiello (2010) used challenge instructions focusing on participants’ abilities to perceive a cognitive task “as a challenge to be met and overcome,” to perceive themselves as someone “capable of meeting that challenge,” and to try hard to do their best (p. 2079). Threat instructions focused on the difficulty of the task and the importance of working “as quickly and efficiently as possible” (p. 2079). Challenge instructions led to challenge appraisals and performance increments, while threat instructions led to threat appraisals and performance decrements. In short, four previous investigations have shown that task instructions can influence challenge and threat cognitive appraisals.

While previous research found that instructions can manipulate challenge and threat appraisals, they did not measure CV reactivity, a vital indicator of challenge and threat states. One study has examined CV reactivity alongside cognitive appraisals to test the assertions of the BPS model. Prior to a mental arithmetic task Tomaka, Blascovich, Kibler, and Ernst (1997) used threat instructions which emphasized the importance of completing the task "as quickly and accurately as possible" and that responses would be "scored for speed and accuracy" (p. 72), and challenge instructions which encouraged participants to "think of the task as a challenge" and to "think of yourself as someone capable of meeting that challenge" (p. 72). Participants given threat task instructions experienced threat CV reactivity and cognitively appraised a mental arithmetic task as threatening. Conversely, participants given challenge task instructions experienced challenge CV reactivity and cognitively appraised the task as challenging. This is an important study as it suggests that challenge and threat states can be manipulated and further validated the causal relationship between cognitive appraisals and CV reactivity.

Reappraisal has emerged as an important strategy of regulating emotions (see Gross, 1998 for review), and two recent studies have used the BPS as a framework to examine the use of reappraisal on challenge and threat states. In one study, participants in a reappraisal condition (anxiety prior to an important exam may be beneficial), exhibited higher catecholamine levels, indicative of SAM activity, and performed better in a subsequent exam compared to a control group (Jamieson, Mendes, Blackstock, & Schmader, 2010). In a second study, participants in a reappraisal condition exhibited increased CO as well as increased TPR, suggesting neither challenge nor threat CV reactivity (Jamieson, Nock, &

Mendes, 2012). These studies offer partial support for the notion that reappraisal may be able to manipulated challenge and threat states in motivated performance situations.

Another method used to manipulate challenge and threat states is to alter the performance environment. For example, participants in one group performed a learned task while participants in another group performed a novel task, both in front of an audience (Blascovich, Mendes, Hunter, & Salomon, 1999). Participants performing the learned task, thus having knowledge of their abilities, exhibited a challenge pattern of CV reactivity, whereas participants who performed the novel task, thus having no knowledge of their abilities, exhibited a threat pattern of CV reactivity. The presence of others most likely affected the demand element of the cognitive appraisals, with perception of danger, uncertainty, and required effort all potentially augmented beyond perceived coping resources. Similarly, a within-subjects analysis was used to examine how challenge and threat appraisals change over multiple tasks (Quigley, Barrett, & Weinstein, 2002). Results indicated that repeated exposure to the task promoted increasing challenge, with changing cognitive appraisals determining changing physiological responses. Thus, a situation that becomes more familiar is purported to promote a challenge appraisal and challenge CV responses due to enhanced coping perceptions (Blascovich et al., 1999; Quigley et al., 2002). These findings echo Ursin et al’s (1978) research where repeated exposure to stressful tasks led to the development of a coping response.

Another way to manipulate cognitive appraisals is to use psychological skills such as imagery. For example, two studies (Williams & Cumming, 2012; Williams, Cumming, & Balanos, 2010) have used challenge and threat imagery to manipulate cognitive appraisals and CV reactivity in line with the BPS model. Williams et al. (2010) found that challenge imagery emphasising that the participants’ coping resources meet the demands of the situation led to less threat appraisals, positive emotion perceptions, and higher confidence.

Threat instructions emphasising that the athlete's resources did not meet the demands of the situation led to more threat appraisals, negative emotion perceptions, and lower confidence. However, CV data revealed no differences between challenge and threat imagery conditions. Similar scripts were used by Williams and Cumming (2012) who found that the challenge script led to challenge appraisals and the threat script led to threat appraisal. CV data were not recorded, but it was found that those who received the threat script reported their emotional responses as more debilitating for performance compared to those who received the challenge script. In sum, it may be possible to manipulate the psychological components that characterise challenge and threat states via challenge and threat imagery scripts.

There are some caveats that should be considered when investigating the manipulation of cognitive appraisals. The BPS model recognises that appraisals can occur on both conscious and nonconcious levels (e.g., Blascovich & Mendes, 2000; Blascovich, Mendes, Hunter, & Lickel, 2000), with appraisals often being made without awareness, and conscious and unconscious appraisals often occurring in parallel. While it has been established that measurable self-reported cognitive appraisals of a situation can causally determine CV responses as purported in the BPS model, there is evidence that the subconscious awareness of evocative stimuli, thus bypassing measurable cognitive appraisal, can also determine CV responses. For example, when presented with un-reportable (presented outside of conscious awareness) negative religious symbols during a tile counting task, participants who delivered a subsequent speech about their own death exhibited a CV pattern consistent with greater threat compared to participants who were subjected to un-reportable positive religious symbols (Weisbuch-Remington, Mendes, Seery, & Blascovich, 2005). This study provides the most direct evidence in support of nonconscious evaluations eliciting challenge and threat CV reactivity patterns. The appraisals were indirectly manipulated on a nonconscious level, supported by the fact that participants could not report or recall the symbols they were exposed to, but challenge and threat responses were nonetheless elicited. This has ramifications for the measurement of conscious self-reflection (self-report), as current measurement tools may not be sensitive to changes in nonconscious evaluation processes manipulated in Weisbuch-Remington et al's (2005) study, particularly as danger cues can be influential even when outside of conscious awareness (e.g., LeDoux, 1996; Murphy & Zajonc, 1993; Ohman & Mineka, 2001).

1.7.4 Performance

Typically, the contexts in which the BPS model has been examined have used an array of task performances in an effort to induce motivated performance situations required for the elicitation of challenge and threat states. Tasks include word finding (Blascovich et al., 2001; Mendes et al., 2007; Mendes et al., 2008; Scheepers, 2009), arithmetic (Quigley et al., 2002; Tomaka & Blascovich, 1994; Tomaka et al., 1997; Vick et al., 2008), problem solving (Chalabaev, Major, Cury, & Sarrizin, 2009), computer simulated performance (Derks et al., 2011), pattern-recognition and number-categorisation (Blascovich et al., 1999), the Remote Associates Test (Seery et al., 2004; Seery, Weisbuch, & Blascovich, 2009; Seery et al., 2008), and emotional expression (Mendes et al., 2003). Collectively, the findings suggest that challenge is associated with superior performance relative to threat. From the levels of engagement reported in these studies using significant increases in HR and attenuation in PEP as key indicators, the tasks used do indeed produce motivated performance situations. However, actual task performance is often treated as inconsequential, not included in study hypotheses, and ignored in the reporting of results. To explain, some studies are simply not as concerned with performance effects as they are psychological variables (e.g., Blascovich et al., 2001; Derks et al., 2011; Quigley et al., 2002; Seery et al., 2009; Tomaka & Blascovich, 1994; Vick et al., 2008). Furthermore, of the studies that do acknowledge and report performance results, some report that performance is not related to CV reactivity (Scheepers, 2009; Tomaka et al., 1997).

The assertion that challenge reactivity is related to superior task performance is based on few studies, in which fundamental procedural limitations prevent a valid assessment of task performance. For example in most studies (e.g., Blascovich et al., 1999; Chalabaev et al., 2009; Mendes et al., 2007; Mendes et al., 2008; Mendes et al., 2003; Seery et al., 2004; Seery et al., 2009), baseline performance (pre-manipulation/stressor) was not measured. This means that pre-existing task ability prior to experimental manipulation was not taken into account, so it is not known whether CV reactivity is at all related to better or worse performance than normal. It is crucial that, when measuring performance in laboratory contexts such as those adopted in previous research, baseline performance is measured. The failure to do this may suggest that in previous studies individuals naturally better at a task exhibit a challenge response, with causation running from ability to reactivity instead of reactivity to task performance. One exception (Derks et al., 2011) obtained practice performance data for a computer simulated car parking task, but did not use the scores to calculate performance change as performance was not the focus of the study. The authors did however recognise that statistically controlling for pre-existing individual differences in parking performance may have produced performance effects, and also suggest the use of a heterogeneous sample with high task ability.

Although lacking a baseline performance measure, three studies have explicitly examined the relationship between CV reactivity and performance. In a predictive validational study, varsity baseball and softball players (N = 27) gave two speeches (baseball relevant and baseball irrelevant), with CV measures taken during the baseball speeches, and used to predict baseball/softball performance over the season (Blascovich, Seery, Mugridge, Norris, & Weisbuch, 2004). Participants who exhibited stronger challenge CV responses performed better (more runs created over a season) than those who exhibited threat CV responses (less runs created over a season). This study is of particular relevance to the current thesis, as it aligned the physiological patterns of challenge and threat with competitive physical performance. In a similar study it was found that challenge and threat reactivity could predict undergraduate course performance (Seery, Weisbuch, Hetenyi, & Blascovich, 2010). CV reactivity of undergraduates (N = 95), again recorded during a speech task (academia relevant), revealed that participants who exhibited a challenge state performed better in the subsequent course than those whose exhibited a threat state. In short, CV reactivity was able to predict longitudinal performance in athletic and academic settings.

The studies by Blascovich et al. and Seery et al. are positive steps toward understanding the influence of challenge and threat CV reactivity and performance, but have some notable limitations. First, performance over a season/academic year is dependent on a multitude of factors that stretch beyond the acute CV reactivity experienced prior to a speech task. Second, it is difficult to ascertain whether the participants displayed similar reactivity to that experienced in the speech task in subsequent motivated performance situations. For example, talking about a difficult situation is very different to approaching an actual situation. Ideally, CV recordings would be obtained prior to numerous performances during the year, or at least one, to validate the claim that challenge and threat states influenced imminent performance. Third, echoing the limitations of research already discussed, there was no assessment of baseline performance prior to the speeches; therefore there was no indication of whether participants' performance was better or worse than usual.

A recent study (Moore, Vine, Wilson, & Freeman, 2012) assessed motor task performance immediately after CV data were collected, thus addressing some of the limitations identified in previous research (e.g., Blascovich et al., 2004; Seery et al., 2010). Moore et al. allocated participants to either a challenge or a threat condition (using instructional sets) and asked them to perform a golf putting task while a range of physiological measurements were taken (Moore et al., 2012). In line with the BPS model, participants in the challenge condition exhibited greater challenge CV reactivity and challenge appraisals compared to participants in the threat condition. Further, participants who exhibited challenge CV reactivity reported more favourable emotions, performed more accurately in the golf putting task and displayed more effective visual gaze, putting kinematics, and muscle activity than participants who exhibited threat CV reactivity.

These intriguing findings advocate the objective measurement of performance variables and support the notion that a challenge state reflects adaptive responding. For example, more effective visual gaze in a challenge state reflects Walter Cannon's (1939) observations that SAM activity is associated with visual efficiency in the face of a potential stressor (e.g., Cox, 1978). Moore et al. conclude that the kinematic variables may be potential mechanisms for the relationship between challenge and threat CV reactivity and motor performance. Moore et al. also recognise the limitations of adopting a between-groups design. Indeed, in real life sport competitions athletes are not usually artificially oriented towards challenge or threat states. Rather, athletes are faced with a stressor and respond according to personal perceptions of resources compared with the situational demands. In addition, similar to Blascovich et al. and Seery et al. task performance was not compared to baseline levels, although the sample did have skill level homogeneity (novice golfers).

In sum, the link between challenge and threat states and performance is inconclusive at present. Further investigation is required, and in particular whether challenge and threat states relate to performance changes from baseline, or related to performance when prior task ability is controlled for, is yet to be ascertained.

1.7.5 Overall summary

In conclusion of the many studies that have examined the BPS model, clear support for the concepts of challenge and threat can be found. Research has successfully manipulated challenge and threat CV reactivity using instructional sets (e.g., Tomaka et al., 1997), reappraisal (e.g., Jamieson et al., 2012) altered performance environments (Blascovich et al., 1999), and imagery (e.g., Williams & Cumming, 2012). Research has also assessed challenge and threat alongside performance, or has at least used a motivated performance situation to examine challenge and threat CV reactivity. The general consensus, although based on a limited assessment of performance, is that challenge CV reactivity is related to superior performance. This has led to the challenge and threat concepts being adopted to explain how athletes respond to stressors, particularly in competitive achievement settings. In addition, the consideration of the complex psychological states athletes experience prior to competition has been married with the challenge and threat concepts to expand the implications of the BPS model relative to sport performance.

1.8 Challenge and Threat States in Sport

One such expansion is the model of adaptive approaches to competition posited by Skinner and Brewer (2002; 2004), where the influence of trait threat and challenge appraisal styles on event-specific appraisals and emotions are mediated by event-specific coping expectancies. In one study (Skinner & Brewer, 2002), participants given a hypothetical situation making threat appraisals showed reduced coping expectations, positive emotions, and positive perceptions of emotions. However, regardless of coping expectancies or emotion valence, a positive reappraisal of the situation as challenging also led to beneficial perceptions of emotions, thus supporting the challenge appraisal style. It was found that, in relation to an actual event, coping confidence and expectancies were positively associated with trait challenge appraisals and negatively associated with trait threat appraisals. Further, trait threat appraisals were related to negative emotions and more harmful perceptions of state appraisals and emotions with trait challenge appraisals related to beneficial perceptions of appraisals and emotions, and positive emotions.

Skinner and Brewer (2004) applied their findings to the sport context, and provided a review of the antecedents and adaptive consequences of positive emotions. They purported that threat appraisals are related to lower coping expectancies (e.g., Skinner & Brewer, 2002), thus increasing anxiety, and supporting previous research (e.g., Lazarus & Folkman, 1984). However, it is recognised that anxiety is not always debilitative for performance. Indeed, when a negative evaluation is made (causing worry), a high expected ability to avoid harm may lead to a facilitative level of anxiety (Skinner & Brewer, 2004). Thus, within a challenge and threat framework, the perception of an emotional response must be considered when deciding whether the appraisal leads to performance decrements/improvements or not. This concept is further discussed by Jones (1995), who asserted that athletes can interpret emotional responses relating to an upcoming event as either helpful or unhelpful. In the model of debilitative and facilitative competitive state anxiety, Jones (1995) states that an athlete’s perceived control over the environment and the self, a positive belief to cope, and the belief that the goal can be achieved may lead to positive interpretations of anxiety. Thus, it would seem that self-efficacy and perceived control determine how emotions are interpreted prior to performance, and are therefore relevant to the challenge and threat conceptualisations.

With the BPS model applicable to many performance environments including sports (Blascovich et al., 2004), a consideration of the complex variables present within competitive achievement settings, such as those discussed by Skinner and Brewer (2002; 2004) and Jones (1995), was required. To this end, the Theory of Challenge and Threat States in Athletes (TCTSA; Jones et al., 2009) draws together Blascovich and Mendes' (2000) BPS model, Skinner and Brewer's (2004) model of adaptive approaches to competition, and Jones' (1995) model of debilitative and facilitative competitive state anxiety. The TCTSA posits how a combination of psychological constructs interacts to determine challenge and threat states in athletes and how challenge and threat states influence performance in sport. The BPS model and model of adaptive approaches to competition have already been discussed, and their contribution to the TCTSA is clear, both referring to challenge and threat appraisals, and both adopting the distinct patterns of CV responsiveness indicative of an individual's experience of challenge and threat states. The TCTSA also encompasses the idea that a positive perception of anxiety symptoms is associated with successful performance (Jones, 1995). In brief, the elements taken from the previous theories contribute to a re-conceptualisation of the appraisal process put forth by Lazarus and Folkman (1984).

In the TCTSA it is proposed that the perceived demands a situation places on an individual influences whether it is perceived as stressful or not, and how an individual appraises his or her resources compared to the perceived demands determines whether he or she experiences a challenge or threat state. The TCTSA refers to "demand appraisals" and "resource appraisals" and this distinguishes it from the process outlined by Lazarus and Folkman (1984). In any situation, *demand appraisals* are made about whether, and to what extent, an event prompts perceptions of danger (physical or esteem), uncertainty, and to what extent physical and mental effort is required in order to cope. *Resource appraisals* comprise three interrelated constructs; self-efficacy, perceptions of control, and goal orientation (Jones et al., 2009), extended from the BPS model (Blascovich & Tomaka, 1996), model of adaptive approaches to competition (Skinner & Brewer, 2004), and the model of debilitative and facilitative competitive state anxiety (Jones, 1995). More precisely, self-efficacy is important in all three models, control is important in the BPS model and the model of debilitative and facilitative competitive state anxiety, and goal orientation is important in the model of adaptive approaches to competition. Jones et al. (2009) suggest that high levels of self-efficacy, high perceived control and a focus on approach goals, represent sufficient resources to cope in a motivated performance situation and are therefore indicative of a challenge state. Conversely, low levels of self-efficacy, low perceived control and a focus on avoidance goals, represent insufficient resources to cope in a motivated performance situation and are indicative of a threat state. To gain a greater understanding of the TCTSA and the determinants of challenge and threat states, each resource appraisal will be discussed separately.

1.8.1 Self-efficacy

Self-efficacy beliefs are judgments of what an individual can accomplish with his or her skills (Bandura, 1986). Based on Bandura's (1997) framework, self-efficacy has established robust supporting evidence within peak performance literature and has been positively associated with adherence (Bungum, Dowda, Weston, Trost, & Pate, 2000), effort and persistence (Wood & Bandura, 1989), self-competence (Weiss & Ferrer-Caja, 2002), and performance (Gould, Horn, & Spreeman, 1983; Treasure, Monson, & Lox, 1996; Weiss & Ferrer-Caja, 2002). Bandura (1986) posited four sources of self-efficacy; performance accomplishments, vicarious experiences, verbal persuasion, and physiological states, with Maddux (1995) suggesting that imaginal experiences and emotional states may also contribute to self-efficacy. Jones et al. (2009) suggested that self-efficacy is an important part of the resource appraisal process because it fuels the perception that an individual can cope with the demands of a situation. It should also be noted that self-efficacy is responsive to stressful situations (Bandura, 1994), thus indicating that while self-efficacy determines stress responses via resource appraisals, stress responses can also influence self-efficacy. For example, drawing on the model of debilitative and facilitative competitive state anxiety (Jones, 1995), an individual who perceives the physiological symptoms of stress negatively will interpret the symptoms as a sign that they are not efficacious about the situation, and therefore are unlikely to deem themselves capable of coping with the demands. An individual who believes they have the skills and resources to cope with a situation will experience a challenge state, as long as they also perceive that they have sufficient control over the situation (Bandura, 1997).

1.8.2 Perceived Control

Control is a central part of self-efficacy. Control is also mentioned as a dispositional factor in the BPS model. Skinner (1996) purported three elements of control; objective control, perceived control, and experiences of control, with perceived control deemed the most powerful predictor of functioning out of the three (Skinner, 1996). Perceived control refers to the beliefs an individual has about how much control is available, and fits in well with the perception driven subjectivity of the psychophysiological stress response in general (e.g., interpretation is the common denominator of the stress response; Wolff, 1953). Objective control refers to how much control is actually available, but arguably has to involve an element of perception for it to become meaningful for an individual in any situation. Experiences of control refer to the feelings of the individual in the situation, influenced by external conditions, subjective interpretations, and individual actions, thus also influenced by perception. In achievement settings, an individual may feel they have adequate skills to perform a given task well, but may not think they will be given the opportunity to perform that task, thus perceiving high self-efficacy but low control. Only if the individual fixates on the uncontrollable aspect will a threat state prevail. If the individual focuses on the aspects they can control, a challenge state will prevail (Jones et al., 2009). Indeed, a relationship has been found between perceptions of control and CV reactivity when under stress. It has been found, that a less robust CV response (increases in heart period, PEP and respiratory sinus arrhythmia) to a video game stressor can be predicted by higher perceptions that powerful others often controls events (Weinstein & Quigley, 2006).

1.8.3 Goals

Goals play an important part in athletes' responses to competitive sport settings, and can have both a promoting and deleterious effect on well-being, potentially mediating the appraisal of stressors (Holt & Dunn, 2004). In the achievement goal theory (Roberts, Treasure, & Conroy, 2007), achievement behaviours are observable through two distinct types of goal; mastery and performance goals. Mastery goals focus on developing competence through mastering tasks and task involvement, whereas performance goals focus on demonstrating competence relative to others and an ego involvement (Dweck, 1986). The TCTSA draws on this theory and represents a 2X2 achievement goal framework that comprises mastery and performance achievement goals, aligned with either goal approach or goal avoidance (Elliott & McGregor, 2001). Approach goals reflect striving for competence and avoidance goals reflect a drive to avoid incompetence. Thus, four types of goal achievement emerge, performance approach goals (PAp), performance avoidance goals (PAv), mastery approach goals (MAp), and mastery avoidance goals (MAv). According to the theory (Elliott & McGregor, 2001), PAp goals reflect a motivation to be seen as more competent than another person, and PAv goals reflect a motivation not to be regarded more incompetent than another person. MAp goals reflect a motivation to appear competent in relation to self-referenced targets and MAv goals reflect a motivation to avoid incompetence in relation to self-referenced targets.

Relative to challenge and threat states, research has found that students holding mastery and PAp goals tended to view an upcoming exam as a challenge, while students holding PAv goals tended to view the exam as a threat (McGregor & Elliott, 2002). Concerning an upcoming sport performance, PAp goals have also been positively related to both challenge and threat appraisals, but more strongly associated with threat (Adie, Duda, & Ntoumanis, 2008). Further, MAp goals have been strongly associated with challenge appraisals of a sport competition, with MAv goals strongly predicting threat appraisals (Adie et al., 2008). More recently, PAp and PAv goals have been examined alongside CV reactivity, with participants split into two instructional performance groups; exceptionally strong (PAp) and exceptionally weak (PAv; Chalabaev et al., 2009). It was found that, in relation to a problem solving task, participants in the PAp group performed better than the PAv group, displayed a CV pattern depicting a challenge state, and reported greater feelings of challenge. Participants in the PAv group displayed a CV pattern depicting a threat state, but did not report greater feelings of threat. The disparity between CV reactivity and self-reported cognitive appraisals lends support to Blascovich and Mendes' (2000) suggestion that challenge and threat states may be best measure physiologically due to potential unconscious underlying mechanisms.

From the research outlined thus far, it can be summarised that individuals with avoidance goals will view an upcoming event as a threat and display the CV characteristics of a threat state, while those with approach goals are more likely to view the event as a challenge and display the CV characteristics of a challenge state. Aligned with the other concepts comprising the resource appraisals; in a challenge state an individual can direct their self-efficacy and perceptions of control towards a more purposeful outcome than simply avoiding incompetence, with challenge CV responsiveness enabling them to mobilise sufficient resources to realise this goal (Jones et al., 2009).

1.8.4 Physiological and Performance Components of the TCTSA

The TCTSA adopts the resource appraisals therefore purporting a different appraisal process than that of the BPS model (Blascovich & Tomaka, 1996). However, the TCTSA does subscribe to the same CV indicators that characterise challenge and threat as put forth in the BPS model. In the TCTSA, challenge and threat states not only have their own set of physiological and psychological associates, but also have differing performance consequences and outcomes in relation to sport. As in the BPS model, a challenge state is characterised by increased SAM activity accompanied by an increase in catecholamine release, indexed by increased HR and CO (i.e., cardiac activity), attenuated PEP, and decreased TPR. In essence, a challenge state promotes efficiency of energy (glucose) delivery and use due to increased blood flow to the brain and muscles, higher blood glucose levels (fuel for the nervous system) and an increase in free fatty acids that can be used by muscles as fuel (e.g., Dienstbier, 1989). Therefore, a challenge state facilitates improved decision making, effective and maintained cognitive function, decreased likelihood of reinvestment, efficient self-regulation, and increased anaerobic power; all of which are likely to lead to successful sports performance (Jones et al., 2009).

In a threat state increased SAM activity is accompanied by increased PAC activity, and subsequent cortisol release. Thus, increased HR and attenuated PEP occurs, but with an increase or stabilisation in TPR, and a small increase or stabilisation in CO. Thus, in a threat state SAM activity is tempered and therefore efficiency of energy use does not occur as blood flow to the brain and muscles is not increased and the mobilisation of usable energy is slower than in a challenge state (e.g., Dienstbier, 1989). Therefore, a threat state leads to ineffective decision making and cognitive function, increased likelihood of reinvestment, inefficient self-regulation, and decreased anaerobic power (compared to a challenge state); all of which are likely to lead to unsuccessful sports performance (Jones et al., 2009). In short, in a challenge state, SAM activation is fast-acting and represents the mobilisation of energy for action (fight or flight) and coping. A threat state accompanies slow-acting PAC (and SAM) activation and represents a 'distress system' associated with perceptions of actual harm (Blascovich & Tomaka, 1996).

1.9 Summary and Aims of Thesis

Research investigating how individuals respond to stressors, or motivated performance situations, has elucidated two patterns indexed using CV reactivity. The BPS model and the TCTSA describe these two patterns as challenge and threat states, which have been empirically validated many times in research. Theory and some research asserts that a challenge state is related to superior performance in motivated performance situations, compared to a threat state. However, the relationship between challenge and threat states and performance has been examined unsystematically and with notable methodological limitations. The present programme of research initially aims to address previous research limitations to more robustly assess the notion that challenge and threat states are related to performance outcomes. In this thesis it is possible to examine the relationships between challenge and threat states and performance using self-report and cardiographic methods validated in previous research (e.g., Blascovich, Mendes, Vanman, & Dickerson, 2011).

This thesis adopts the TCTSA as a framework to first examine the relationships between challenge and threat states and changes in performance from baseline levels, and the performance of elite athletes. The TCTSA suggests that a challenge state should accompany superior performance compared to threat, but this assertion has not been tested with baseline performance levels taken into account and has not been examined with elite athletes. If as predicted a challenge state is related to superior performance, ways in which a challenge sate can be promoted may be valuable. Therefore, secondly this thesis will assess whether challenge and threat states can be manipulated using the resource appraisals while maintaining perceptions of task importance as proposed in the TCTSA for the first time. Specifically, differing instructional sets will be used to promote either high (challenge) or low (threat) resource appraisals. To explain, this thesis will assess whether challenge framed task instructions elicit a challenge state and whether threat framed task instructions elicit a threat state.

This thesis extends previous research (e.g., Blascovich et al., 2004) by adopting methodological approaches that allow CV reactivity to be related to changes in performance from baseline levels. As noted previously, research has failed to do this, even though determining normal performance levels is necessary in understanding performance changes in motivated performance situations. As well as assessing performance changes from baseline, this thesis adopts the TCTSA as a framework to examine the psychophysiological variables associated with challenge and threat states, in order to examine the associations between psychological states, emotional states, and CV reactivity. The TCTSA has not yet been fully examined in the literature so this thesis offers an important extension of the research area. Gaining an understanding of how individuals react psychophysiologically in motivated performance situations, whether that reaction is helpful for performance or not, and whether those reactions can be manipulated, could be valuable for athletes and sport psychologists. By being able to identify the state in which an individual approaches an important event (challenge or threat) it may be possible to predict success or failure and formulate strategies (via task instructions for example) to help individuals better approach those situations.

1.9.1 Aims

This thesis builds on previous research examining the relationship between challenge and threat states and performance, and research assessing the influence of task instructions on challenge and threat states. This thesis also adds to previous literature exploring the relationships between CV reactivity, psychological, and emotional states. The aims of this thesis are:

1) to examine the relationship between challenge and threat states and changes in cognitive performance from baseline levels;

2) to examine the relationship between challenge and threat states and changes in motor performance from baseline levels;

3) to examine the relationship between challenge and threat states and sport performance in elite athletes;

4) to explore the use of task instructions aimed at either promoting or minimising resource appraisals as outlined in the TCTSA, while maintaining task importance, to manipulate challenge and threat states in a competitive situation; and

5) to explore the use of task instructions aimed at either promoting or minimising resource appraisals as outlined in the TCTSA, while maintaining task importance, to manipulate challenge and threat states in a physically demanding situation.

CHAPTER 2: CARDIOVASCULAR INDICES OF CHALLENGE AND THREAT STATES PREDICT COMPETITIVE PERFORMANCE

2.1 Introduction

Chapter 1 outlined theory and research that described and explained how stress is proposed to influence performance in motivated performance situations. The influence of psychological stressors on performance has been explored in a range of contexts, such as work, sport, and academia (e.g., Beilock & Ramirez, 2011; Hardy & Parfitt, 1991; Masters & Maxwell, 2008). In a motivated performance situation an individual must exert effort to achieve goals that are self-relevant or important (Seery, 2011; Seery et al., 2009), therefore competitive tasks where performance is scrutinised and compared to peers may provide a useful context within which the relationship between stress and performance can be examined (Harrison, Denning, Easton, Hall, Burns, Ring, & Carroll, 2001; Salvador, 2005). The present chapter reports two studies in which competition is used to explore the relationships between CV reactivity indexing challenge and threat states and performance.

One approach that elucidates how CV responses in motivated performance situations reflects either a helpful or unhelpful approach is the BPS model of challenge and threat (Blascovich & Mendes, 2000; Blascovich & Tomaka, 1996). Lazarus and Folkman (1984) have theorised that motivated performance situations can be appraised as a challenge, a threat, or sometimes both. Building on Lazarus and Folkman's work and informed by the work of Obrist (1981) and Dienstbier (1989), in the BPS model a challenge state is experienced when sufficient, or nearly sufficient, resources to meet the demands of a situation are perceived, whereas a threat state is experienced when insufficient resources to meet the demands of a situation are perceived (Blascovich & Mendes, 2000; Blascovich & Tomaka, 1996). Demand appraisals include the perception of danger, uncertainty and required effort in a situation. Resource appraisals relate to perceived ability to cope with the demands of a situation and include skills, knowledge, abilities, dispositional factors and external support available to a person (Blascovich, Mendes, Tomaka, Salomon, & Seery, 2003). These demand and resource appraisals are reflected in two distinct patterns of CV reactivity that distinguish challenge and threat.

In the BPS model it is proposed that challenge is accompanied by increased catecholamine output (epinephrine and norepinephrine) indicating SAM activity. This is evidenced by changes from resting baseline in four CV indices. In challenge this is increased HR and CO, attenuated PEP, and decreased TPR. Increased HR and attenuation of PEP from baseline indicates motivation to engage in the task (e.g., Obrist, 1981). A challenge response is proposed to promote efficient energy use through increased blood flow to the brain and muscles, higher blood glucose levels (fuel for the nervous system) and an increase in free fatty acids that can be used by muscles as fuel (e.g., Dienstbier, 1989). Threat is similarly marked by increased SAM activity, but is also characterised by increased PAC activity, accompanied by cortisol release. This is also evidenced by changes from resting baseline in four CV indices; increased HR and attenuated PEP, but with an increase or stabilisation in TPR, and minimal changes in CO. Consequently, compared to challenge, the mobilization of energy is less efficient as blood flow to the brain and muscles is restricted (e.g., Dienstbier, 1989). In short, both challenge and threat are evidenced by increased HR and decreased PEP reactivity, which are indicators of motivated performance. In challenge, the proposed underlying SAM activation is fast-acting and represents the efficient mobilisation of energy for action, reflected by increased CO and decreased TPR reactivity. Threat reflects PAC (and SAM) activation and is considered a ‘distress system’ characterised by decreased CO and increased TPR reactivity (Blascovich & Mendes, 2000). In sum increased HR and attenuation of PEP from baseline indicates motivation to engage in the task while changes from baseline in CO and TPR are the key indices of challenge and threat (Blascovich & Tomaka, 1996; Seery, 2011).

Recently the BPS model has served as a basis for the TCTSA (Jones et al., 2009), that provides a second framework for the present study. The TCTSA outlines the specific constructs that underpin challenge and threat states and the nature of accompanying emotions. TCTSA proposes that prior to competition high levels of self-efficacy, perceived control, and a focus on approach goals underpin a challenge state, while low levels of self-efficacy, perceived control, and a focus on avoidance goals underpin a threat state. These resource appraisals have been manipulated to induce challenge and threat states (e.g., Seery et al., 2009; Tomaka et al., 1997, Study 1), although comparatively little research has explored whether a person's self-reported resource appraisals relate to the CV responses indicative of challenge and threat states. In one study avoidance goals were associated with threat CV reactivity and poorer problem solving performance, compared to approach goals (Chalabaev et al., 2009). However, in contrast to what might be expected, self-efficacy has been associated with CV responses indicative of a threat state (Hoyt & Blascovich, 2010).

The TCTSA also proposes that positive emotions will typically, but not exclusively, be associated with a challenge state and negative emotions will typically, but not exclusively, be associated with a threat state. In one study for example, while individuals who displayed a CV reactivity pattern representing threat experienced increased negative affect, those displaying a CV reactivity pattern representing challenge reported less negative affect and a tendency towards positive affect when asked to complete a mental arithmetic task (Schneider, 2008). In another study, CV reactivity consistent with a challenge state was associated with higher levels of anger in participants who experienced social rejection (Mendes et al., 2008). Although differences in the intensity of emotions experienced by individuals in a challenge state compared to a threat state may be inconsistent, the TCTSA proposes that those in a challenge state will perceive their emotions as helpful for upcoming performance and their emotions in a threat state as unhelpful for upcoming performance (e.g., Skinner & Brewer, 2004).

It is the perception of situational demands and personal resources in a situation (e.g., arriving at an examination hall) that elicits CV reactivity of either a challenge or threat state, which reflects an individual's psychological approach to a situation. In the TCTSA a challenge state facilitates improved decision making, effective and maintained cognitive function, decreased likelihood of reinvestment, efficient self-regulation, and increased anaerobic power; which are likely to lead to successful performance. A threat state leads to ineffective decision-making and cognitive function, increased likelihood of reinvestment, inefficient self-regulation, and decreased anaerobic power (compared to a challenge state); which are likely to lead to unsuccessful performance (Jones et al., 2009).

The CV patterns that index challenge and threat proposed in the BPS model and TCTSA have been validated many times empirically (see Blascovich et al., 2011; Seery, 2011 for reviews). Further, the relationship between challenge and threat CV patterns and performance has been examined in a range of tasks such as: word search tasks (e.g., Mendes et al., 2008); arithmetic (e.g., Tomaka et al., 1997); problem solving (e.g., Chalabaev et al., 2009); pattern-recognition and number-categorisation (e.g., Blascovich et al., 1999); university course success (e.g., Seery et al., 2010); and sport performance (Blascovich et al., 2004). Collectively the findings outline a positive association between a challenge CV pattern and performance (and the converse for threat). However, this does not conclusively demonstrate that a challenge CV pattern can predict improved performance; it is possible that individuals who have greater ability at a task may be more likely to respond with a challenge state (e.g., Blascovich et al., 1999). Accordingly the main purpose of the present chapter is to test the BPS and TCTSA's proposal that CV responses indicative of challenge and threat states relate to individuals performing *better* or *worse* than baseline levels. We also build on previous studies exploring the associations between psychological and emotional responses to motivated performance situations and CV reactivity. Study 1 uses a competitive cognitive task (modified Stroop Test), and study 2 uses a competitive motor task (netball shooting). The main aim of both studies is to examine the relationship between CV responses to a description of a motivated performance situation (stressor) and subsequent performance changes from baseline.

2.2 Study 1

The present study contributes to the literature by exploring whether CV patterns that index challenge and threat states relate to individuals performing *better* or *worse* than baseline on a competitive cognitive task. We chose a modified Stroop Test which allowed us to explore decision making and cognitive function (cf. Spreen & Strauss, 1998; Stroop, 1935; von Hippel & Gonsalkorale, 2005), aspects purported in the TCTSA to be influenced by challenge and threat states. Even though the modified Stroop Test used in this study is not a sport task it was competitive in nature, so we anticipated the predictions of the TCTSA would apply. It was hypothesised that greater challenge, indicated by decreased TPR and increased CO reactivity, would predict more accurate and faster responses (better performance) in the modified Stroop Test than greater threat, indicated by increased TPR and decreased/stabilised CO reactivity (e.g., Chalabaev et al., 2009). The present study also contributes to the literature by exploring the cognitive and emotional correlates of CV responses indicative of the challenge and threat states. Based on the TCTSA (Jones et al., 2009) it was hypothesised that CV patterns that index challenge would be positively associated with self-reported appraisals of challenge, self-efficacy, perceived control, a greater focus on approach goals, and higher levels of positive emotions. Conversely, it was hypothesised that CV patterns that index threat states would be positively associated with self-reported appraisals of threat, negatively associated with self-efficacy and perceived control, a higher focus on avoidance goals, and higher levels of negative emotions.

2.3 Methods

2.3.1 Participants

Twenty five (*Female* = 9, *Male* = 16) members of academic staff (*M*age = 33.96 years, *SD*age = 8.99 years) at two Universities in the UK participated; all participants reported being in good health. Ethical approval was granted from the Universities and individual informed consent was obtained prior to data collection (see appendix 1). No inducement was offered to participants for taking part.

2.3.2 Measures

Cardiovascular. A Bio-Impedance cardiograph integrated system (model HIC-3004), along with a BP monitor (Suntech Tango+) was used to measure all cardiac and vascular responses, following guidelines presented by Sherwood (1993). Impedance cardiographic (ZKG) and electrocardiographic (ECG) recordings provided continuous measurement of CV performance. Impedance cardiograph measurement utilised a tetra-polar band electrode configuration (Kubicek, Karnegis, Patterson, Witsoe, & Mattson, 1966) widely used in similar research (see Blascovich et al., 2011). External ECG recordings were obtained using a Lead II configuration (right arm, left arm, and left leg). A Suntech Tango+ Stress Test BP Monitor was used to record continuous non-invasive blood pressure from the brachial artery of the participant's non-preferred arm. CopWin integrated the ZKG, ECG, and BP recordings to provide the four CV indices that differentiate challenge and threat. Specifically, HR, PEP, CO, and TPR were used.

Emotions. The Sport Emotion Questionnaire (SEQ; Jones, Lane, Bray, Uphill, & Catlin, 2005) is a 22-item measure assessing anger (4 items), anxiety (5 items), dejection (5 items), excitement (4 items), and happiness (4 items) and was modified for the present task by asking participants to indicate “how you felt immediately prior to the final test” on a 5-point Likert-scale ranging from 0 (*not at all*) to 4 (*extremely*). Cronbach’s alpha for the SEQ subscales from the current sample were: anger = .41, anxiety = .65, dejection = .67, excitement = .85, happiness = .76. Variables anger (*M* = .08, *SD* = .15) and dejection (*M* = .08, *SD* = .25) were omitted from all subsequent analyses due to low scores. In addition, a single item was added in which participants were asked to indicate how helpful they perceived their overall emotional state to be on a 5-point Likert-scale ranging from 0 (*not at all*) to 4 (*extremely*).

Achievement Goals. The Achievement Goals Questionnaire (AGQ: Conroy, Elliot, & Hofer, 2003) consists of twelve questions with three questions per subscale; Mastery Approach (MAp), Mastery Avoidance (MAv), Performance Approach (PAp), and Performance Avoidance (PAv). The AGQ was modified by asking participants to indicate how they felt immediately prior to the final test. Reponses were made on a 7-point Likert-scale ranging from 1 (*Not at all true*) to 7 (*Very true*). Cronbach’s alpha for the AGQ subscales from the current sample were: MAp = .89, MAv = .73, PAp = .94, PAv = .92.

Self-Efficacy. A single item measured self-efficacy which was: How confident did you feel about performing to the best of your ability in the final Stroop Test? The participants responded by rating the item on a 5-point Likert-scale ranging from 1 (*not at all*) to 5 (*completely*).

Perceived Control. Participants completed a single item in relation to the final Stroop Test, adapted from the Academic Control Scale (Perry, Hladkyj, Pekrun, & Pelletier, 2001) in which participants were asked to rate how much they agree that “The more effort I put into this test, the better I will do.” The item was recorded on a 5-point Likert-scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

Cognitive Appraisal. Participants completed a single item indicating "how challenged or threatened they felt prior to the final test" on a 9-point Likert-scale ranging from -4 (*threatened*) to +4 (*challenged*).

Task Importance. Participants completed a single item indicating "how important doing well in the task was to them" on a 6-point Likert-scale ranging from 0 (*not at all*) to 5 (*very much so*).

Modified Stroop Test Performance. The Stroop Test (Stroop, 1935; modified by Beran, 2006) assesses attentional flexibility by testing individuals' accuracy and speed (latency) in responding to a set of colored words, where the colors of the word either correspond to the meaning of the word or not. For example, the word green may be colored green (congruent), in which case the correct response is green. But if the word green is colored blue (incongruent), requiring the individual to inhibit his or her automatic tendency to read the word, the individual must respond by naming the color of the word (blue), not the meaning of the word. Finally, in the modified version of the Stroop Test that we used, if the word was presented in a rectangle, the color must be ignored, as it is the meaning of the word that is required (incongruent – memory load). This mixture of congruent, incongruent, and incongruent – memory load word/color presentations requires flexible, and increased allocation of, attentional resources influencing response accuracy and reaction time (or latency). In total three colors (red, blue, green) were used in the modified version of the Stroop Test. Two performance variables were available, percentage accuracy and latency (ms).

2.3.3 Procedures

Laboratory set-up. Data collection took place in laboratories on two university campuses. Participants were asked to refrain from participating in heavy exercise in the 24 hours prior to data collection and to refrain from consuming caffeine, food, and sports drinks in the two hours preceding their laboratory appointment. On entry to the lab participants were given a brief outline of the protocol to desensitise them to the environment and demystify the equipment. Participants were informed where the band electrodes, ECG electrodes, and BP cuff would be placed, and shown equipment that recorded CV data (HIC-3004).

Participant preparation. Participants were then asked to clean the skin for electrode placements. The band and spot electrodes were then placed on the participants following relevant guidelines (e.g., Sherwood, 1993). The BP cuff was then placed on the participants' upper non-dominant arm, ensuring that the cuff was comfortable for the participants. The participants were then connected to the cardiogram, after which participants were asked to relax while the experimenter visually assessed the ZKG and ECG signals to ensure they were suitable for recording. Participants were informed that they would undertake four trials (pre-instructions performance) on the Stroop Test, after which there would be a five minute rest period in which CV data would be collected, and that they would then hear a set of audio-taped instructions. Finally, the participants were asked to sit upright and remain as still as possible.

Pre-Instructions Stroop Test Performance. To become familiar with the task and give an indication of performance in the absence of competition, participants undertook four 60-second trials on the modified Stroop Test, with 60-seconds rest between each test. Participants were told to try their best to score highly in each trial and were given two minutes before the first trial to read the instructions for the modified Stroop Test. During the test participants responded as quickly and accurately as possible using three keys on the laptop keyboard which corresponded to the three colours (red, blue, green). The experimenter timed each of the four trials and rest periods.

Cardiovascular and psychological data collection. After the four pre-instruction trials, baseline CV data recording took place for five minutes, at the end of which participants were informed that the task instructions would begin. Then, standardised audio-taped task instructions were delivered, lasting for one minute, designed to induce a motivated performance situation. The instructions comprised demand appraisals in line with the BPS and TCTSA which informed participants that the Stroop Test indicated cognitive ability, that they would be required to complete one final 60-second Stroop Test, that their score in the final test (post-instructions) would be compared to all other participants and publically posted in ranking order, and that they would need to try very hard to perform well. In pilot testing, task instructions engendered CV reactivity indicative of engagement, and similar types of instructions have been used in previous competitive settings as a stressor (e.g., Barker, Jones, & Greenlees, 2010; Hardy, Parfitt, & Pates, 1994; Hardy, Beattie, & Woodman, 2007). Participants were then asked to mentally prepare for the upcoming final test for a further two minutes. See figure 2.1 for diagrammatic representation of the data collection protocol.

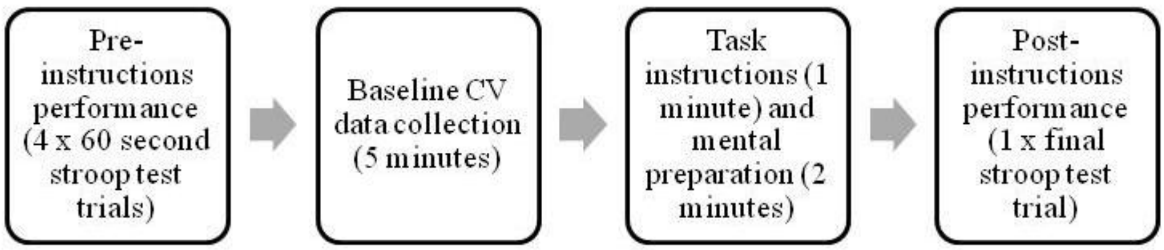

Figure 2.1. Diagrammatic representation of data collection protocols for Study 1.

Post-Instructions Stroop Test Performance and Self-Report Measures. At the end of the post-instructions CV data collection, participants completed the final (post-instructions) modified Stroop Test. After this all self-report measures relating to the task assessing emotion, achievement goals, self-efficacy, perceived control, cognitive appraisal, and task importance were completed (see appendix 1). Finally, the ZKG, ECG, and BP equipment were removed and participants received a full debrief before departing.

2.3.4 Analytic Strategy

Prior to main analyses, Shapiro Wilks tests were performed. If the presence of outliers were indicated then z scores for significant outliers were assessed (Mendes et al., 2003; Seery et al., 2008). Data with z scores greater than two were omitted from further analyses. The analytic strategy for the CV data comprised four steps. First, in line with previous studies using a similar protocol (e.g., Mendes et al., 2003; Seery et al., 2010), HR and PEP averaged across the three minute post-task instructions (one minute task instructions + two minutes mental preparation) phase was compared to HR and PEP in the last minute of the baseline CV data collection phase. This was to determine if the task represented a motivated performance situation for participants. Second, as in similar studies (e.g., Blascovich et al., 2004) hierarchical multiple regression was used in two steps to predict Stroop Test performance (percentage accuracy and latency) with TPR and CO reactivity. CV reactivity scores were calculated for CO and TPR by subtracting the raw CV responses for the last minute of baseline CV data collection phase from the average raw CV responses across the three minute post-task instructions CV data collection phase (Seery et al., 2004; Seery et al., 2009). Third, in line with similar research (e.g., Blascovich et al., 2004; Seery et al., 2010), CO and TPR were combined into a single challenge and threat index, and two separate hierarchical multiple regression analyses were conducted to predict Stroop Test performance (percentage accuracy and latency) with the challenge and threat index. Finally, Pearson’s correlation analyses were conducted to examine the association between psychological components of the TCTSA, CV reactivity, and performance. All multicollinearity, normality and outlier checks met the assumptions necessary for all data analyses.

2.4 Results

2.4.1 Task Engagement

Two separate paired samples *t*-tests were conducted and Cohen's *d* (values of .2 = small, .5 = medium, .8 = large effects; Cohen, 1992) calculated ([*M*time2 - *M*time1] ÷ *SD*time1) to compare the last minute of baseline HR and PEP with HR and PEP averaged across the three minute post-task instruction CV data collection phase for all participants[1]. For HR, there was a significant increase from the last minute (M = 62.12bpm, SD = 16.18bpm) of baseline to the post-task instruction phase (M = 63.79bpm, SD = 15.25bpm), $t(24) = 2.26$, $p < .05$, $d = .10$. For PEP, there was a significant attenuation from the last minute (M = 140.08ms, SD = 10.93ms) of baseline to the post-task instruction phase (M = 135.33ms, SD = 11.79ms), $t(23) = 5.21$, $p < .001$, $d = .43$. HR and PEP reactivity indicated that participants engaged with the competitive task, an important prerequisite for the analysis of challenge and threat CV reactivity (Blascovich et al., 2011). In addition, participants indicated that task success was important ($M = 2.75$, $SD = .99$) to them, $t(23) = 13.62$, $p < .001$, supporting the CV data that participants engaged in the task.

2.4.2 Cardiovascular reactivity and performance indicators

On average, participants CV responses comprised a significant increase in CO, $t(24) = 2.12$, $p < .05$, ($M = 0.14$, $SD = 0.32$); but no change in TPR, $t(22) = 0.75$, $p > .05$, ($M = -11.09$, $SD = 70.56$). Changes in CO ranged from -.43 to .80 ($SD = .14$), while changes in TPR ranged from -187.00 to 106.33 ($SD = 70.56$). Average performance did not change significantly from baseline to the final performance for either percentage accuracy change, $t(23) = 0.27$, $p > .05$, ($M = .52\%$, $SD = 9.33\%$), nor change in latency, $t(23) = 1.78$, $p > .05$, (M = -0.25ms, SD = 0.69ms). To examine the relationships between TPR and CO reactivity

[1] Data from 1 participant was excluded from all PEP analyses as it was identified as a significant outlier using a Shapiro Wilks test.

and performance in competition[2], four separate hierarchical multiple regression analyses were carried out, with post-instructions Stroop Test performance (either percentage accuracy or latency) as the outcome variable, predicted by pre-instructions Stroop Test performance and either CO or TPR[3] reactivity. Pre-instructions Stroop Test performance was entered in step 1, in step 2 either CO reactivity or TPR reactivity was entered. For both percentage accuracy, $F(3, 21) = 3.49$, $p < .05$, $\eta^2 = .33$, and latency, $F(3, 21) = 28.97$, $p < .01$, $\eta^2 = .81$ there was a significant change over the four pre-instructions performances, reflecting a learning effect. For percentage accuracy participants improved from Trials 1 to 3 (Trial 1 $M = 73.51$, $SD = 28.36$; Trial 2 $M = 84.10$, $SD = 18.74$; Trial 3 $M = 92.50$, $SD = 12.30$; Trial 4 $M = 89.80$, $SD = 11.16$); Trials 3 and 4 did not differ significantly, $t(23) = 1.74$, $p > .05$, $d = .22$. Accordingly, pre-instructions performance accuracy was calculated by an average of Trials 3 and 4 only. A similar pre-instructions performance score was adopted for latency. However latency decreased throughout all trials (Trial 1 $M = 4.13$, $SD = 1.69$; Trial 2 $M = 2.86$, $SD = 1.50$; Trial 3 $M = 2.40$, $SD = 1.14$; Trial 4 $M = 2.04$, $SD = 1.08$); including Trials 3 and 4, $t(23) = 2.71$, $p < .02$, $d = .32$. Accordingly, for latency only, data were also analysed using Trial 4 as the pre-instructions performance; findings did not differ in this analysis from those reported below.

Percentage accuracy. In step 1 a significant proportion of variance was accounted for, $R^2 = .42$, $p = .001$. For TPR a significant proportion of variance was accounted for by the addition of step 2, $R^2 = .20$, $p < .01$. Higher TPR was significantly associated with lower accuracy ($b = -.07$, $\beta = -.45$). For CO, a significant proportion of variance was accounted for by the addition of step 2, $R^2 = .12$, $p < .03$. Higher CO was significantly associated with higher accuracy ($b = 11.82$, $\beta = .35$).

[2] Data from 1 participant was excluded from all percentage accuracy change and change in latency analyses as it was identified as a significant outlier using a Shapiro Wilks test.

[3] Data from 2 participants were excluded from all TPR analyses as they were identified as significant outliers using a Shapiro Wilks test.

Latency. In step 1 a significant proportion of variance was accounted for, $R^2 = .56$, $p < .001$. For TPR, the addition of step 2 did not account for a significant proportion of variance, $R^2 = .00$, $p > .05$. For CO, the addition of step 2 did not account for a significant proportion of variance, $R^2 = .01$, $p > .05$.

2.4.3 Challenge and threat index and performance indicators

A single challenge and threat index was calculated by converting the CO and TPR reactivity values into z-scores and summing them. CO was assigned a weight of +1 while TPR was assigned a weight of -1, so that larger values reflected challenge reactivity. Following previous research (Blascovich et al., 2004; Seery et al., 2010), the challenge and threat index allows the pattern of reactivity to be assessed in one hierarchical multiple regression analysis per performance indicator, and accounts for the balance of the relationship between CO and TPR. To examine the relationships between the challenge and threat index and performance in competition, two separate hierarchical multiple regression analyses were carried out, with post-instructions Stroop Test performance (either percentage accuracy or latency) as the outcome variable, predicted by pre-instructions Stroop Test performance and the challenge and threat index. Pre-instructions Stroop Test performance was entered in step 1, and in step 2 the challenge and threat index was entered.

Percentage accuracy. In step 1 a significant proportion of variance was accounted for, $R^2 = .42$, $p = .001$. The addition of the challenge and threat index in step 2 made a significant contribution to the proportion of variance accounted for in the model, $R^2 Change = .16$, $p < .02$. A higher challenge and threat index value was significantly associated with higher accuracy ($\beta = .40$, $p < .02$).

Latency. In step 1 a significant proportion of variance was accounted for, $R^2 = .56$, $p = .001$. The addition of the challenge and threat index in step 2 did not make a significant contribution to the proportion of variance accounted for in the model, $R^2 Change = .004$, $p >$

.05. A higher challenge and threat index value was marginally associated with higher latency (β = .08, p > .05).

2.4.4 Cardiovascular reactivity, psychological components of the TCTSA, and performance

For the correlation analyses (see table 2.1), the discrepancy between pre-instructions and post-instructions performance scores was calculated for accuracy and latency (post-instructions - pre-instructions) and used to produce a percentage change value (performance discrepancy ÷ baseline × 100) for each participant. Percentage performance change was used as a way to standardise the changes in performance and indicated the extent to which post-instructions performance had increased or decreased from pre-instructions performance scores. Pearson's correlation analyses revealed significant positive associations between TPR reactivity and excitement (r = .44, p < .01), along with accuracy change and MAv goals (r = .41, p < .05). There was also a significant negative association between TPR and MAv goals (r = -.42, p < .05), and for change in latency and PAp goals (r = -.41, p < .05). No other correlations were significant and the effect sizes associated with the correlations were small to medium (Cohen, 1992).

2.5 Discussion

The results of Study 1 showed that CV reactions to a psychological stressor (description of the competitive performance in the modified Stroop Test) related to subsequent performance changes from pre-instructions levels (baseline) in the modified Stroop Test. That is, CV reactivity predicted performance accuracy in competition independently of baseline accuracy. Specifically, CV reactivity indicative of a challenge state was associated with greater accuracy whereas CV reactivity indicative of a threat state was associated with poorer accuracy. While CV reactivity was not associated with changes in latency, participants may not have reached a performance plateau on this variable; latency decreased across all four practice trials. As such it is possible that performance under competition was not compared to a true baseline in terms of latency.

Table 2.1. *M* ± *SD* and correlation analyses for performance indicators, psychological variables, and average TPR and CO reactivity in the Modified Stroop Test.

Variable	*M* ± *SD*	Average TPR reactivity	Average CO reactivity	Percentage Accuracy Change	Change in Latency
Percentage Accuracy Change	-.85 ± 9.00	-.57**	.39	-	-.11
Change in Latency	.43 ± .55	.13	.00	-.11	-
Cognitive Appraisal	1.76 ± 1.20	-.22	.29	.22	-.14
Self-Efficacy	3.78 ± .59	.21	-.21	-.11	-.11
Perceived Control	3.48 ± 1.08	-.22	.23	.31	.12
MAp	15.88 ± 4.15	-.19	.24	.06	.18
MAv	11.08 ± 4.06	-.42*	.22	.41*	-.38
PAp	10.44 ± 4.79	-.03	-.09	.28	-.42*
PAv	9.84 ± 4.96	-.20	.02	.32	-.33
Task Importance	2.75 ± .99	.17	-.06	-.21	-.09
Anxiety	.99 ± .62	.19	.04	-.04	-.18
Excitement	.97 ± .62	.44*	-.27	-.08	-.25
Happiness	.76 ± .40	.18	-.08	-.21	-.14
Perceived Helpfulness of Emotional State	1.96 ± 1.06	-.32	.16	.35	-.28

Note. * $p < .05$, ** $p < .01$

Interestingly, taken collectively participants' performance did not change from baseline levels, with some participants performing better and some worse. This finding may reflect that although participants who performed worse experienced performance decrements (M = -7.21, SD = 7.02) greater than the performance increments experienced by the participants who scored better (M = 2.97, SD = 8.00), better performers (N = 15) outnumbered worse performers (N = 9) thus constricting the mean performance value across all participants.

We also tested whether cognitive and emotional measures were correlated with CV responses indicative of challenge and threat states as outlined in the TCTSA. The only consistent associations to emerge were for the MAv goals variable, with higher levels of avoidance related to CV reactivity indicative of a challenge state (reduced TPR) and better performance (increased accuracy and reduced latency). These findings are counterintuitive and contrary the TCTSA and previous research (e.g., Chalabaev et al., 2009), and given the lack of further correlations, may simply be chance findings. However, self-report measures were taken retrospectively to facilitate exploration of the relationship between CV responses to a stressor and performance, potentially obscuring relationships between self-report measures and CV reactivity.

In summary, given the Stroop Test provides a widely recognised measure of attention, decision making, and self-regulation (Spreen & Strauss, 1998; Stroop, 1935; von Hippel & Gonsalkorale, 2005) the findings of Study 1 support the TCTSA's predictions that a challenge state relates to improved decision making and cognitive function. In Study 2, we build on these findings by using a similar competitive setting and instead take self-report measures before the final sport-specific motor task.

2.6 Study 2

In Study 2 we examine whether challenge and threat CV reactivity can predict performance in a netball shooting task. Shooting in netball, as in many competitive sport situations, requires the accurate control and mobilisation of motor movement (Crocker & Hadd, 2005). In the TCTSA, it is predicted that the likelihood for reinvestment, known to disrupt motor performance (e.g., Liao & Master, 2002), will increase in a threat state and decrease in a challenge state. The motor performance of athletes has seldom been examined in relation to CV indicators of challenge and threat, with only one study adopting competitive sport as a performance context. In this study by Blascovich et al. (2004) CV reactivity of 27 varsity baseball and softball players was recorded during a baseball specific speech task which was then used to predict performance over a season (runs created). Results showed that players who showed a challenge response performed better over the season (more runs created), than players who showed a threat response. While Blascovich et al. used runs created over a season as a performance indicator it is possible that this may reflect that individuals who have greater ability at a task respond with a challenge state when asked to consider performing that task (e.g., Blascovich et al., 1999). It did not permit an assessment of whether participants' performance was better or worse than baseline, which is the focus of this present chapter.

It was hypothesised that greater challenge, indicated by decreased TPR and increased CO reactivity, would predict higher scores (better performance) in the netball task than greater threat, indicated by increased TPR and decreased/stabilised CO reactivity. Based on the TCTSA it was hypothesised that CV patterns that index challenge would be positively associated with self-reported appraisals of challenge, self-efficacy, perceived control, a greater focus on approach goals, and higher levels of positive emotions. Conversely, it was hypothesised that CV patterns that index threat states would be positively associated with self-reported appraisals of threat, self-efficacy, perceived control, a higher focus on avoidance goals, and higher levels of negative emotions.

2.7 Method

2.7.1 Participants

Twenty one female netball players (*M*age = 21.09 years, *SD*age = 3.54years, *M*exp = 9.19years, *SD*exp = 4.00years) who participated in varsity teams (*N* = 19) or club teams (*N* = 2); all participants reported being in good health. Ethical approval was granted from the University and individual informed consent was obtained prior to data collection (see appendix 2). No inducement was offered to participants for taking part.

2.7.2 Measures

As in Study 1, CV measures were recorded using a Bio-Impedance cardiograph integrated system (model HIC-3004), along with a BP monitor (Suntech Tango+). Sport emotions were measured via the SEQ (Jones et al., 2005), and Cronbach's alpha for the SEQ subscales from the current sample were: anger = .77, anxiety = .95, dejection = .79, excitement .71, happiness = .89[4]. The single item measure assessing perceived helpfulness of participants' emotional state was omitted in error from the SEQ in this study. Achievement goals were measured using the AGQ (adapted from Conroy et al., 2003) and Cronbach's alpha for the AGQ subscales from the current sample were: MAp = .70, MAv = .89, PAp = .92, PAv = .92. The same measure was also used for perceived control but in relation to the netball shooting task. Self-reported task importance was not assessed but determined solely from CV indicators of task engagement.

Self-Efficacy. A specific Self-Efficacy Scale (SES) was developed based on Bandura's (2006) guidelines, and comprised seven items relating to performance in the netball shooting task. The seven items were: get the ball on target and score highly, stay focussed, mobilise all your resources, perform well even if things get tough, raise the level of your performance, stay motivated, and shoot accurately in the task. The participants responded by rating each item in relation to the extent that they felt confident about executing each of the seven items, with reference to the upcoming performance in the netball shooting task. Responses were made on a 5-point Likert-scale ranging from 1 (*not at all*) to 5 (*completely*). A self-efficacy score was calculated by averaging the 7 scores. Cronbach's alpha for the SES was .89.

Cognitive Appraisal. Participants completed two items pertaining to how threatening and how challenging they expect the task to be. Unlike Study 1, challenge and threat appraisals were not measured along a single dichotomous scale as it is possible that social

[4] Variables anger (M = .53, SD = .11) and dejection (M = .02, SD = .09) were omitted from all subsequent analysis because of their low total scores.

desirability may discourage some athletes from indicating that they are threatened if given the choice between challenge or threat. Indeed, in Study 1 only one participant reported that they felt threatened. Separate challenge and threat items allows for the assessment of challenge *and* threat appraisals, rather than challenge *or* threat appraisals. Scores were recorded on a 6-point Likert-scale ranging from 0 (*not at all*) to 5 (*very much so*).

Performance. Performance data were collected on two occasions, forming baseline performance and final performance. For baseline performance, participants took 48 shots from four different specified positions (i.e., twelve shots from each position) in the shooting area (called the ‘D’). Scores were averaged (48 shots ÷ 4) to form a single score for 12 shots. Final performance involved taking four shots from each position in the ‘D’, totalling 12 shots, which was then comparable to the average baseline scores.

2.7.3 Procedures

Data collection spanned two stages, with informed consent, demographic information, and baseline netball shooting performance obtained at stage one, and CV, psychological, and final performance data obtained at stage two.

Pre-Instructions Netball Shooting Performance. Participants completed the pre-instructions shooting performance in a sports hall. A netball net was set up with three cones indicating the positions from which the throws were to be taken inside the ‘D’. The first position was situated 0.70m from the backline and 2m from the post (diagonally facing the net), the second position was situated 3.6m from the post (directly facing the net), and the third position was situated 2.5m from the backline and 2.6m from the post (diagonally facing the net). Participants were then instructed that they were to throw four shots from each position in sequence, from first to third positions, after which they were to return to the first position and repeat the process three more times (i.e., four times in total), thus totalling forty eight shots. The score for each shot was recorded after each throw, with a score (ball through the net) counting as 2 points, hitting the rim counting as 1 point, and a complete miss counting as 0 points. Participants were made aware of the scoring prior to performance. Pre-instructions performance ended when the participants had taken all 48 shots. After the pre-instructions shooting data had been obtained, participants were allocated a time to attend the CV and psychological data collection session.

Cardiovascular and Psychological Data Collection. Laboratory and participant set-up followed the same protocol as in Study 1, with two exceptions. First, baseline performance data had already been collected, thus CV data commenced when the participant verbally indicated that they were sufficiently relaxed and comfortable (approximately 20 minutes after entering the laboratory). Second, self-report data was collected before post-instructions performance, not retrospectively. Baseline CV data followed the same protocol as in Study 1, and after five minutes of data collection the participant was informed that the task instructions would begin. Then, standardised task instructions regarding the final netball shooting task performance were delivered by the experimenter from a script, lasting one minute. Similar to Study 1 the script was designed to act as a stressor and create a motivated performance situation. In line with the BPS and TCTSA the script informed participants that their scores in the final performance would be compared to all other participants in a league table, that they would need to try very hard to perform well, and that the performance would be video recorded and viewed by a national netball coach. Participants were then asked to mentally prepare for the task for a further two minutes, while CV data collection continued, after which the participant was given the pre-task questionnaires, comprising all self-report inventories (see appendix 2). See figure 2.2 for diagrammatic representation of the data collection protocol.

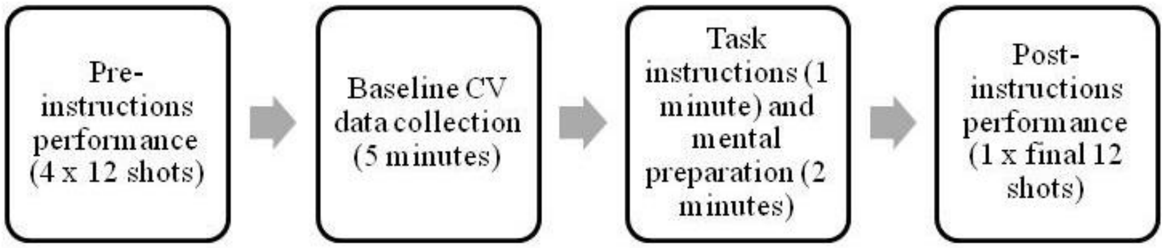

Figure 2.2. Diagrammatic representation of data collection protocols for Study 2.

Post-Instructions Netball Shooting Performance. Once the participants had completed the self-report measures, CV equipment was removed and participants departed having been allocated a time within the next 24 hours to attend the post-instructions performance session in the sports hall. On arrival to the sports hall, participants were directed to the netball and their first throwing position in the ‘D’, and then instructed to begin and that the task would end when they had thrown all 12 shots from three throwing positions. Scores were recorded in the same manner as in the pre-instructions performance data collection. Participants then received a full debrief and departed.

2.7.4 Analytic Strategy

The analytic strategy comprised the same steps as detailed in Study 1 with some additional analyses. As participants were experienced netball players, we controlled for years experience in the regression analyses. Further, as participants in this study were experienced in the sport (if not the specific task), and individuals who have greater ability at a task may be more likely to respond with a challenge state (e.g., Blascovich et al., 1999), we compared the CV reactivity of the ten highest scoring participants with the eleven lowest scoring participants to assess the influence of skill level on CV reactivity.

2.8 Results

2.8.1 Task Engagement

For HR[5], there was a significant increase from the last minute of baseline (*M* = 69.95bpm, *SD* = 9.88bpm) to the post-task instructions CV data collection phase (*M* = 72.21bpm, *SD* = 9.10bpm), $t(19) = 4.28$, $p < .001$, $d = .23$. For PEP[6], there was a significant attenuation from the last minute of baseline (*M* = 135.10ms, *SD* = 9.55ms) to the post-task instructions CV data collection phase (*M* = 132.53ms, *SD* = 9.15ms), $t(19) = 3.76$, $p < .002$, $d = .27$. As in Study 1, participants engaged with the competitive task.

2.8.2 Cardiovascular reactivity and percentage performance change

On average, participants' CV responses comprised a significant increase in TPR, $t(20) = 3.32$, $p < .05$ (*M* = 30.62, *SD* = 42.32); but no change in CO, $t(20) = 0.95$, $p > .05$ (*M* = -0.08, *SD* = 0.39). Changes in CO ranged from -.10 to .87 (*SD* = .39), while changes in TPR ranged from -58.33 to 141.00 (*SD* = 42.50). Average performance did decrease significantly from baseline to the final performance, $t(20) = 2.79$, $p < .05$ (*M* = -10.59%, *SD* = 17.41%). An independent samples *t*-test revealed no difference in TPR reactivity for the ten highest scorers during the pre-instructions shooting performance (*M* = 30.53, *SD* = 23.54) compared to the eleven lowest scorers (*M* = 30.90, *SD* = 58.30), $t(19) = .02$, $p > .05$, $d = .02$. There was also no difference in CO reactivity for the ten highest scorers during the pre-instructions shooting performance (*M* = .00, *SD* = .44) compared to the eleven lowest scorers (*M* = -.16, *SD* = .35), $t(19) = .91$, $p > .05$, $d = .36$. Therefore skill level was not related to challenge and threat CV reactivity. To examine the relationships between TPR and CO reactivity and performance in competition, a hierarchical multiple regression analysis was carried out, with post-instructions performance as the outcome variable, predicted by pre-instructions

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[5] Data from 1 participant was excluded from all HR analyses as it was identified as significant outlier using a Shapiro Wilks test.
[6] Data from 1 participant was excluded from all PEP analyses as it was identified as a significant outlier using a Shapiro Wilks test.

performance and either CO or TPR reactivity. Pre-instructions performance and netball experience were entered in step 1, and either CO reactivity or TPR reactivity was entered into step 2. For netball shooting, $F(3, 18) = 4.47$, $p < .02$, $\eta^2 = .43$, there was a significant change over pre-instructions performances, reflecting a learning effect (Trial 1 $M = 13.00$, $SD = 4.12$; Trial 2 $M = 13.24$, $SD = 4.06$; Trial 3 $M = 14.29$, $SD = 3.61$; Trial 4 $M = 14.76$, $SD = 3.82$). Participants reached a performance plateau in Trials 3 and 4, which did not differ significantly, $t(20) = .82$, $p > .05$, $d = .13$. Accordingly, as in Study 1 pre-instructions performance was calculated by an average of Trials 3 and 4. In step 1 a significant proportion of variance was accounted for, $R^2 = .62$, $p < .001$. For TPR, a significant proportion of variance was accounted for by the addition of step 2, $R^2 = .13$, $p < .01$. Higher TPR was significantly associated with poorer accuracy ($b = -.03$, $\beta = -.36$). For CO, a significant proportion of variance was accounted for by the addition of step 2, $R^2 = .11$, $p < .02$. Higher CO was significantly associated with higher accuracy ($b = 3.45$, $\beta = .33$).

2.8.3 Challenge and threat index and percentage performance change

In step 1 a significant proportion of variance was accounted for, $R^2 = .62$, $p < .001$. The addition of the challenge and threat index in step 2 made a significant contribution to the proportion of variance accounted for in the model, $R^2 Change = .14$, $p < .01$. A higher challenge and threat index value was significantly associated with higher accuracy ($\beta = .37$, $p < .01$).

2.8.4 Cardiovascular reactivity, the psychological components of the TCTSA, and performance

As in Study 1, for the correlation analyses (see table 2.2) percentage performance change was used as a way to standardise the changes in performance and indicated the extent to which post-instructions performance had increased or decreased from pre-instructions performance scores. There were no significant correlations between cognitive and emotional measures, CO and TPR reactivity, and performance. All correlations showed small to medium associations (Cohen, 1992).

Table 2.2. *M* ± *SD* and correlation analyses for percentage performance change, psychological variables, and average TPR and CO reactivity in the netball task.

Variable	*M* ± *SD*	Average TPR reactivity	Average CO reactivity	Percentage Performance Change
Percentage Performance Change	-15.33 ± 16.59	-.58**	.56**	-
Challenge Appraisal	3.71 ± .85	-.17	.22	.23
Threat Appraisal	1.81 ± 1.33	-.25	.31	-.02
Self-Efficacy	3.21 ± .73	.06	-.07	-.03
Perceived Control	4.05 ± .86	.26	-.25	-.18
MAp	16.90 ± 3.20	-.07	.07	.24
MAv	14.76 ± 4.36	-.03	.21	.02
PAp	13.33 ± 4.96	.07	.21	.29
PAv	12.71 ± 6.12	-.05	.21	.28
Anxiety	1.42 ± 1.06	-.26	.27	.14
Excitement	1.92 ± .72	-.25	.08	.10
Happiness	1.63 ± .77	-.12	-.05	.24

Note. ** $p < .01$

2.9 Discussion

The results of Study 2 support that of Study 1 in that CV reactivity predicted performance in competition independent of baseline (pre-instructions) performance, this time in a competitive motor task. As in Study 1 CV reactivity indicative of a challenge state predicted better performance than CV reactivity indicative of a threat state. These results are consistent with the predictions of the BPS and TCTSA and support previous research that CV responses indicative of a challenge state are associated with superior sport performance (Blascovich et al., 2004). Similar to Study 1 the association between CV reactivity and psychological and emotional responses was weak or absent. Again this is contrary to the predictions of the TCTSA and previous research (e.g., Chalabaev et al., 2009). In this study self-report measures were taken immediately after the CV measurements to afford a better test of the relationships between CV reactivity and psychological states, yet significant associations did not emerge.

2.10 General Discussion

Collectively the findings from both studies demonstrate that CV reactivity indicative of challenge and threat states predicted cognitive and motor performance in competitive tasks. Specifically, independently of baseline performance challenge reactivity predicted superior performance in both modified Stroop Test (cognitive) and netball shooting (motor) tasks, compared to threat reactivity. However, in both studies the association between CV reactivity and the psychological and emotional responses outlined by the TCTSA was weak.

The present chapter supports previous research outlining that CV indicators of challenge and threat states relate to performance (e.g., Blascovich et al., 2004; Seery et al., 2004). It also supports theoretical predictions (BPS and TCTSA) that CV indicators of a challenge state should be associated with better performance in a motivated performance situation. It extends research by demonstrating that CV patterns that index challenge and threat states relate to individuals performing *better* or *worse* than baseline. The CV reactivity to a stressor predicted both immediate (straight after CV measures; Study 1) and more delayed (24 hours after CV measures; Study 2) performance.

One explanation for this association is that challenge reactivity reflects a positive psychological approach to the tasks, and threat reactivity reflects a negative psychological approach. Previous research has shown that mental processes drive challenge and threat reactivity (e.g., Tomaka et al., 1993) and the TCTSA asserts that the psychological constructs that accompany a challenge state should facilitate performance (Jones et al., 2009). However, in the current chapter, self-reported psychological factors were not consistently related to CV reactivity or performance. An explanation for this finding is that both studies were underpowered to detect a relationship between psychological states and CV measures. Specifically, the approximate power for these relationships for studies one and two was .42 and .35 respectively, and further, both studies required a sample of 70 participants to achieve a power of .8 for significant medium effects ($r = .30$, $p < .05$) to emerge via correlation analyses (Clark-Carter, 2010). It is also possible that challenge and threat states are more difficult to assess via self-report measures (Chalabaev et al., 2009). The social desirability inherent in self-report measures may also play a role and it is possible that an individual would not admit, to others and themselves a lack of confidence prior to a meaningful event, for fear of a self-fulfilling prophecy (Williams & Krane, 1992). In addition, the BPS model recognises that appraisals can occur on both conscious and nonconcious levels (e.g., Blascovich & Mendes, 2000), with appraisals often being made without awareness, and conscious and unconscious appraisals often occurring in parallel. In fact, there is evidence that the subconscious awareness of evocative stimuli, thus bypassing measurable cognitive appraisal, can also determine CV responses (e.g., Weisbuch-Remington et al., 2005). Perhaps, participants responded to the self-report scales, but were unaware of underlying cognitive appraisals, indeed research has shown that self-reported stress levels may be unrelated to physiological responses (e.g., Martinek, Oberascher-Holzinger, Weishuhn, Klimesch, & Kerschbaum, 2003). Because of this, CV reactivity may be the most effective way of assessing challenge and threat states (Blascovich et al., 2004).

Despite the modest participant numbers the associations between CV reactivity and performance, which was the main focus of the present paper, were consistent across both tasks. It is possible that the reactivity may reflect underlying physiological changes that could potentially have had a direct influence on performance. This assumption is particularly tangible in Study 1 where final performance directly followed data collection. For example, challenge reactivity is proposed to reflect the efficient release and delivery of energy via increase blood flow to the muscles and brain in motivated performance situations (Blascovich & Tomaka, 1996) which may facilitate decision making and attention to relevant cues (Jones et al., 2009). However, this chapter contains no direct evidence of the underpinning mechanisms by which challenge and threat reactivity influences cognitive and motor performance. In other words, it is not known exactly how challenge CV reactivity facilitates performance, or how threat CV reactivity disrupts performance, if at all. Further, the underlying physiological mechanisms for CO and TPR changes in preparation for motivated performance situations are still yet to be fully understood. Although the BPS model and the TCTSA suggest that endocrinal mechanisms cause different CO and TPR reactivity in challenge and threat states, there are alternative explanations. For example, when approaching a motivated performance situation increased muscular tension, as part of an anxiety response, may inhibit vessel dilation and thus TPR increases.

The present chapter demonstrates a relationship between CV reactivity and performance consistently over two different tasks. It is interesting that in Study 1, CV reactivity was only able to predict accuracy in the Stroop Test and not latency. It would appear from these findings that regardless of how long participants took to respond to the words in the Stroop Test, accuracy was negatively affected by the elicitation of threat CV reactivity. Theoretically, one would expect a faster reaction time to be associated with challenge CV reactivity as this would be consistent with approach behaviour (Jones et al., 2009). However, as pre-instructions latency scores did not plateau, it may be possible that lack of relationships between latency and CV reactivity reflects unstable pre-instruction performance levels. What is particularly interesting is that in the netball competition, task performance was predicted by CV reactivity up to a day earlier. Clearly, the CV reactivity elicited by the description of a task is unlikely to persist for 24 hours. So it suggests that CV reactivity elicited at the time of task presentation and during mental preparation may be consistent with the CV reactivity that occurs when the participant engages with the task itself. That is, there may be a consistency of response over time to both preparing mentally for a task and actually engaging in the task.

The limitations of the present studies do outline some potential areas for future research. While both performance contexts adequately elicited CV reactivity indicating engagement (increased HR and decreased PEP; Blascovich et al., 2011), the mean changes in HR were small compared to most challenge and threat research (e.g., Blascovich et al., 2004). Perhaps the use of a real life competitive event may engender clearer changes in HR and allow the relationship between CV responses and self-report measures, and CV responses and performance to be examined in a more ecologically valid manner. A larger sample of participants than used in the current study would allow stronger conclusions to be made as to the relationships between CV reactivity, psychological variables, and performance change from baseline. Specifically, as has been conducted in previous research with fewer variables (e.g., Chalabaev et al., 2009), an examination of how CV reactivity mediates the relationships between *all* psychological variables relevant to the TCTSA and performance would add significantly to the literature. Finally, it was not possible to examine exactly what the participants were thinking about when asked to prepare mentally for the upcoming tasks.

The findings of the current studies offer clear applications to a range of motivated performance situations. In both studies it is the CV reactivity to the psychological stressor (description of an upcoming competition) that is the focus of analyses and not CV reactivity during the task itself. The method we chose indicated how the participants responded to the description of the task demands (competition) in the laboratory, but not how participants felt during the task itself (although in Study 1, the CV reactivity was assessed close to the competitive task). As such our studies are analogous to how people may respond when confronted with a stressor, such as a student turning over an exam paper and viewing the questions for the first time, or athlete being informed of selection for an important end of season game. The present studies suggest CV reactivity to a stressor not only predicts performance when the task is imminent (Stroop Test) but also when the task is some time away (netball task). This suggests that for the students in an exam and the athletes informed of selection, CV reactivity to the initial information may be predictive of performance. An implication of this finding is that strategies that promote challenge under stress may be helpful for performance. For example, research has successfully shown that challenge cognitive appraisal and CV reactivity can be elicited through the implementation of imagery (Williams et al., 2010), and task instructions (Tomaka et al., 1997).

To conclude, these are the first studies to show that challenge and threat CV reactivity are associated with performance change from baseline in competitive cognitive and motor tasks. Specifically, challenge reactivity predicted superior performance in both tasks from baseline levels compared to threat reactivity. However, the association between cognitive and emotional states and CV reactivity were weak or absent. Future research could explore the emotional correlates of CV reactivity, assessing broader emotional responses that may accompany challenge and threat states, such as embarrassment and pride (e.g., Kreibig, 2010). The present studies suggest that the assessment of CV reactivity may be a valid way of determining performance in competitive settings, and as such could be used to help form a more complete picture of how able an individual is to reach their potential when facing a motivated performance situation. The next chapter will build on the findings of the present studies by examining the relationships between challenge and threat states and performance specifically in an elite athlete sample and context, where performance in a more ecologically valid and personally relevant task is used.

CHAPTER 3: WHO THRIVES UNDER PRESSURE? PREDICTING THE PERFORMANCE OF ELITE ACADEMY CRICKETERS USING THE CARDIOVASCULAR INDICATORS OF CHALLENGE AND THREAT STATES

3.1 Introduction

Chapter two showed that CV indices of challenge and threat states predicted changes in performance from baseline in both cognitive and motor tasks. Specifically, it was found that challenge CV reactivity predicted improvements in performance compared to threat CV reactivity. Chapter three builds on chapter two by recruiting elite athletes and by employing a performance task that is more relevant to participants, and therefore more ecologically valid.

Competition is stressful (Harrison et al., 2001; Salvador, 2005), and for elite athletes, competitive stress is intensified by the career implications of success and failure, and the scrutiny under which they perform (Jordet, 2009). For an elite academy cricketer, performance scrutiny is unremitting even in training, where the athlete is compared to others for team selection under conditions of high expectation, requiring a continuous investment of substantial effort in the pursuit of successful performance. It is within this stressful academy context (Barker, McCarthy, & Harwood, 2011) that the present study examines whether psychophysiological stress responses predict cricket batting performance under pressure.

In motivated performance situations, such as sport, performance may be disrupted (Seery, 2011). A variety of approaches have described this phenomenon, considering the role of the Autonomic Nervous System in driving physiological arousal (e.g., Catastrophe Theory; Hardy, 1990; Multidimensional Anxiety Theory; Martens et al., 1990). However, whether an elite athlete's CV reaction to psychological stress can predict performance is yet to be fully understood. In the present paper, CV reactivity to a psychological stressor (i.e., verbal description of a cricket Batting Test) is used to predict performance in a cricket Batting Test. That is, individuals' responses to the description of a task are used to predict subsequent performance in the task. The chapter adopts the BPS model of challenge and threat (Blascovich & Mendes, 2000) as a framework. The BPS model, informed by the work of Lazarus (e.g., Lazarus & Folkman, 1984) and Dienstbier (1989), proposes two distinct patterns of CV reactivity that distinguish challenge (adaptive response to stress) and threat (maladaptive response to stress). Providing a secondary framework, and based on the BPS model, the TCTSA (Jones et al., 2009) brings together psychological and emotional factors that underpin an athlete's performance in motivated performance situations.

At the core of the TCTSA is the notion that some athletes excel in motivated performance situations while others fail to perform (Jones et al., 2009). The TCTSA proposes that in competitive situations demand evaluations are made about the extent to which an event prompts perceptions of danger (physical or esteem), uncertainty, and effort (physical and psychological). In the TCTSA resource evaluations determine whether an individual perceives sufficient or insufficient resources to meet the demands of a situation. The resource evaluations comprise three interrelated constructs self-efficacy, perceptions of control, and achievement goals. Specifically, high levels of self-efficacy, perceived control, and a focus on approach goals underpin a challenge state, while low levels of self-efficacy, perceived control, and a focus on avoidance goals underpin a threat state. Evidence linking the resource appraisals to challenge and threat states has emerged in a number of studies (e.g., Chalabaev et al., 2009; Quested et al., 2011).

In the TCTSA challenge and threat states have their own distinct patterns of CV reactivity, adopted from the BPS model and validated many times empirically (for reviews see Blascovich et al., 2011; Seery, 2011). These distinct patterns of CV reactivity are proposed to have differing performance implications. Primarily, the CV indices of challenge and threat are an indicator of an athlete's ability to adapt in motivated performance situations, and therefore may be able to predict performance in competition. A challenge state is accompanied by increased catecholamine output (epinephrine and norepinephrine) indicating SAM activity, which is reflected in increased HR and CO, attenuated PEP, and decreased TPR. This challenge CV reactivity pattern represents an efficient physiological response to stressors, where the energy needed for successful performance (e.g., glucose) is released into the blood, and can reach the brain and muscles efficiently due to decreased vascular resistance and enhanced blood flow (Dienstbier, 1989, 1992). Consequently, a challenge state is proposed to facilitate improved decision making, effective and maintained cognitive function, decreased likelihood of reinvestment, efficient self-regulation, and increased anaerobic power; likely to lead to successful competitive performance (Jones et al., 2009). A threat state is also marked by increased SAM activity, but is accompanied by increased PAC activity, accompanied by cortisol release. Thus, increased HR and attenuated PEP occurs, but with an increase or stabilisation in TPR, and a small increase, decrease, or stabilisation in CO. In this threat CV reactivity pattern Pituitary Adreno-Cortical activity is thought to temper Sympathetic Adreno-Medullary activity, therefore compared to a challenge CV reactivity pattern, efficient energy delivery to the brain and muscles does not occur (Dienstbier, 1989, 1992). Consequently, a threat state is proposed to lead to ineffective decision making and cognitive function, increased likelihood of reinvestment, inefficient self-regulation, and decreased anaerobic power (compared to a challenge state); likely to lead to unsuccessful competitive performance (Jones et al., 2009).

A growing body of research indicates that challenge CV reactivity can predict superior athletic performance compared to threat (e.g., Blascovich et al., 2004; Moore et al., 2012; Chapter 2). Blascovich et al. (2004) found that in response to a speech task about competing, athletes who exhibited stronger challenge CV reactivity performed better over a competitive season, compared to participants exhibiting threat CV reactivity. One recent paper builds on the work of Blascovich et al., in sport. Moore et al. (2012) found that participants with challenge CV reactivity performed more accurately in a golf putting task and displayed more effective visual gaze, putting kinematics, and muscle activity than participants who exhibited threat CV reactivity. In addition, chapter 2 in this thesis showed that challenge CV reactivity was related to better netball shooting from baseline levels, performed 24 hours after CV data collection. In sum challenge CV reactivity is associated with superior athletic performance.

The present study examined whether challenge and threat CV reactivity to a stressor (description of upcoming pressured Batting Test) can predict subsequent performance of elite cricketers in a pressured Batting Test. This study contributes to the extant literature in two main ways. First, the current study uses a skilled population, elite academy cricketers (comprising the top 30 players in their age group in the UK and 12 players from a professional county cricket club), building on the work of Blascovich et al. (2004) who used high-level varsity athletes. Second, performance is determined by a specifically designed (by national cricket coaches) one-off pressured Batting Test, offering a more valid assessment of how CV reactivity relates to imminent and pressured performance than previous studies. Based on the TCTSA and previous research findings (e.g., Blascovich et al., 2004; Moore et al., 2012; Chapter 2) it was hypothesised that CV reactivity indicating challenge would be associated with self-reported evaluations of challenge, higher self-efficacy, higher perceived control, a greater focus on approach goals, higher levels of positive emotions, and superior performance in the Batting Test, compared to CV reactivity indicating threat.

3.2 Method

3.2.1 Participants

Forty two elite-level (30 national, 12 county) male academy cricketers (*M*age = 16.45years, *SD*age = 1.38years; *M*exp = 8.40years, *SD*exp = 2.44years)[7]. Participants represented two typical roles in cricket; batsmen (*N* = 25) and bowlers (*N* = 17). No inducement was offered to participants for taking part. All participants reported being normotensive and in good health. Ethical approval was granted from the University and individual informed consent was obtained prior to all data collection (see appendix 3).

3.2.2 Measures

Cardiovascular. A Bio-Impedance cardiograph integrated system (model HIC-3004), along with a BP monitor (Suntech Tango+) was used to measure all cardiac and vascular responses, following guidelines presented by Sherwood (1993). Impedance cardiographic (ZKG) and electrocardiographic (ECG) recordings provided continuous measurement of CV performance. Impedance cardiograph measurement utilised a tetra-polar band electrode configuration widely used in similar research (see Blascovich et al., 2011). External ECG recordings were obtained using a Lead II configuration (right arm, left arm, and left leg). A Suntech Tango+ Stress Test BP Monitor was used to record continuous non-invasive blood pressure from the brachial artery of the participant's non-preferred arm. CopWin integrated the ZKG, ECG, and BP recordings to provide the four CV indices that differentiate challenge and threat. Specifically, HR, PEP, CO, and TPR were used.

Emotions. For brevity emotions were assessed using 5 items that assessed the emotions assessed in the Sport Emotion Questionnaire (SEQ; Jones et al., 2005). These were; anger, anxiety, dejection, excitement, and happiness and participants indicated how they felt about the imminent upcoming Batting Test on a 5-point Likert-scale ranging from 0 (*not at*

[7] A further 5 participants data were collected but omitted due to poor quality impedance signal (*N* = 3) and failure to attend that Batting Test (*N* = 2).

all) to 4 (*extremely*). In addition, a single item asked participants to indicate how helpful they perceived their emotional state to be on a 5-point Likert-scale ranging from 0 (*not at all*) to 4 (*extremely*).

Achievement goals. The Achievement Goals Questionnaire (AGQ: Conroy et al., 2003) measures mastery approach goals, mastery avoidance goals, performance approach goals, and performance avoidance goals. The AGQ was reduced to 4 items (one item for each subscale). Participants were asked how they about the imminent upcoming Batting Test on a 7-point Likert-scale ranging from 1 (*not at all true*) to 7 (*very true*).

Self-efficacy. A specific Self-Efficacy Scale (SES) was developed based on Bandura's (2006) guidelines comprising two items; "to what extent do you feel confident that you can score highly" and "to what extent do you feel confident that you can make the right shot decisions/selections?" The participants responded on a 5-point Likert-scale ranging from 1 (*not at all*) to 5 (*completely*).

Perceived control. Adapted from the Academic Control Scale (Perry et al., 2001), participants were asked to rate how much they agreed that "The more effort I put into this test, the better I will do," on a 5-point Likert-scale ranging from 1 (*strongly disagree*) to 5 (*strongly agree*).

Cognitive appraisal. Participants indicated how challenged or threatened they felt about the imminent upcoming Batting Test on a 9-point Likert-scale ranging from -4 (*threatened*) to +4 (*challenged*).

Task importance. Participants were asked how important doing well in the imminent upcoming Batting Test was for them on a 6-point Likert-scale ranging from 0 (*not at all*) to 5 (*very much so*).

The Batting Test. The Batting Test is conducted periodically with all cricketers at national academy level and assesses a cricketer's ability to perform under pressured simulated match circumstances. The Batting Test took place at a top-level training facility on three separate occasions (two for national level athletes and one for county level athletes). Participants performed alone and were given 30 deliveries from a pace bowling machine (set at 80 mph) from which they were to score 36 runs in total. Runs were allocated by coaching staff who decided how many runs each shot was worth depending on the speed and trajectory of the ball in relation to the position of the field. As would be required in an actual match, participants had to run the number of runs allocated by the coaching staff (unless a boundary was scored). The position of the field was formed using cones placed in the following positions: fine leg, deep square leg, mid-wicket, mid-on, third man, point, cover (sweeper), cover (saving one run), mid-off, wicket keeper, and bowler (field reversed for left-handed batsman). For each shot, participants could score zero, one, two, three, four, or six runs. Five runs were deducted for any dismissal (bowled, caught, or Leg Before Wicket), which was decided by the coaching staff, and the participants continued the test until 30 balls had been faced, even if the 36 run target had been reached.

Performance. Batting Test scores for each participant were calculated by adding all runs scored and subtracting five runs per dismissal.

3.2.3 Procedures

Laboratory set-up. Data collection took place in a laboratory at each academy training facility on three separate occasions. Participants were asked to refrain from participating in heavy exercise in the 24 hours prior to data collection and to refrain from consuming caffeine, food, and sports drinks in the two hours preceding their laboratory appointment. On entry to the laboratory participants were given a brief outline of the CV data collection protocol to demystify the process and equipment.

Participant preparation. Participants were prepared for data collection in the same manner as in chapter 2, and followed relevant guidelines (Blascovich et al., 2011; Sherwood, 1993). This included placement of band electrodes, spot electrodes, BP cuff, and attachment to the impedance cardiogram. Participants were then informed that there would be a five minute rest period, after which they would hear a set of audio-taped instructions.

Cardiovascular and psychological data collection. CV data recording continued through the five minute rest period (baseline) and post-task instruction phases. Standardized audio-taped task instructions lasted for one minute and were designed to induce perceptions of a motivated performance situation as in previous studies (e.g., Chapter 2). The instructions informed participants that the Batting Test assesses an ability to perform under pressure, that they would be required to face 30 balls and attain 36 runs in order to be successful, that their total score would be compared to all other participants (ego-threatening). The instructions also stated that coaches would consider their performance in the Batting Test when making future decisions about program selection, and therefore they would have to try very hard to perform well. Similar types of instructions have been successfully used in previous competitive settings as a stressor (e.g., Barker et al., 2010; Hardy, Beattie, & Woodman, 2007). Participants were then asked to mentally prepare for the upcoming Batting Test for two minutes. After the two minutes of mental preparation, participants completed all self-report measures in relation to the imminent and upcoming Batting Test (see appendix 3).

Manipulation check. At the end of the self-report measures, participants were asked to detail their thoughts in the two minutes mental preparation time after hearing the instructions. This item was used to determine the extent participants engaged in task-relevant thoughts while CV data was being recorded. Participants responded by writing their thoughts on a designated answer sheet.

Batting Test performance. After CV and self-report data collection, participants were informed that the test would begin in 30 minutes, during which time they were to change into all necessary batting equipment. When the participants arrived at the nets coaching staff reminded them of the specific rules (30 balls to get 36 runs, 5 run deductions for dismissals) and the field positions. Participants were given two ‘sighters’ (practice deliveries) from the pace bowling machine to help familiarise them with the speed and pitch of the ball. The test began with the delivery of the next ball. After the Batting Test participants received a full debrief.

3.2.4 Analytic Strategy

As in chapter 2 Shapiro Wilks tests were performed prior to main analyses. If the presence of outliers were indicated then z scores for significant outliers were assessed (e.g., Mendes et al., 2003). Data with z scores greater than two were omitted from further analyses. The analytic strategy for the CV data comprised six steps. First, in line with previous studies using a similar protocol (e.g., Mendes et al., 2003; Chapter 2) HR and PEP averaged across the three minute post-task instructions (one minute task instructions and two minutes mental preparation) phase were compared to HR and PEP in the last minute of the baseline CV data collection phase. This was to determine if the task represented a motivated performance situation for participants. Second, differences in CV reactivity and performance were explored between participant level (county academy, national academy) and role (batsmen, bowlers). Third, hierarchical multiple regression was used in two steps to predict Batting Test performance with TPR and CO reactivity. Participants experience, level, and role, was entered in step 1, and either CO reactivity or TPR reactivity were entered into step 2. CV reactivity scores were calculated for CO and TPR by subtracting the raw CV responses for the last minute of baseline CV data collection phase from the average raw CV responses across the three minute post-task instructions CV data collection phase (Seery et al., 2009). Fourth, in line with similar research (e.g., Blascovich et al., 2004; Chapter 2), average CO and TPR reactivity were combined into a single challenge and threat index, and a separate hierarchical multiple regression analyses was conducted to predict Batting Test performance with the challenge and threat index. Fifth, individual differences in the CV reactivity-batting performance relationship were explored by conducting independent *t*-tests examining differences in the self-report variables between participants who performed well in a challenge state with those who did not, and differences in the self-report variables between participants who performed poorly in a threat state with those who did not. Finally, Pearson's correlation analyses were conducted to examine the associations between CV reactivity, self-reported psychological states, and performance. All multicollinearity, normality and outlier checks met the assumptions necessary for all data analyses.

3.3 Results

3.3.1 Task engagement

Two separate paired samples *t*-tests were conducted and Cohen's *d* calculated to compare the last minute of baseline HR and PEP with HR and PEP averaged across the three minute post-task instruction CV data collection phase for all participants[8]. For HR, there was a significant increase, $t(38) = 3.97$, $p < .001$, $d = .20$, from the last minute ($M = 72.54$bpm, $SD = 10.28$bpm) of baseline to the post-task instruction phase ($M = 74.50$bpm, $SD = 10.12$bpm). For PEP, there was a significant attenuation, $t(41) = 4.09$, $p < .001$, $d = .14$, from the last minute ($M = 133.10$ms, $SD = 18.53$ms) of baseline to the post-task instruction phase ($M = 130.46$ms, $SD = 18.13$ms). HR and PEP reactivity indicated that participants engaged in the task, an important prerequisite for the analysis of challenge and threat CV reactivity (Blascovich et al., 2011). In addition, participants indicated that Batting Test success was important to them ($M = 4.30$, $SD = .72$), $t(39) = 37.60$, $p < .001$, and the manipulation check indicated that all participants engaged in task relevant thoughts while thinking about the upcoming Batting Test, supporting CV data suggesting that participants engaged in the task[9].

[8] Data for HR from 3 participants were omitted as they were outliers.
[9] Data for task importance from 2 participants were omitted as they were outliers.

3.3.2 Differences between participants' levels and roles

Independent *t*-tests revealed that there were no significant differences between county academy participants and national academy participants in TPR reactivity, $t(40) = .29$, $p > .05$, CO reactivity, $t(40) = .14$, $p > .05$, or performance, $t(40) = .17$, $p > .05$. In addition, there were no significant differences between batsmen and bowlers in TPR reactivity, $t(40) = .68$, $p > .05$, CO reactivity, $t(40) = 1.27$, $p > .05$, or performance, $t(40) = .46$, $p > .05$.

3.3.3 Cardiovascular reactivity and performance

To examine the relationships between CO and TPR reactivity and performance, two separate hierarchical multiple regression analyses were carried out, with total Batting Test score as the outcome variable (controlling for cricket experience, level, and role) predicted by either CO or TPR reactivity. Level and role were included in step 1 to account for the potential influence of these variables in predicting performance in the regression analyses. Cricket experience, level, and role, were entered in step 1, in step 2 either CO reactivity or TPR reactivity was entered. In step 1 a significant proportion of variance was not accounted for, $R^2 = .05$, $p > .05$. For TPR a significant proportion of variance was accounted for by the addition of step 2, $R^2 = .26$, $p = .001$. Higher TPR was significantly associated with lower total score ($b = -.10$, $\beta = -.51$). For CO, a significant proportion of variance was accounted for by the addition of step 2, $R^2 = .31$, $p < .001$. Higher CO was significantly associated with higher total score ($b = 27.59$, $\beta = .57$).

Challenge and threat index and performance. A single challenge and threat index was calculated by converting average CO and average TPR reactivity values into z-scores and summing them. CO was assigned a weight of +1 while TPR was assigned a weight of -1, so that larger values reflected challenge reactivity. Following previous research (e.g., Blascovich et al., 2004), the index allows the pattern of reactivity to be assessed in one hierarchical multiple regression analysis, and accounts for the interrelatedness of CO and

TPR reactivity measures. To examine the relationships between the challenge and threat index and performance, a hierarchical multiple regression analysis was carried out, with performance as the outcome variable, controlling for cricket experience, level, and role, predicted by the challenge and threat index. Cricket experience, level, and role, were entered in step 1, and in step 2 the challenge and threat index was entered. In step 1 a significant proportion of variance was not accounted for, $R^2 = .07$, $p > .05$. The addition of the challenge and threat index in step 2 made a significant contribution to the proportion of variance accounted for in the model, $R^2 = .41$, $p < .001$. A higher challenge and threat index value (indicating challenge reactivity) was significantly associated with higher total score ($b = 4.61$, $\beta = .65$).

Challenge and threat index, psychological components of the TCTSA, and performance. Pearson's correlation analyses[10, 11] (see table 3.1) revealed significant positive associations ($p < .05$) between the challenge and threat index and helpfulness of emotional state ($r = .36$). In addition, performance was positively and significantly associated with performance approach goals ($r = .35$) and self-efficacy ($r = .33$). All other correlations were non-significant and the effect sizes associated with the correlations were small to medium (Cohen, 1992).

3.3.4 Exploring individual differences in the CV reactivity-batting performance relationship

While in general challenge CV reactivity predicted success and threat CV reactivity predicted poor performance this relationship did not hold for all participants. We explored the role that psychological aspects may play in explaining these individual differences.

[10] Participants data for happiness ($N = 2$), helpfulness of emotion ($N = 1$), performance approach goals ($N = 2$), performance avoidance goals ($N = 2$), mastery approach goals ($N = 1$), mastery avoidance goals ($N = 1$), control ($N = 2$), self-efficacy ($N = 1$), cognitive evaluation ($N = 3$), and task importance ($N = 2$) were omitted as they were outliers.

[11] Variables anger ($M = .00$, $SD = .00$) and dejected ($M = .18$, $SD = .38$) were omitted from all analysis because of their low total scores.

Threat CV reactivity and Batting Test success. Five participants exhibited threat CV reactivity but reached or almost reached (within 2 Standard Errors of mean performance) the Batting Test target score of 36 runs. Self-report scores for the five participants were compared to the seventeen participants that exhibited threat CV reactivity but performed poorly. Independent *t*-tests revealed a significant difference in self-efficacy, $t(20) = .42$, $p < .02$, $d = 1.76$, between the five participants ($M = 4.50$, $SD = .50$) that performed well and the seventeen participants that performed poorly ($M = 3.62$, $SD = .65$). All means, standard deviations and non-significant differences can be seen in table 3.2.

Table 3.1. $M \pm SD$ and correlation analyses for performance, psychological variables, and the challenge and threat index.

Variable	$M \pm SD$	Challenge and threat index	Performance
Performance	27.09 ± 11.80	.64**	-
Anxiety	1.93 ± 1.11	-.07	-.09
Excitement	2.62 ± .88	-.04	-.18
Happiness	2.28 ± .75	.03	-.19
Helpfulness of Emotional State	3.24 ± .73	.36*	.17
Performance Approach Goals	6.63 ± .63	.25	.35*
Performance Avoidance Goals	3.38 ± 1.35	-.09	-.14
Mastery Approach Goals	5.20 ± 1.40	-.10	-.06
Mastery Avoidance Goals	2.98 ± 1.44	-.07	-.01
Control	4.10 ± 1.08	.14	.10
Self-Efficacy	3.84 ± .67	.30	.33*
Cognitive Evaluations	2.31 ± 1.08	.21	.02
Task Importance	4.30 ± .72	-.01	-.19

Note. * $p < .05$, ** $p < .01$

Challenge CV reactivity and Batting Test failure. Six participants exhibited challenge CV reactivity but did not reach or almost reach (within 2 Standard Errors of mean performance) the Batting Test target score of 36 runs. Self-report scores for the six participants were compared to the fourteen participants that exhibited challenge CV reactivity and did reach or almost reach the runs target. Independent *t*-tests revealed a significant difference in performance avoidance goals, $t(17) = 2.25$, $p < .03$, $d = 1.04$, between the six participants that performed poorly ($M = 4.50$, $SD = 1.52$) and the fourteen participants that performed well ($M = 2.92$, $SD = 1.19$). All means, standard deviations and non-significant differences can be seen in table 3.2.

3.4 Discussion

The current study is the first to demonstrate that imminent performance in elite athletes can be predicted by challenge and threat CV reactivity. Specifically, in response to a psychological stressor (description of the Batting Test), challenge CV reactivity predicted superior performance in the Batting Test, compared to threat CV reactivity. However, overall the associations between CV reactivity and self-report responses were weak. It was also found that the small number of participants who exhibited threat reactivity but performed well had significantly higher levels of self-efficacy than participants who exhibited threat reactivity and performed poorly. In addition, a small number of participants exhibited challenge CV reactivity but performed poorly. When compared to participants who exhibited challenge reactivity and performed well, participants who performed poorly had significantly higher performance avoidance goals. Therefore, differences in psychological approach may in part explain the small number of instances of counter theoretical performance effects.

The present chapter supports growing research showing that CV indicators of challenge and threat states relate to athletic performance. This study also supports theoretical predictions (BPS and TCTSA) that CV indicators of a challenge state should be associated with superior performance in motivated performance situations. Importantly, the current chapter extends research by using an elite athlete sample in an imminent and more personally relevant performance setting than used in previous research (e.g., Moore et al., 2012; Chapter 2). Notably, CV reactivity was able to predict performance 30 minutes after CV data collection. This finding adds to research showing that CV reactivity to a stressor (description of an upcoming task) predicts performance in both immediate (Moore et al., 2012) and more delayed competitions (Blascovich et al., 2004; Chapter 2).

The relationship between CV reactivity and performance in the present study, which was the main focus, was consistent and strong. CV reactivity measured the participants' immediate reactions to being told about the upcoming Batting Test, a scenario analogous to situations in which an athlete receives information about an important competition. For example, a cricketer next in the batting order seeing his teammate get dismissed realizing he is next to bat, having to prepare mentally to execute skills and tactics relevant to the specific match situation. In other words, CV reactivity in the minutes following the onset of a psychological stressor is an important indicator of how athletes will subsequently perform. Exactly how CV reactivity exerts an influence on imminent and delayed performance is not evidenced in the present study, but some mechanisms can be postulated.

Table 3.2. $M \pm SD$, and *t*-tests for the individual differences in the CV reactivity-batting performance relationship

	Threat reactivity			Challenge reactivity		
	Performed well	Performed poorly		Performed well	Performed poorly	
Variable	$M \pm SD$	$M \pm SD$	*t*-test	$M \pm SD$	$M \pm SD$	*t*-test
TPR reactivity	39.46 ± 16.21	47.92 ± 36.38	.74	-52.43 ± 53.89	-20.35 ± 12.56	.17
CO reactivity	.19 ± .38	-.12 ± .16	1.89	.15 ± .16	.14 ± .31	.05
Performance	35.20 ± .84	17.00 ± 11.08	6.71**	37.65 ± 2.31	30.00 ± 2.61	6.54**
Anxiety	1.80 ± .84	1.94 ± 1.25	.24	1.64 ± 1.01	2.67 ± 1.03	2.07
Excitement	3.20 ± .84	2.82 ± .73	.99	2.29 ± .10	2.33 ± .82	.10
Happiness	2.40 ± .89	2.38 ± .72	.06	2.08 ± .86	2.33 ± .52	.67
Helpfulness of Emotional State	3.40 ± .89	3.00 ± .89	.87	3.43 ± .51	3.33 ± .52	.38
Performance Approach Goals	6.80 ± .45	6.44 ± .81	.94	6.77 ± .44	6.67 ± .52	.45
Performance Avoidance Goals	2.60 ± 1.14	3.56 ± 1.26	1.51	2.92 ± 1.19	4.50 ± 1.52	2.47*
Mastery Approach Goals	5.80 ± 1.30	5.38 ± 1.45	.58	4.64 ± 1.34	5.50 ± 1.38	1.30
Mastery Avoidance Goals	2.50 ± 1.73	3.00 ± 1.41	.61	2.71 ± 1.33	3.83 ± 1.60	1.63
Control	4.40 ± .89	4.00 ± .97	.82	4.31 ± 1.32	3.67 ± 1.03	1.05
Self-Efficacy	4.50 ± .50	3.62 ± .65	2.78*	4.00 ± .68	3.58 ± .38	1.40
Cognitive Appraisal	2.20 ± .45	2.13 ± 1.02	.16	2.46 ± 1.39	2.60 ± .89	.21
Task Importance	4.40 ± .55	4.44 ± .63	.12	4.08 ± .95	4.33 ± .52	.61

Note. * $p < .03$, ** $p < .001$

It is possible that challenge CV reactivity exhibited in response to the stressor (description of the Batting Test) reflected more helpful thoughts and feelings on approach to the motivated performance situation (e.g., Chalabaev et al., 2009), although self-report data from previous research (e.g., Chapter 2) and the current study does not fully support this assertion. Alternatively, physiological factors could help to explain the performance effects, particularly if the responses to the description of the competition are mimicked in the event itself. For example, muscular tension is likely to be higher in a threat state than in a challenge state (Wright & Kirby, 2003), which has obvious implications for skilled motor performance. Further, Moore et al. (2012) found that compared to a threat state, a challenge state was marked by more effective movement patterns (kinematics) and less muscular activation, widely recognised as contributing to successful motor performance (e.g., Lay, Sparrow, Hughes, & O'Dwyer, 2002). Based on recent findings, a full investigation of the potential psychophysiological mechanisms causing observed performance effects in challenge and threat states is warranted.

In the current study, relationships between CV reactivity and self-reported psychological states were weak and inconsistent. The only significant relationship to emerge was a positive association between the challenge and threat index and helpfulness of emotional states. To explain, higher challenge CV reactivity was related to more helpful perceptions of emotional states prior to the Batting Test. While this finding is in the hypothesized direction, the findings were largely unsupportive of the TCTSA's predictions concerning cognitive and emotional correlates of challenge and threat states. Research testing the predictions of the TCTSA with the regard to the relationship between psychological states and CV reactivity is beginning to emerge (e.g., Williams & Cumming, 2012; Chapter 2) and this growing body of evidence should help to elucidate the relationships between psychological states and CV reactivity, and help to refine the TCTSA.

There were also significant positive associations between Batting Test performance and self-reported performance approach goals and self-efficacy. Specifically, a higher focus on approach goals and higher self-efficacy was related to superior performance in the Batting Test. These findings are consistent with the predictions of the TCTSA, and support much of the sport psychology literature. For example, the positive link between self-efficacy and sports performance is widely recognised (e.g., Bandura, 2006). The positive association between performance approach goals and performance found in the current chapter is also consistent with theory and research (Chalabaev et al., 2009; Jones et al., 2009) and is especially plausible considering the nature of the Batting Test. To explain, performance approach goals reflect a motivation to be seen as more competent that other persons, and with comparison between participants emphasised in the Batting Test instructions prior to performance, it is perhaps unsurprising that a higher focus on performance approach goals was related to better performance. It should be noted that in a cricket academy context, even though the cricketers perform together as a team, comparison between cricketers is ubiquitous and necessary (Barker et al., 2011) to facilitate future academy selection decisions, perhaps reflected by the performance approach goals results in the current chapter.

An intriguing result in the present study was that some participants exhibited threat reactivity but performed well, and some participants in a challenge state performed poorly, representing an important exception to the predictive reliability of challenge and threat CV reactivity. These findings are interesting because they suggest that some individuals, despite exhibiting a challenge or threat state, performed contrary to our expectations and theoretical predictions. Investigation of self-report responses showed that participants who performed well after exhibiting threat CV reactivity had higher self-efficacy, while those who performed poorly after exhibiting challenge CV reactivity had higher avoidance goals. Suggesting cognitions do have a role to play in either inoculating against the influence of threat CV reactivity on skilled performance, or marring the effect of challenge reactivity on performance. This finding is consistent with previous research outlining the interplay between psychological states and emotional responses such as Jones' (1995) model of debilitative and facilitative competitive state anxiety and Hardy's butterfly catastrophe model (Hardy, 1990). It is also consistent with previous challenge and threat research (Hoyt & Blascovich, 2010) which suggests that individuals who exhibit threat CV reactivity but report high self-efficacy may be reacting to the threat of the situation in a way that allows maintained or improved performance. Although interesting, the findings that suggest cognitions may moderate the CV reactivity-performance relationship should be considered cautiously as the analysis lacked statistical power (5 vs. 17 in the threat 'group', and 6 vs. 14 in the challenge 'group'). Future research could aim for sufficient participant numbers to statistically test for the moderation effects of resource appraisals on the CV reactivity-performance relationship.[12]

Despite some significant relationships and interesting findings emerging for self-report data in the current study, the relationships between self-reported psychological states and CV reactivity were weak and inconsistent. These absent associations could be explained in various ways. First, the social desirability inherent in elite sport settings may cause elite athletes to respond in a biased way to questions concerning psychological states (Williams & Krane, 1992). Second, many of the self-reported psychological constructs were measured using shortened versions of the measures they derived from in order to shorten the time between self-report data collection and Batting Test performance. For example, only one item (instead of four) assessed each type of achievement goal, and the SEQ measuring emotions was reduced from 22 items to 5 items, one for each subscale. This shortening may have altered scale reliability and limited participant responses to one opportunity to express their

[12] We conducted a series of regression analyses to examine potential moderation effects of the resource evaluations on the CV reactivity-performance relationship with the sample as a whole, and for the challenge and threat 'groups' separately. No significant moderation effects emerged.

psychological experiences. Third, many authors suggest that self-reports are a poor window into how individuals process consciously available evaluations, and no window at all into processes that may occur unconsciously, such as the immediate evaluation of a stressor (e.g., LeDoux, 1998; Blascovich & Mendes, 2000). There is evidence that the subconscious awareness of evocative stimuli, thus bypassing measurable cognitive evaluation, can determine CV responses (e.g., Weisbuch-Remington et al., 2005), and numerous challenge and threat studies illustrate a disjunction of CV responses with those that are under conscious control (e.g., self-report; Mendes, Blascovich, Lickel, & Hunter, 2002). Finally, challenge and threat states may be more difficult to assess via self-report measures than through CV reactivity (Chalabaev et al., 2009). Therefore, it is still important that techniques that do not depend on verbal reports are used (Scherer, 1993), or that questionnaires be less susceptible to response bias, or be more able to assess deeper cognitions. For instance perhaps a measure of dispositional evaluations (e.g., Roesch & Rowley, 2005) is necessary, alongside specifically validated measures that assess challenge and threat states in athletes.

There are some limitations to the present study which outline potential areas of future research. Unlike in chapter 2, we were unable to measure baseline batting performance. However, the participants were selected because of their elite athletic status and it was possible to statistically control for differences in cricket experience and level as recommended in previous research (e.g., Derks et al., 2011). An obvious development would be to obtain baseline performance in an elite athlete sample so changes in performance from the norm can be ascertained. Also, the Batting Test was rendered meaningful for the athletes by describing the evaluative circumstances of the test, and by creating a pseudo match scenario. But actual competitive performance is likely to be more meaningful to athletes, and therefore potentially more stressful, which may influence CV reactivity and change its relationship to psychological and performance variables. While the performance context adequately elicited CV reactivity indicating engagement (increased HR and decreased PEP; Blascovich et al., 2011), the mean changes in HR were small compared to other challenge and threat research studies (e.g., Blascovich et al., 2004). Alternatively, the knowledge of a 30 minute gap between stressor and performance may have had a diminishing affect on HR that may not occur if CV data were collected directly prior to athletic performance (e.g., Epstein & Fenz, 1965; Moore et al., 2012). Finally, it may be suggested that a better method to explore challenge and threat states and performance would be to create challenge and threat conditions similar to previous research (e.g., Moore et al., 2012; Tomaka et al., 1997) and examine the between conditions performance effects. However, in competition, individuals are not usually artificially oriented to challenge or threat states, but appraise the situation quickly and often unconsciously (e.g., LeDoux, 1998). Therefore we felt that inducing psychological stress in the participants and then exploring their unconditioned responses was more realistic and ecologically valid.

The findings of chapter 3 have implications for the assessment and development of elite athletes. CV reactivity measured 30 minutes prior to an important competition predicted athletic performance offering clear applications to sport settings, especially for sport psychology practitioners. This type of assessment eliminates the social desirability inherent in self-report measures. Alongside other psychological and behavioural screening tools, a psychologist can form a detailed picture of when athletes will flourish, or succumb under pressure. Further, by measuring an athlete’s CV reactivity in relation to their thoughts about an upcoming competition, it is possible to determine how the athlete will approach that situation, prompting interventions to promote a challenge state. For example, research has shown that individuals encouraged via instructional sets to think of themselves “capable of meeting that challenge” (p. 72), approach tasks as a challenge and exhibit challenge CV reactivity (Tomaka et al., 1997). In addition, athletes undertaking challenge imagery appraise upcoming tasks as a challenge, experience facilitative anxiety, and feel more in control (e.g., Hale & Whitehouse, 1998; Williams & Cumming, 2012; Williams et al., 2010). Specifically, in one study (Williams et al., 2010) a challenge imagery script emphasized that the athlete's resources met the demands of the situation, that they could be confident (high self-efficacy), demonstrate competence (high perceived control), and had a lot to gain (approach goals). Results showed that the challenge script led athletes to feel that their emotional response was more helpful for performance, were more confident, and appraised the situation as less threatening.

For athlete development, CV reactivity information could help athletes to better understand their responses to pressure thus encouraging them to seek assistance and guidance in strategies to enhance their ability to deal with pressure. It is also possible to assess the effects of stress inoculation on athletes by repeatedly exposing them to pressure situations such as the Batting Test and recording CV reactivity prior to their performance. In fact, research has shown that prior task exposure (Kelsey, Blascovich, Tomaka, Leitten, Schneider, & Wiens, 1999) and stress inoculation programmes integrating visualisation, self-talk, and relaxation strategies (Mace & Carroll, 1989) can diminish the effects of SAM activity on the heart, which may render the athletes more relaxed for performance under pressure. Indeed, prior task exposure may have had an influence on the results of the present study and future research should obtain prior exposure information to help statistically control for it in analyses.

To conclude, this is the first study to show that challenge and threat CV reactivity can predict imminent sport performance in elite athletes. Specifically, challenge CV reactivity predicted superior performance in a pressured cricket Batting Test compared to threat CV reactivity. It was also found that participants who exhibited threat CV reactivity but performed well, reported greater self-efficacy than participants who exhibited threat CV reactivity but performed poorly. Also, participants who exhibited challenge CV reactivity but performed poorly, reported higher avoidance goals than participants who exhibited challenge CV reactivity and performed well. Sport psychologists could explore strategies to promote a challenge state, given the evidence beginning to emerge attesting to the benefits of a challenge state for performance. The present chapter suggests that the assessment of CV reactivity may be a valid way of predicting pressured sport performance in elite athletes, and as such could be used to help form a more complete picture of how able an athlete is to reach their potential in motivated performance situations.

CHAPTER 4: MANIPULATING CARDIOVASCULAR INDICES OF CHALLENGE AND THREAT STATES WHILE MAINTAINING TASK IMPORTANCE

4.1 Introduction

Chapters two and three showed that the CV indices of challenge and threat states predicted performance in a range of tasks and in a variety of samples. Specifically, challenge CV reactivity predicted superior performance in cognitive, motor, and competitive sport tasks, in academic staff, varsity athletes, and elite athletes, compared to threat CV reactivity. Given the findings that challenge CV reactivity can predict superior performance, ways in which a challenge state can be promoted are valuable. Therefore, chapter four extends chapters two and three by examining the use of task instructions to manipulate challenge and threat states.

Challenge and threat states reflect two distinct psychophysiological responses to stressors (see Blascovich et al., 2011; Seery, 2011). A challenge state is considered an adaptive approach to a motivated performance situation (e.g., a stressor such as competition), occurring when personal resources meet or exceed perceived situational demands. A threat state is considered maladaptive occurring when personal resources do not meet perceived situational demands (Blascovich & Mendes, 2000). Predictably, research has attempted to promote challenge states, and many investigations have used instructional sets concerning an upcoming stressor or task to do so (e.g., Tomaka et al., 1997). Typically, challenge instructions have devalued the importance of an upcoming task compared with threat instructions. However, in motivated performance situations the task is usually perceived as important, and therefore attempts to devalue the task in actual performance settings may be unrealistic. To extend the challenge and threat research area the studies in the present chapter are the first to manipulate challenge and threat states by only altering perceptions of personal resources without altering perceived task importance. Fundamentally, this chapter posits a practical method for promoting challenge states in motivated performance situations.

Challenge and threat states are underpinned by cognitive appraisal, proposed by Lazarus (1966) to be the perceptual mediator between stressor and stress response. In brief, Lazarus proposed that stress is produced, proliferated and mediated by a pattern of appraisals, determined by personal (e.g., motivational dispositions, goals, values, and generalized expectations) and situational factors (predictability, controllability and imminence of stressful event). That stress responses depend largely on one's perception of a stressor is widely accepted in theory, and is supported by empirical research (e.g., Allred & Smith, 1989; Holmes & Houston, 1974; Koriat et al., 1971; Nisbett & Schachter, 1966; Speisman, Lazarus, Mardkott, & Davidson, 1964). In addition, the idea that differences in stress responses can be indexed via CV measures is also widely recognized (e.g., Blascovich et al., 2011; Obrist, 1981; Wright & Kirkby, 2003), and helps to illuminate the relationship between perception and physiological stress responses. Challenge appraisals are associated with challenge CV reactivity and threat appraisals are associated with threat CV reactivity (Blascovich & Mendes, 2000). The link between cognitive appraisal and CV reactivity offers a more objective measure of challenge and threat states, which is important because previous research has indicated that self-reported psychological states are sensitive to social desirability (Paunonen & LeBel, 2012), do not always correlate with CV reactivity (e.g., Martinek et al., 2003; Chapter 2), and may not always reflect complex and often unconscious mental processes (LeDoux, 1998).

In an extension to his cognitive appraisal theory, Lazarus distinguished primary and secondary appraisals, with primary appraisals concerned with whether an event is relevant to the individual's well-being, and secondary appraisals concerned with the coping options in that given event. In a later revision (Lazarus & Folkman, 1984) the concepts of challenge and threat were introduced as two possible cognitive appraisals leading to two different stress responses. Threat appraisals occur when secondary appraisal indicates that an individual's coping potential is not sufficient, thus deeming harm potentially imminent. Challenge is experienced when secondary appraisal indicates that an individual's coping potential is sufficient, thus deeming harm less likely. The concepts of challenge and threat have been revised many times (e.g., Dienstbier, 1989; Lazarus, 1966; Lazarus, 1991; Lazarus & Folkman, 1984), but generally, challenge is considered an adaptive approach associated with superior performance, and threat a maladaptive approach associated with inferior performance in a range of tasks (e.g., Blascovich et al., 2004; Moore et al., 2012; Schneider, 2008; Chapter 2). The present paper examines a revision of the cognitive appraisal concepts as proposed in the TCTSA (Jones et al., 2009). The TCTSA adopts the demand appraisals from the BPS model of challenge and threat (Blascovich & Mendes, 2000), which includes the perceptions of danger (physical and esteem), uncertainty and required effort in a situation. The TCTSA then outlines the resource appraisals, which comprise self-efficacy, perceived control, and achievement goals. Analogous to Lazarus' primary and secondary appraisal concepts, on approaching a motivated performance situation, when an individual perceives that they have sufficient resources to meet the situational demands, a challenge state occurs. In contrast, when insufficient resources to meet the situational demands are perceived, a threat state occurs. Specifically, high levels of self-efficacy, perceived control, and a focus on approach goals are posited to underpin a challenge state, while low levels of self-efficacy, perceived control, and a focus on avoidance goals are posited to underpin a threat state (e.g., Moore et al., 2012; Williams et al., 2010; Chapter 2).

The consistent body of research suggesting that individuals appraise, and respond to, motivated performance situations (stressors such as competition) as a challenge or a threat forms the basis for the present chapter (e.g., Dienstbier, 1989; Lazarus, 1966; Lazarus &

Folkman, 1984; Cerin, Szabo, Hunt, & Williams, 2000). The present chapter is the first to use resource appraisals to manipulate challenge and threat states, examining the influence of self-efficacy, perceived control, and achievement goals on the exhibition of challenge and threat CV reactivity. To manipulate challenge and threat states research has used challenge and threat instructional sets (e.g., Alter et al., 2010; Hemenover & Dienstbier, 1996; Feinberg & Aiello, 2010; Taylor & Scogin, 1992; Tomaka et al., 1997). However, in an attempt to promote challenge states, past research has devalued the importance of motivated performance situations by framing challenge instructions in such a way that the upcoming task is perceived as less important relative to threat instructions. For example, prior to a mental arithmetic task Tomaka et al. (1997) used threat instructions which emphasized the importance of completing the task "as quickly and efficiently as possible" (p. 72), and challenge instructions which encouraged participants to "think of the task as a challenge to be met" (p. 72). Moreover, challenge instructions may also have altered resource appraisals, specifically self-efficacy, for example by encouraging the participants to "think of yourself as someone capable of meeting that challenge" (p. 72); the threat instructions did not. Participants given threat task instructions exhibited threat CV reactivity and cognitively appraised the task as a threat, and participants given challenge task instructions exhibited challenge CV reactivity and cognitively appraised the task as a challenge. There were no performance differences between conditions.

But in motivated performance situations, the task is normally deemed important due to the requirement for effort, and potential danger to well-being (Seery, 2011; Seery et al., 2009), so devaluing an important task via challenge framed instructions may be unrealistic in actual performance contexts. For example, it may be very difficult to convince a person who has an upcoming interview for a promotion that it is not important for her career, and suggesting that she simply do her best may be insufficient to counter the importance of the potential promotion. In fact, it is often precisely the importance of an event that provides the motivation to succeed (e.g., Eysenck & Calvo, 1992).

By adopting only the resource appraisals to manipulate challenge and threat states in the present chapter, we propose to maintain the perceived importance of the situation (i.e., demand appraisals), offering a more realistic method of manipulating challenge and threat states. Finding strategies to successfully promote a challenge state without altering the perceived importance of the motivated performance situation is important as research suggests that a challenge state is associated with superior performance compared to a threat state (e.g., Blascovich et al., 2004; Moore et al., 2012; Seery et al., 2010; Chapter 2).

The TCTSA adopts CV reactivity patterns associated with challenge and threat states as proposed in the BPS model. Challenge and threat states are associated with different patterns of CV reactivity, enabling the states to be measured physiologically, offering a more objective marker of individual stress responses. A challenge state is accompanied by increased catecholamine output (epinephrine and norepinephrine) indicating SAM activity, which is reflected in increased HR and CO, attenuated PEP, and decreased TPR. This challenge CV reactivity pattern represents an efficient physiological response to stressors, where the energy needed for successful performance (e.g., glucose) is released into the blood, and can reach the brain and muscles efficiently due to decreased vascular resistance and enhanced blood flow (Dienstbier, 1989, 1992). A threat state is also marked by increased SAM activity, but is characterised by increased PAC activity, accompanied by cortisol release. Thus, increased HR and attenuated PEP occurs, which indexes task engagement in both a challenge and a threat state, but with an increase or stabilisation in TPR, and a small increase, decrease, or stabilisation in CO. In this threat CV reactivity pattern PAC activity is thought to temper SAM activity, therefore compared to a challenge CV reactivity pattern, efficient energy delivery to the brain and muscles does not occur (Dienstbier, 1989, 1992). A consistent body of evidence supports the BPS model (see Blascovich et al., 2011; Seery, 2011 for reviews).

The focus of the present chapter is on the use of task instructions to manipulate challenge and threat CV reactivity, a strategy adopted in previous research (e.g., Tomaka et al., 1997). However, unlike past research, these studies do not aim to devalue the importance of the performance situation in the challenge instructions, or indeed accentuate the importance in the threat instructions. As such, the present chapter seeks to extend the current research by adopting task instructions to manipulate challenge and threat CV reactivity that do not alter perceptions of task importance by using only the resource appraisals as put forth in the TCTSA. In addition, in line with recommendations (Feinberg & Aiello, 2010) analogous instructions between challenge and threat conditions are used to eliminate potential confounds. This is because sizable differences in wordings between challenge and threat instructions used in previous research may have introduced confounding effects on performance and challenge and threat responses (Tomaka et al., 1997). For example, Feinberg and Aiello's (2010) threat instructions emphasized speed and accuracy while the challenge instructions did not. The focus on resource appraisals in the present chapter is representative of motivated performance situations in which the situational and personal demands (importance) are constant (i.e., stress provoking). Thus, participants' experience of challenge and threat states is dependent on resource appraisals which vary between two sets of task instructions.

The present chapter is the first to manipulate challenge and threat states using only the resource appraisals via task instructions. This chapter presents two studies examining whether challenge task instructions yield a challenge state and threat task instructions yield a threat state. Two studies were conducted as we wanted to explore the use of challenge and threat instructions when task importance was underpinned by both competitive and physically demanding properties. In Study 1 a novel bean-bag throwing task was performed under competitive conditions to create a motivated performance situation. A novel task was used so that participants would not have prior task experiences that may nullify the effects of the task instructions. In Study 2 a physically demanding climbing task (also novel to participants) was used to create a situation in which there was danger of actual harm, rather than danger to esteem through social comparison as in Study 1. Climbing has been used several times in research to assess both physiological and psychological aspects of emotional response and performance (e.g., Hardy & Hutchinson, 2007; Janot, Steffen, Porcari, & Maher, 2000; Jones, Mace, Bray, MacRae, & Stockbridge, 2002). Climbing is also a suitable task because climbers need to use complex problem solving skills in order to succeed and considerable physical effort is required to calculate how to perform complex movements (Hardy & Hutchinson, 2007; Janot et al., 2000).

In both Study 1 and Study 2, the resource appraisals proposed in the TCTSA were varied between challenge and threat instructions, but task importance was kept constant between conditions. Based upon the TCTSA it was hypothesized that challenge task instructions would yield CV reactivity associated with a challenge state (i.e., decreased TPR and increased CO), and threat task instructions would yield CV reactivity associated with a threat state (i.e., increased TPR and decreased or stabilised CO). It was also hypothesized that challenge instructions would result in higher self-efficacy, higher perceived control, and a focus on approach goals, compared to threat instructions.

4.2 Study 1

4.3 Methods

4.3.1 Participants

Forty six (*Female* = 22, *Male* = 24) undergraduate students and academic staff (*M*age = 21.7years, *SD*age = 3.40years) from a UK University were randomly allocated to either the challenge ($N = 23$) or threat ($N = 23$) task instruction conditions[13]. All participants were normotensive and reported being in good health. Ethical approval was granted from the University and individual informed consent was obtained prior to data collection (see appendix 4). Participants were told that by taking part they had the chance to win £10 in shopping vouchers.

4.3.2 Measures

Cardiovascular. A Bio-Impedance cardiograph integrated system (model HIC-3004), along with a BP monitor (Suntech Tango+) was used to measure all CV responses (Sherwood, 1993). Impedance cardiographic (ZKG) and electrocardiographic (ECG) recordings provided continuous measurement of CV performance. Impedance cardiograph measurement utilized a tetra-polar band electrode configuration widely used in similar research (see Blascovich et al., 2011). External ECG recordings were obtained using a Lead II configuration (right arm, left arm, and left leg). CopWin integrated the ZKG, ECG, and BP recordings to provide the four CV indices that differentiate challenge and threat; HR, PEP, CO, and TPR.

Emotions. The Sport Emotion Questionnaire (SEQ; Jones et al., 2005) is a 22 item measure assessing anger (4 items), anxiety (5 items), dejection (5 items), excitement (4 items), and happiness (4 items). Only anxiety, excitement, and happiness were assessed in present study as anger and dejection typically do not occur pre-task (cf. Chapter 2). Participants were asked to indicate "how you feel right now at this moment in relation to the upcoming bean-bag throwing task" on a 5-point Likert-scale ranging from 0 (*not at all*) to 4 (*extremely*). Cronbach's alpha for the SEQ subscales from the current sample were: anxiety = .90, excitement = .75, and happiness = .81.

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[13] Further to this, data from six participants (*female* = 3, *male* = 3) were excluded from the study, three due to poor quality impedance data, and three due to equipment failure during data collection. Exclusion of data due to equipment failure and poor signal is not uncommon when using impedance cardiography (see Seery et al., 2010).

Achievement Goals. The Achievement Goals Questionnaire (AGQ: Conroy et al., 2003) consists of twelve questions with three questions per subscale; Mastery Approach (MAp), Mastery Avoidance (MAv), Performance Approach (PAp), and Performance Avoidance (PAv). The AGQ was modified for the present study by asking participants to indicate their thoughts and feelings about the upcoming bean-bag throwing task. Reponses were made on a 7-point Likert-scale ranging from 1 (*Not at all true*) to 7 (*Very true*). Cronbach's alpha for the AGQ subscales from the current sample were: MAp = .65, MAv = .90, PAp = .93, PAv = .86, which is in line with previous research (Muis & Winne, 2012).

Self-Efficacy. A Self-Efficacy Scale (SES) was developed in line with suggested guidelines (Bandura, 2006) and comprised seven items relating to successful performance in the bean-bag throwing task. The seven items were: hit the centre of the target and score highly, stay focused, mobilize all your resources, perform well even if things get tough, raise the level of your performance, stay motivated, and throw the bean-bag accurately. Participants responded by rating how confident they felt executing each skill in the upcoming bean-bag throwing task. Responses were made on a 5-point Likert-scale ranging from 1 (*not at all*) to 5 (*completely*). A self-efficacy score was calculated by averaging the seven scores. Cronbach's alpha for the SES from the current sample was .87.

Perceived Control. Participants completed one item, adapted from the Academic Control Scale (Perry et al., 2001) in which they rated how much they agreed with the statement, "The more effort I put into this task, the better I will do," on a 5-point Likert-scale ranging from 1 (*No Control*) to 5 (*Total Control*).

Task Importance. Participants completed a single item indicating "how important doing well in the task was to them" on a 6-point Likert-scale ranging from 0 (*not at all*) to 5 (*very much so*).

Cognitive Appraisal. Separate items were used to assess how threatening and how challenging participants expected the task to be. Items were: how threatening do you expect the upcoming Bean-Bag Throwing Test to be, and how challenging do you expect the upcoming Bean-Bag Throwing Test to be? Scores were recorded on a 6-point Likert-scale ranging from 0 (*not at all*) to 5 (*very much so*).

Bean-Bag Throwing Task Performance. The bean-bag throwing task consisted of 10 throws with the non-dominant arm toward a target on the floor six meters away from the throwing position. The target comprised a centre circle worth 10 points, surrounded by four concentric circles worth 8, 6, 4, and 2 points respectively. Zero points were scored outside of the circles. Higher scores indicated better performance, with a possible maximum total score of 100 and minimum of 0.

4.3.3 Procedures

Laboratory set-up. Data collection took place in a laboratory on the university campus. Participants were asked to refrain from participating in heavy exercise in the 24 hours prior to data collection, and to refrain from consuming caffeine, food, and sports drinks in the two hours preceding data collection. Prior to arrival participants were randomly and unknowingly allocated to either the challenge or threat condition. On entry to the lab participants were given a brief outline of the protocol to desensitize them to the environment and demystify the equipment.

Participant preparation. Participants were prepared following relevant guidelines (Blascovich et al., 2011; Sherwood, 1993) and connected to the cardiogram. The participants were then informed that a five-minute rest period would commence in which CV data would be collected, after which they would hear a set of audio-instructions via a set of PC speakers. Participants were asked to sit upright, remain as still as possible, keep their arm rested on a support set at heart level, and to keep their feet at a ninety degree angle facing forward.

Cardiovascular and psychological data collection. CV data recording took place through baseline and post-task instruction phases. After five minutes of baseline data collection participants were informed that the instructions would begin. Then, participants listened to one of two audio-taped instructions about an upcoming bean-bag throwing task, depending on which condition they were allocated. Audio instructions lasted for two minutes. The first minute was standardized for all participants and was aimed at promoting high demand appraisals for all participants, typical in the majority of motivated performance settings. Participants were informed that the task was difficult (thus requiring effort), was an important indicator of human movement (danger to esteem), with the novel nature of the task aimed at promoting perceptions of uncertainty regarding performance. The second minute contained the challenge or threat manipulation, in line with the resource appraisals put forth in the TCTSA (Jones et al., 2009). Challenge instructions informed participants that "*you will have performed similar throwing tasks in the past. Because of this experience, you can feel confident that you will score highly"* (promoting high self-efficacy), to *"try your upmost to hit the centre of the target"* (promoting a focus on approach goals) and that "*the equipment is set up to allow you to complete the task without complications"* (promoting high perceptions of control). Threat instructions informed participants that "*It is unlikely that you will have done a task like this before so you obviously can't be sure that you will perform well*" (promoting low self-efficacy), to "*avoid the low scoring areas of the target"* (promoting a focus on avoidance goals), and that *"the bean-bags vary in weight which influences their flight"* (promoting low perceptions of control). The final part of the task instructions asked participants to mentally prepare for the upcoming bean-bag throwing task by thinking about their performance for two minutes. After the final two minutes had lapsed participants completed the self-report measures in relation to the upcoming bean-bag throwing task (see appendix 4). The participants then completed the bean-bag throwing task.

Bean-Bag Throwing Task. Once participants had completed the questionnaires, all equipment was removed so they could perform the task. Participants were then directed to the bean-bags and the location from which they would throw, and asked to begin. The score was recorded after each throw, and the task ended when participants had thrown all bean-bags. Participants were then debriefed before departing.

4.4 Analytic Strategy

Prior to main analyses separate Shapiro Wilks tests were performed for each condition. If outliers were present then z scores for significant outliers were assessed (Mendes et al., 2003; Seery et al., 2008). Data with z scores greater than two were omitted from further analyses. The analytic strategy for all data comprised two steps. First, in line with previous studies using a similar protocol (e.g., Mendes et al., 2003; Chapter 2), HR and PEP in the first minute of task instructions was compared to HR and PEP in the fifth minute of baseline. This was to determine engagement in the task. Second, separate independent *t*-tests were conducted for CV reactivity, self-report variables, and performance (bean-bag throwing score) to assess differences between challenge and threat task instruction conditions. As is common in challenge and threat research, CV reactivity scores were calculated for CO and TPR by subtracting the raw CV responses for the last minute of baseline from the raw CV responses for the periods of time of interest (Seery et al., 2004; Seery et al., 2009). For example, the average CV reactivity for the four minutes of post-task instruction data (two minutes task instructions plus two minutes of mental preparation) were subtracted from the fifth minute of baseline data. All multicollinearity, homogeneity, normality and outlier checks met the assumptions necessary for all data analyses.

4.5 Results

4.5.1 Task engagement

Two separate paired samples *t*-tests were conducted and Cohen's *d* calculated to compare the fifth minute of baseline HR and PEP with HR and PEP in the first minute of the task instruction phase[14]. For HR, there was a significant increase, $t(45) = 4.41$, $p < .001$, $d = .17$, from the fifth minute ($M = 66.30$bpm, $SD = 16.34$bpm) of baseline to the first minute ($M = 69.09$bpm, $SD = 17.20$bpm) of task instructions. For PEP, there was a significant attenuation, $t(43) = 5.71$, $p < .001$, $d = .23$, from the fifth minute ($M = 136.86$ms, $SD = 13.72$ms) of baseline to the first minute ($M = 133.73$ms, $SD = 13.64$ms) of task instructions. HR and PEP reactivity indicated that participants engaged with the task. In addition, participants indicated that task success ($M = 3.63$, $SD = .14$) was important to them, $t(42) = 26.42$, $p < .001$. Task importance did not differ, $t(41) = .39$, $p > .05$, between challenge and threat conditions.

4.5.2 Cardiovascular reactivity between conditions

The CV reactivity between conditions is shown in figure 4.1. Independent *t*-tests showed that participants in the challenge condition ($M = -8.67$, $SD = 40.76$) displayed significantly lower TPR[15] reactivity, $t(42) = 4.54$, $p < .001$, $d = 1.37$, than participants in the threat condition ($M = 47.88$, $SD = 41.68$). In addition, participants in the challenge condition ($M = .18$, $SD = .20$) displayed significantly higher CO[16] reactivity, $t(41) = 4.58$, $p < .001$, $d = 1.42$, than participants in the threat condition ($M = -.09$, $SD = .18$).

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[14] PEP data from two participants were excluded from further analyses as they were identified as significant outliers.

[15] TPR data from two participants were excluded from further analyses as they were identified as significant outliers.

[16] CO data from five participants were excluded from further analyses as they were identified as significant outliers.

4.5.3 Psychological components of the TCTSA and performance

The means of the self-reported psychological states are shown in table 4.1. Independent *t*-tests revealed no significant differences for self-reported psychological states[17] and performance between challenge and threat conditions.

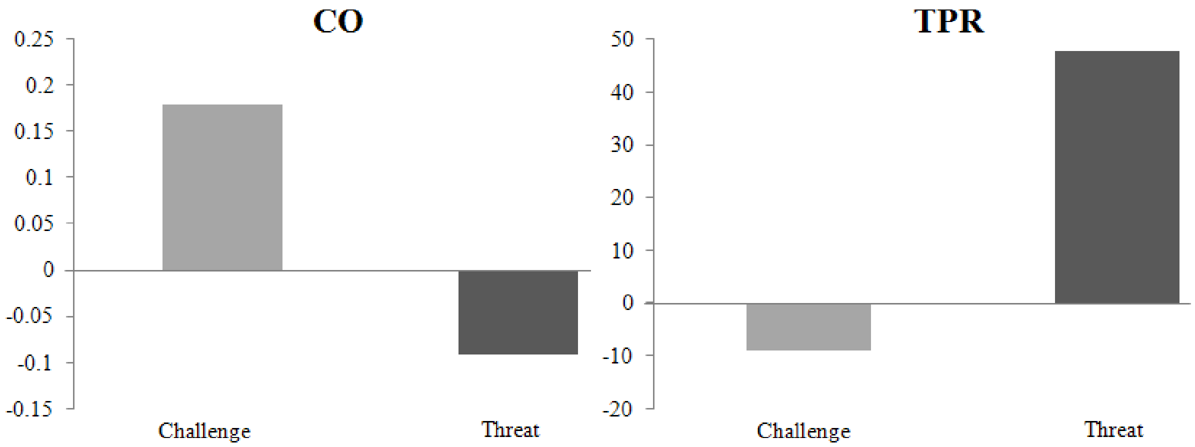

Figure 4.1. CO and TPR reactivity between challenge and threat conditions in Study 1.

4.6 Discussion

The results of Study 1 showed that challenge and threat instructions led to CV reactivity indicative of challenge and threat states respectively. This is the first study to show that it is possible to manipulate CV reactivity using task instructions based primarily on the resource appraisals, without altering the importance of the task between challenge and threat conditions. This further extends previous research by making task instructions more analogous between conditions than in previous research (e.g., Atler et al., 2010; Feinberg & Aiello, 2010; Hemenover & Dienstbier, 1996; Taylor & Scogin, 1992; Tomaka et al., 1997). Indeed, there were no differences in self-reported task importance between conditions. Although TPR and CO reactivity differed between conditions in the hypothesized directions, there were no differences in self-reported psychological states or performance.

[17] Self-report data identified as significant outliers were excluded from further analyses including anxiety (*N* = 3), control (*N* = 2), appraisal (*N* = 4), and task importance (*N* = 3).

Table 4.1. Study 1 and Study 2 self-report and performance $M \pm SD$ and Cohen's d for the challenge and threat task instruction conditions.

	Study 1			Study 2		
	Challenge $M \pm SD$	Threat $M \pm SD$	d	Challenge $M \pm SD$	Threat $M \pm SD$	d
Cognitive Appraisal	NA	NA	NA	2.26 ± .92	2.29 ± 1.06	.03
Challenge Appraisal	2.69 ± 1.06	3.08 ± 1.04	.37	NA	NA	NA
Threat Appraisal	1.15 ± .67	1.28 ± .84	.17	NA	NA	NA
Control	3.90 ± .61	4.27 ± .63	.60	5.12 ± 1.02	4.86 ± 1.11	.24
Self-Efficacy	54.21 ± 18.67	49.78 ± 12.88	.28	6.59 ± 1.61	6.23 ± 1.74	.21
MAp	17.57 ± 2.54	16.13 ± 2.96	.52	11.79 ± 2.36	11.68 ± 2.08	.05
MAv	11.96 ± 5.16	11.00 ± 4.91	.19	10.71 ± 4.05	10.91 ± 5.34	.04
PAp	12.78 ± 5.26	11.43 ± 4.88	.27	13.63 ± 5.14	12.09 ± 6.38	.27
PAv	12.48 ± 5.22	11.04 ± 4.34	.30	12.46 ± 5.08	11.23 ± 6.20	.22
Anxiety	.70 ± .62	.68 ± .65	.03	1.21 ± .95	1.19 ± .85	.02
Excitement	1.43 ± .69	1.29 ± .83	.18	1.73 ± .74	2.06 ± 1.05	.36
Happiness	1.36 ± .67	1.52 ± .89	.20	1.49 ± .78	1.94 ± .98	.51
Helpfulness of Emotion	NA	NA	NA	2.45 ± .89	2.76 ± .89	.35
Bean-Bag Performance	94.57 ± 17.39	85.65 ± 18.00	.50	NA	NA	NA

Although the bean-bag throwing task yielded task engagement and self-reported perceptions of task importance, the lack of ecological validity inherent in the throwing task may have limited task importance. To address this, in Study 2 we examined if similar task instructions could manipulate challenge and threat states with regard to a more meaningful task (i.e., a task that has implications for actual physical harm). Study 2 has similar experimental and analytical strategies, but it differed in three main ways. First, task instructions were related to a physically demanding climbing task and second, the manipulation of the resource appraisals between conditions took place in the first minute of task instructions, unlike Study 1 in which the first minute was standardized across conditions.

In addition, we added measures to assess participants' thoughts immediately after receiving task instructions. Thoughts were recorded qualitatively via self-report to indicate engagement in task relevant thoughts during the two minutes of post-task instruction mental preparation.

4.7 Study 2

4.8 Methods

4.8.1 Participants

Forty six (*Female* = 9, *Male* = 41) undergraduate students (*M*age = 21.02years, *SD*age = 2.46years) from a UK University were randomly allocated to either a challenge (N = 24) or threat (N = 22) task video condition[18]; all participants were normotensive and reported being in good health. Only novice climbers[19] were recruited as climbing experience is a determinant of climbing stress and anxiety (Hardy & Hutchinson, 2007; Janot et al., 2000). Ethical approval was granted from the University and individual informed consent was obtained prior to data collection (see appendix 5). Participants received course credit for taking part.

4.8.2 Measures

CV measures were recorded in the same way as in Study 1. So too were emotions (Cronbachs Alpha: anxiety = .92, excitement = .85, happiness = .93), achievement goals (Cronbachs Alpha: MAp = .81[20], MAv = .87, PAp = .93, PAv = .91), and task importance, but with reference to the climbing task. In addition, a single item was added to the SEQ in which participants were asked to indicate how helpful they perceived their overall emotional state to be on a 5-point Likert-scale ranging from 0 (*not at all*) to 4 (*extremely*).

Self-Efficacy. Participants were asked "With reference to the upcoming climbing performance, to what extent do you feel confident that you can climb effectively in the

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[18] Further to this, data from four participants (*female* = 1, *male* = 3) was excluded from the study, one due to poor quality impedance data, and three due to experimenter error during data collection

[19] One participant indicated a moderate level of climbing experience and climbs four times a year. Therefore all analyses were performed twice; once with this participant excluded and once with this participant included. The exclusion of this participant did not alter the results of the data analyses markedly.

[20] For MAp, Cronbachs' alpha was .49 so one item was removed. The removed item did not correlate well with the other two items for this subscale (r = .03).

upcoming climbing task?" Responses were recorded on a 9-point Likert-scale ranging from 1 (*not at all*) to 9 (*completely*).

Perceived Control. Participants completed one item in relation to the climbing task, adapted from the Academic Control Scale (Perry et al., 2001). Participants were asked "to what extent do you feel that you have control over the factors that will determine your climbing performance?" Responses were recorded on a 7-point Likert-scale ranging from 1 (*No Control*) to 7 (*Total Control*).

Cognitive Appraisal. Participants were asked "Overall, how do you feel about your upcoming Climbing Task performance?" Responses were recorded on a 9-point Likert-scale ranging from -4 (*threatened*) to +4 (*challenged*).

Thoughts About the Climbing Task. To confirm that participants used the two minutes of mental preparation to engage in task-relevant thoughts, participants were asked to write down what they were thinking in the two minutes immediately after CV data collection.

Climbing Task Performance. The climbing task required participants to ascend a 10-meter climbing wall located in the university sports hall. A climbing instructor set-up an F2 sport climbing route for the task (strictly vertical, 3 meters wide, and a moderate difficulty level). Participants were given five-minutes to climb the wall and could stop climbing at any point. If participants fell off or came detached from foot- and hand-holds, the instructor supported their weight while they decided whether to continue the climb or to stop. On reaching the top of the wall, participants were lowered to the ground by the instructor. If after five minutes the participant had not completed the climb, they were asked to stop climbing and were lowered to the ground. Height climbed was used as the performance indicator. The wall was split into five sections and each section was worth 10-points with participants accumulating points as they ascended. Participants were considered to have reached a section when both feet were in that section. The bottom two-meters of the wall was worth 10 points, the next two-meter section was worth an additional 10 points, and this scoring accumulated all the way up the wall for each of the additional three sections. Finishing the wall was worth 50 points. If the participant decided to stop climbing they were awarded points relating to the highest section they reached.

4.8.3 Procedures

Laboratory and participant preparation followed the same procedures as in Study 1, but in Study 2 participants were informed that they would watch a short video on a laptop computer accompanied by a set of audio instructions in which key phrases were reinforced in text on the screen.

Cardiovascular and psychological data collection. CV data followed the same protocol as in Study 1, but in Study 2 participants watched one of two videos about an upcoming climbing task, depending on whether they were allocated to the challenge or threat condition. The videos lasted for one minute and were designed to induce either a challenge or threat state in a similar way to the instructions in Study 1. Both videos contained the same visual footage of the climbing wall from a first-person perspective and multiple angles below, on, and above the wall, but different audio instructions. Instructions in the challenge video promoted resource appraisals of high self-efficacy (“you can feel confident that you will be able to climb effectively”), high perceived control (“you have control over the skills required to climb well”), and a focus on approach goals (“try your best to stay on the wall and get as high as you can”). The threat video promoted resource appraisals of low self-efficacy (“you obviously can’t be sure that you will climb the wall effectively”), low perceived control (“how well you do on the task may be related to factors outside of your control”), and a focus on avoidance goals (“try your best not to fall off the wall at any point”). In addition both sets of instructions informed participants that they had five minutes to complete the climbing task, that they would be given climbing guidance, and that their climb would be video recorded and later viewed so climbing ability could be assessed. Importantly, while CV data were collected participants were told that they would be escorted to the climbing wall immediately after data collection had ceased. This was to ensure that CV and self-report measures reflected participants' responses to approaching an imminent climbing task, even though the climbing session was to be arranged for a different day. The final part of the videos instructed participants to mentally prepare for the climbing task for two minutes by thinking about performing the climb. After two minutes had lapsed participants completed the self-report measures in relation to the upcoming climbing task (see appendix 5). Then, participants were informed that they would not be climbing at that moment in time and to indicate the climbing session that they could attend from the options available. Participants were given a choice of four climbing sessions to attend, each on a different day across four weeks at 9:00am. At this point, four participants indicated that they could not attend any of the sessions due to academic timetable clashes. All other participants agreed to attend one of the sessions and were given an information sheet detailing that they were in no way obligated to climb. Participants received no inducement and were not contacted prior to their climb, as we did not want to coerce participants into attending. After indicating a climbing session the CV recording equipment were removed from participants, after which they were briefed about the climbing task (no obligation to attend and safety information) before departing.

Climbing Task. Eighteen participants attended the climbing task in total. On arrival to the sports hall for the climbing task, participants were given climbing instructions by a qualified (Single Pitch Award) climbing instructor (Chairman of University Mountaineering Club) who was blind to the instructions participants had received. The guidance provided by the instructor was identical for both conditions and included safety information, demystification of the climbing equipment, and simple advice such as "use your legs to push up rather than your arms to pull up" to avoid injury. Participants were then fastened to a climbing harness and attached to a safety rope so the instructor could belay the participants up (and down) the wall. Participants were then reminded once more that they had five minutes to climb and that they could cease climbing at any point. After being lowered to the ground, participants were released from the safety rope and harness, and were provided with a full debrief about the study.

4.9 Analytic Strategy

The analytic strategy followed that used in Study 1. All multicollinearity, normality and outlier checks met the assumptions necessary for all data analyses.

4.10 Results

4.10.1 Task engagement

Two separate paired samples *t*-tests were conducted and Cohen's *d* calculated to compare the fifth minute of baseline HR and PEP with HR and PEP in the first minute of the task instruction phase for all participants[21,22]. For HR, there was a significant increase, $t(43) = 2.85$, $p < .01$, $d = .21$, from the fifth minute ($M = 67.73$bpm, $SD = 9.95$bpm) of baseline to the first minute ($M = 69.93$bpm, $SD = 11.36$bpm) of task instructions. For PEP, there was a significant attenuation, $t(43) = 4.95$, $p < .001$, $d = .24$, from the fifth minute ($M = 128.09$ms, $SD = 14.42$ms) of baseline to the first minute ($M = 124.64$ms, $SD = 14.36$ms) of task instructions. HR and PEP reactivity indicated that participants engaged with climbing task (e.g., Blascovich et al., 2011). In addition, participants indicated that task success was important ($M = 5.80$, $SD = 1.34$) to them, $t(45) = 29.30$, $p < .001$. Task importance did not differ, $t(44) = .42$, $p > .05$, between challenge and threat conditions.

[21] HR data from two participants were excluded from further analyses as they were identified as significant outliers.
[22] PEP data from two participants were excluded from further analyses as they were identified as significant outliers.

4.10.2 Cardiovascular reactivity between conditions

Independent *t*-tests and inspection of mean values (see figure 4.2) showed that participants in the challenge condition (M = -9.80, SD = 39.95) displayed significantly lower TPR reactivity, $t(44) = 2.60$, $p < .02$, $d = .76$, than participants in the threat condition (M = 24.44, SD = 49.18). In addition, participants in the challenge condition (M = .22, SD = .19) displayed significantly higher CO reactivity, $t(44) = 3.39$, $p < .01$, $d = .99$, than participants in the threat condition (M = -.09, SD = .40).

4.10.3 Psychological components of the TCTSA and climbing performance

The means of the self-reported psychological states are shown in table 4.1. Independent *t*-tests revealed no significant differences for self-reported psychological states between challenge and threat conditions[23]. Because only 18 participants attended the climbing task, we do not report any performance scores.

4.11 Discussion

The results from Study 2 show that challenge and threat instructions led to CV reactivity indicative of challenge and threat states respectively. The findings of Study 2 support Study 1 by showing for the first time that it is possible to manipulate CV reactivity using task instructions varying only the resource appraisals without altering the perceived importance of the task between challenge and threat conditions. Indeed, as in Study 1, self-reported task importance did not differ between conditions. Study 2 extended Study 1 by adopting a physically demanding task with the potential for physical harm, and by delivering task instructions using video.

[23] Self-report data identified as significant outliers were excluded from further analyses including control (N = 2), and helpfulness of emotional state (N = 2).

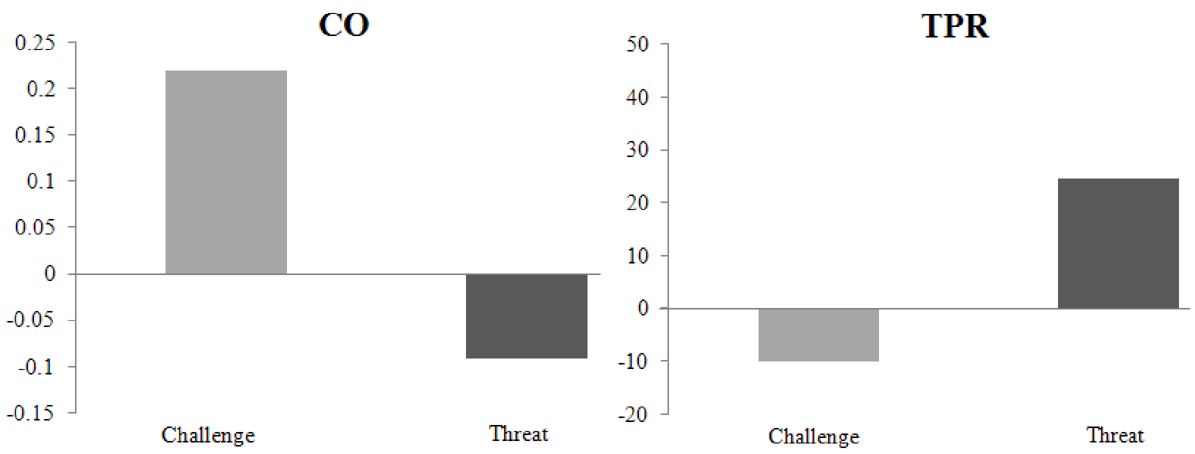

Figure 4.2. CO and TPR reactivity between challenge and threat conditions in Study 2.

4.12 General Discussion

Collectively, the results from Studies 1 and 2 add to the extant literature by demonstrating for the first time that challenge and threat CV reactivity can be manipulated using task instructions in relation to both competitive and physically demanding motivated performance situations, without altering task importance. In both studies, self-reported task importance did not differ between conditions. Specifically, challenge instructions that only promoted high self-efficacy, high perceived control, and approach goals led to challenge CV reactivity. Threat instructions that only promoted low self-efficacy, low perceived control, and avoidance goals led to threat CV reactivity. These are the first studies to show that challenge CV reactivity can be promoted by task instructions without devaluing the importance of the motivated performance situation. Notably, both studies indicate that although challenge and threat CV states were manipulated psychologically using the resource appraisals, there were no differences in self-reported resource appraisals (self-efficacy, control, and achievement goals) between challenge and threat instruction conditions, counter to what we hypothesized.

The present chapter supports previous studies indicating that challenge and threat CV reactivity can be manipulated using instructional sets, and extends previous research (e.g., Tomaka et al., 1997) by manipulating challenge and threat CV reactivity without varying the importance of the motivated performance situation and by using more analogous instructional sets. This chapter used only the resources appraisals as outlined in the TCTSA thus rendering the tasks equally important between challenge and threat conditions. Hence, the present chapter supports the theoretical components of the TCTSA (Jones et al., 2009) and offers further validation for the challenge and threat CV reactivity patterns put forth in the BPS model (Blascovich & Mendes, 2000).

The main aim of this chapter was to manipulated challenge and threat states as measured via CV methods, using the TCTSA as a framework, thus it was anticipated that by varying the resource appraisals, corresponding differences in self-report measures between conditions would emerge (e.g., the promotion of high self-efficacy in the challenge instructions would be reflected in high self-efficacy scores on the self-report measure). However, the self-report data revealed no differences between the challenge and threat instruction conditions. This is intriguing because although participants in the challenge condition were encouraged to be more confident, more in control, and adopt approach goals, and indeed exhibited challenge CV reactivity, self-report measures indicated that they were no more confident, in control, or approach orientated than the participants in the threat condition. Counter-intuitive, or counter-theoretical, self-report results are consistent with previous challenge and threat research (e.g., Mendes et al., 2008; Chapter 2) and it is possible that challenge and threat states are more difficult to assess via self-report measures (Chalabaev et al., 2009), and that social desirability inherent in self-report measures may play a role (Paunonen & LeBel, 2012).

There is a possibility that the subtle differences in semantics between conditions may have presented the tasks more positively in the challenge condition than in the threat condition. To explain, words like “can” and “have” were used in the challenge instructions, whereas “cant”, “may be”, and “not” were used in the threat instructions. While we related these words to the resource appraisals (e.g., “can feel confident” in challenge instructions vs. “can’t be sure” in threat instructions to manipulate self-efficacy), it may be that the use of concomitant verbs may have contributed to the experiences of challenge and threat CV states in the present chapter. It is also possible that in the present chapter the instructions influenced appraisals not immediately accessible to the participants. Indeed, it may be that only some aspects of cognitive appraisal are consciously accessible with an even smaller subset of those perceptions deemed acceptable to report by the individual (e.g., Blascovich & Mendes, 2000; Greenwald & Banaji, 1995; LeDoux, 1998; Quigley et al., 2002). Further, there is evidence that the subconscious awareness of evocative stimuli can determine CV responses, bypassing measurable cognitive appraisal, (e.g., Weisbuch-Remington et al., 2005), and that self-reported stress levels may be unrelated to physiological responses (e.g., Martinek et al., 2003). Overall, we consider the lack of findings for the self-report data perplexing and cannot attribute any one specific cause for the counter-intuitive and counter-theoretical results.

The key findings from the present chapter have implications for stress management and leadership in motivated performance settings. Importantly the present chapter shows that a challenge state can be promoted without altering the importance of an upcoming task. This finding is valuable because influencing the importance of a task in actual performance settings is difficult. For example, convincing a student approaching a final examination that they have studied hard for and will determine their eligibility for college that it is not important is unrealistic and would require a significant amount of cognitive restructuring. In contrast, convincing them that they have the skills to succeed, have control over their performance, while encouraging them to focus on success, is simple and logical. From a leadership perspective this means that creating the climate for success under pressure could involve using challenge-framed instructions directly prior to an important event. It is well established that leaders can have an important influence on their subordinates’ responses to stressful situations (e.g., Baker, Cote, & Hawes, 2000; Smith, Smoll, & Weichman, 1998). For example, a coach could laden her team talk with references to confidence, control and approach goals to promote a challenge state in her athletes, while retaining references to the importance of the occasion. Indeed, research suggests that speeches with high instructional content increase athletes' functional emotions (Vargas-Tonsing, 2009). Importantly, as well as encouraging effective stress management, the promotion of challenge states may facilitate performance (e.g., Blascovich et al., 2004; Moore et al., 2012; Seery et al., 2010; Chapter 2). While an increase in performance was not observed in the present chapter, it was not the main focus and as such there are limitations in the way performance was assessed, for example no baseline measures of performance were taken. In sum, based on the studies reported in the present paper, and previous research, challenge framed instructions could promote stress management and facilitate performance.

By addressing the limitations in the present chapter, the findings from the two studies would be strengthened. In particular, to understand the relationships between CV reactivity, psychological, and performance variables, the use of regression analyses is required, for which a larger participant sample is needed. Also, the situations created in both studies represent artificial circumstances made meaningful by creating a competition (as in Study 1) and using a physically demanding task (as in Study 2). Therefore, how individuals respond in real-life situations, which are more self-relevant, and further how instructions could alter these responses, is not yet known. The findings within this chapter, along with findings from previous research, present a number of potentially fruitful avenues of future research. For example, it would be interesting to examine whether a set of instructions can promote challenge reactivity and improve performance above normal levels in a given task. In the present paper, performance was assessed without accounting for baseline levels, unlike previous research (e.g., Chapter 2), and only 18 out of 46 participants attended the climbing task. Furthermore, a repeated measures design, in which a participant receives both challenge and threat instructions (counterbalanced), would determine the ability of instructions to elicit challenge and threat reactivity beyond potential trait responses. Finally, although the instructions used in the current chapter were more analogous between challenge and threat conditions than instructions used in previous research (e.g., Feinberg & Aiello, 2010), the slight variation in semantics could be addressed by developing instructions that are semantically identical, while still manipulating the resource appraisals.

To conclude, these are the first studies to show that challenge CV reactivity can be promoted using task instructions developed using the resource appraisals from the TCTSA without devaluing task importance. Future research should employ repeated measures methods in order to examine the within participant effects of using challenge and threat task instructions to elicit challenge and threat states (e.g., Quigley et al., 2002). The present paper has implications for the management of psychophysiological responses to motivated performance situations through the use of task instructions which promote the self-efficacy, perceived control, and a focus on approach goals.

CHAPTER 5: DISCUSSION

5.1 Summary of Findings

The aims of this thesis were to examine the relationships between challenge and threat states and performance, and to examine the use of task instructions based on the resource appraisals to manipulate challenge and threat states. The aims were primarily based on hypotheses proposed in the TCTSA (Jones et al., 2009), which asserts that a challenge state should be associated with superior performance compared to a threat state, and that challenge and threat states are associated with a specific constellation of psychological factors.

Chapter two examined the relationships between challenge and threat states and performance in cognitive and motor tasks. Importantly, competitive task performance was compared to baseline performance, so that changes from normal levels could be determined. Results showed that CV indicators of challenge and threat states were able to predict changes in cognitive and motor performance from baseline. Specifically, challenge CV reactivity (decreased TPR and increased CO) was related to improvements in performance, and threat CV reactivity (increased TPR and decreased CO) was related to decrements in performance in both tasks. Self-reported psychological states were not related to CV reactivity or performance changes from baseline in either task.

Chapter three examined the relationships between challenge and threat states and sports performance in elite academy athletes. Chapter three used a sport task in a more ecologically valid sport setting, the Batting Test, and recruited elite academy athletes for whom task performance was highly meaningful. As in chapter two results showed that CV indicators of challenge and threat states were able to predict Batting Test performance. Specifically, challenge CV reactivity was related to higher scores in the Batting Test, and threat CV reactivity was related to lower scores in the Batting Test. In addition, participants who exhibited threat CV reactivity but performed well reported significantly greater self-efficacy than participants who exhibited threat CV reactivity but performed poorly. Further, participants who exhibited challenge CV reactivity but performed poorly reported significantly greater performance avoidance goals than participants who exhibited challenge CV reactivity and performed well. Again, self-reported psychological states were not related to CV reactivity or sports performance.

Chapter four examined the use of challenge and threat task instructions to manipulate challenge and threat states in both a competitive motor task and a physically demanding motor task. Previous research has used task instructions to manipulate challenge and threat states (e.g., Tomaka et al., 1997), but have altered perceived task importance to do so, therefore, chapter four extended previous research by maintaining task importance between challenge and threat instructions. Challenge and threat instructions emphasised resource appraisals without altering perceived task importance. To explain, challenge task instructions promoted high self-efficacy, high perceived control, and a focus on approach goals, without devaluing task importance. Threat task instructions promoted low self-efficacy, low perceived control, and a focus on avoidance goals, without emphasising task importance. Results showed that challenge task instructions led to challenge CV reactivity and threat task instructions led to threat CV reactivity. In short, challenge task instructions led to challenge CV reactivity without devaluing task importance, and threat task instructions led to threat CV reactivity without overemphasising task importance, for the first time in research. There were no differences in self-reported psychological states between challenge and threat task instruction conditions.

In summary, this thesis shows that motivated performance in motor, cognitive, and sports tasks can be predicted using CV indicators of challenge and threat states. Specifically, challenge CV reactivity was related to superior performance compared to threat CV reactivity in cognitive and motor tasks, from baseline performance levels (chapter 2) and in elite level highly skilled athletes (chapter 3). Given the relationship between challenge CV reactivity and performance, strategies to promote a challenge state are valuable. Chapter four showed that challenge and threat CV reactivity was manipulated by task instructions constructed using the resource appraisals as put forth in the TCTSA (Jones et al., 2009). Crucially, the importance of the motivated performance situations were not altered between challenge and threat task instruction conditions. Principally, challenge instructions that promoted resource appraisals of high self-efficacy, high perceived control, and a focus on approach goals, led to challenge CV reactivity. Overall, the results of this thesis relate challenge CV reactivity to superior performance and propose an effective and practical strategy for the promotion of challenge states. Counter to the hypotheses posited in each chapter, self-reported psychological states were unrelated to CV reactivity and performance, and no differences were found between challenge and threat task instruction conditions in chapter four. The chapters that comprise this thesis consistently illustrated that self-reported psychological states did not relate to CV reactivity as proposed in the TCTSA and BPS model.

5.2 Explanation of Findings

5.2.1 Challenge and Threat CV Reactivity and Performance

The TCTSA posits how a constellation of psychophysiological factors determine performance in motivated performance situations. Chapters two and three support the hypothesis proposed in the TCTSA that challenge CV reactivity would be related to superior performance compared to threat CV reactivity. Chapter two showed how challenge CV reactivity predicted increased performance from baseline levels in cognitive and motor tasks, and chapter three showed how challenge CV reactivity predicted superior performance compared to threat reactivity in elite level athletes. Counter to the TCTSA and BPS model, no consistent associations between psychological variables and CV reactivity or performance were found. To explain the findings from chapters two and three, the relationships between CV reactivity and performance will be discussed.

Chapters two and three extended previous research (e.g., Blascovich et al., 2004, Moore et al., 2012; Seery et al., 2010) in two main ways. First, chapter two showed that challenge CV reactivity was related to superior performance compared to threat CV reactivity, from baseline performance levels. Previous research does not assess performance changes from baseline and therefore does not conclusively demonstrate that a challenge CV pattern can predict improved performance; it is possible that individuals who have greater ability at a task may be more likely to respond with a challenge state. Second, chapter three showed challenge CV reactivity was related to superior performance in elite academy athletes offering a more valid assessment of how CV reactivity relates to imminent and pressured performance than previous studies. There are a number of mechanisms, both cognitive and physiological, through which CV reactivity could influence performance.

Cognitive. One explanation for the relationship between challenge CV reactivity and performance is that challenge reactivity reflects an adaptive psychological approach to motivated performance situations. Previous research has shown that mental processes drive challenge and threat reactivity (e.g., Tomaka et al., 1993) and the TCTSA asserts that the psychological constructs that accompany a challenge state should facilitate performance (Jones et al., 2009). To expand, the TCTSA posits that if an individual's self-efficacy, perceived control, and approach focus, exceeds the perceived situational demands, a challenge state should occur, and in turn, performance will be facilitated. Indeed, it is hard to imagine an individual with low self-efficacy, low perceived control, and a focus on avoidance goals, performing well in any meaningful task, or for that matter exhibiting an adaptive physiological response. However, one could argue that given the lack of consistent associations between self-reported psychological data and CV reactivity in this thesis, psychological mechanisms could not explain the relationships between CV reactivity and performance found in the three studies comprising chapters two and three.

Despite the lack of findings for self-report data in this thesis, Study 1 in chapter two, coupled with Moore et al's (2012) findings may shed some light on potential cognitive mechanisms through which performance effects could be realized. To expand, both studies used objective measures of attention to examine challenge and threat states and performance, that are not as subject to response bias as self-report questionnaires. In this thesis, Study 1 in chapter two reported that challenge CV reactivity was related to more accurate and faster responses in the Stroop Test, which is a valid test of attentional control in relation to decision making and self-regulation (cf. Spreen & Strauss, 1998; Stroop, 1935; von Hippel & Gonsalkorale, 2005). In other words, participants who exhibited challenge CV reactivity had better attentional control and thus were more able to accurately and quickly respond to the items in the Stroop Test. In addition, as baseline Stroop Test performance was accounted for, it is not likely that those participants had superior attentional control in general. That is, as challenge CV reactivity was related to performance improvements from baseline, and self-report data revealed nothing, increased attentional control may be the key mechanism behind the performance effects.

Moore et al. (2012), examined differences in quiet eye measures using eye-tracking alongside kinematic and muscle activity variables, between a challenge and a threat condition. Participants who received challenge instructions, exhibited challenge CV reactivity, made challenge appraisals, and showed longer quiet eye duration before executing a fine motor task (golf putting), compared to participants who received threat instructions. Longer quiet eye durations facilitate the gathering of task-relevant information by preparatory gaze fixations. The longer duration allows for effective processing of task-relevant information used to select, fine-tune, and program responses, resulting in more accurate performance (Janelle et al., 2000; Mann, Coombes, Mousseau, & Janelle, 2011; Wilson, Vine, & Wood, 2009). Quiet eye duration is characteristic of a specific visuo-motor strategy defined as the final fixation or tracking gaze directed to a single location or object in the visuo-motor workspace with 3 degrees or less for a minimum of 100milliseconds (Behan & Wilson, 2008). Importantly, anxiety typically reduces quiet eye duration (e.g., Wilson et al., 2009), which is symptomatic of reduced attentional control. Therefore individuals who show extended quiet eye duration under stressful conditions may be able to maintain their performance. In sum, Moore et al. (2012) offered a mechanism through which challenge states may lead to superior performance, which can be objectively measured, and which supports the predictions of the TCTSA.

Although the self-report psychological data did not relate to CV reactivity or performance at a correlational level, chapter three illustrates that whether an individual exhibits challenge or threat CV reactivity, it may be an individual's psychological approach that in part determines performance. Specifically, cricketers who exhibited threat reactivity performed well when reporting high levels of self-efficacy compared to athletes who exhibited threat reactivity but performed poorly. Further, cricketers who exhibited challenge CV reactivity performed poorly when reporting a high focus on avoidance goals, compared to cricketers who exhibited challenge reactivity and performed well. There are numerous ways to explain these intriguing findings.

First, it may be that certain psychological states have a bigger impact on performance when counter to the initial appraisal of, and subsequent CV reactivity to, a motivated performance situation. For example, it is possible that high levels of self-efficacy help inoculate individuals from the performance debilitating effects of threat CV reactivity. This may indicate that it is especially when an individual exhibits threat CV reactivity that their cognitions with regards to meaningful situations are most important for performance. In other words, when approaching a motivated situation with high self-efficacy, the effects of threat CV reactivity on performance may be counteracted, or at least reduced. This finding is consistent with previous research (Hoyt & Blascovich, 2010) which suggests that individuals who exhibit threat CV reactivity but report high self-efficacy may be reacting to the threat of the situation in a way that allows maintained or improved performance. In addition, the finding that self-efficacy is an important factor in the relationship between stress and performance supports the ideas posited in Fazey and Hardy's (1988) butterfly catastrophe model. To explain, the butterfly catastrophe model illustrates how self-confidence, a more general form of self-efficacy, interacts with cognitive anxiety and physiological arousal to determine performance outcomes. A high level of self-confidence allows a cognitively anxious individual to tolerate a higher level of physiological arousal before performance dramatically decreases (hysteresis). In addition, self-confidence is relatively independent of cognitive anxiety but may protect against its effect on performance (Hardy, 1996), echoing the findings in chapter three where the results showed that despite a threat CV state, high self-efficacy protected against performance disruption.

A focus on avoidance goals has been linked to poor performance in past research (Chalabaev et al., 2009). Chapter three illustrates how influential avoidance goals may be on performance, but only when exhibiting challenge CV reactivity, as they emerged as the denominator between those who performed well and those who performed poorly. Avoidance goals reflect the desire to avoid a negative outcome (failure), and more specific to the findings of chapter three, performance avoidance goals reflect the desire to avoid being regarded as a less competent athlete than someone else (Elliot & McGregor, 2001). Somewhat mirroring the approach and avoidance concepts posited in the TCTSA, two alternative concepts, promotion focus and prevention focus, have been put forth that may help to explain the mechanisms through which approach and avoidance goals may influence performance (e.g., Worthy, Markman, & Maddox, 2009a; Worthy, Markman, & Maddox, 2009b). Worthy and colleagues assert that under pressure (induced in chapters 2 and 3 using ego-threat instructions) individuals may adopt a situational prevention focus (e.g., trying not to succumb to the pressure; Worthy et al., 2009a). If the individual also adopts a global prevention focus (avoidance goals; trying to avoid failure), performance is likely to suffer. This is because there is a regulatory fit between the situational and global focus (both reflecting avoidance) which may lead to increased executive resources used to monitor the processes involved for skilled performance, thus harming performance. In contrast, even if the individual has a situational prevention focus, providing they adopt a global promotion focus (approach goals; trying to win), performance may actually improve, due to a decrease in executive resources needed to monitor the skilled processes involved (Worthy et al., 2009b). Worthy et al found that elite professional basketball athletes taking match-deciding free throws (situational prevention focus) when an actual game was tied (global promotion – trying to win), on average performed better than their normal standards. But, athletes taking a match-deciding free throw (situational prevention focus) when their team was behind by one point (global prevention focus – trying not to lose), on average performance worse than their normal standards ("choked"). Therefore, some participants in chapter 3 despite exhibiting challenge CV reactivity, the use of avoidance goals may have influenced the attentional process needed to produce the skilled motor performance required to score highly. Further, when considered in the context of a pressured Batting Test against a pace bowling machine at 80mph (where physical harm is possible), where elite participants were pitted against each other, it is perhaps unsurprising that avoidance goals emerged and influenced performance as observed. The fact that avoidance goals emerged as the key variable in those who exhibited challenge CV reactivity may suggest that even though the initial (and perhaps unconscious;

Blascovich & Mendes, 2000) appraisal was that of challenge, thus leading to challenge CV reactivity, a subsequent focus on avoidance goals may be enough to disrupt performance.

The notion that it may be possible to assuage potential performance disruption indicated by threat CV reactivity by adopting high self-efficacy and low avoidance goals suggests that the initial and often unconscious appraisals that give rise to challenge and threat CV reactivity may not be the appraisals taken forth into the actual performance. In other words, the process through which stress influences performance may not always be linear and may involve iterative appraisals that occur as more task information is made available (Blascovich & Mendes, 2000; Lerner & Keltner, 2000; Schneider, 2008). Therefore, psychological states reported three minutes after the presentation of a stressor (description of upcoming task), as was the method used in chapters two and three, may reflect the product of an iterative appraisal process and therefore may not reflect the initial appraisal (which gave rise to CV reactivity) of the stressor. A non-linear process would allow an individual to counteract initial threat appraisal by focusing on efficacy beliefs and performance approach goals promoting perceptions of challenge and therefore assuaging potential performance disruption. A pictorial representation of a non-linear model is shown in figure 5.1.

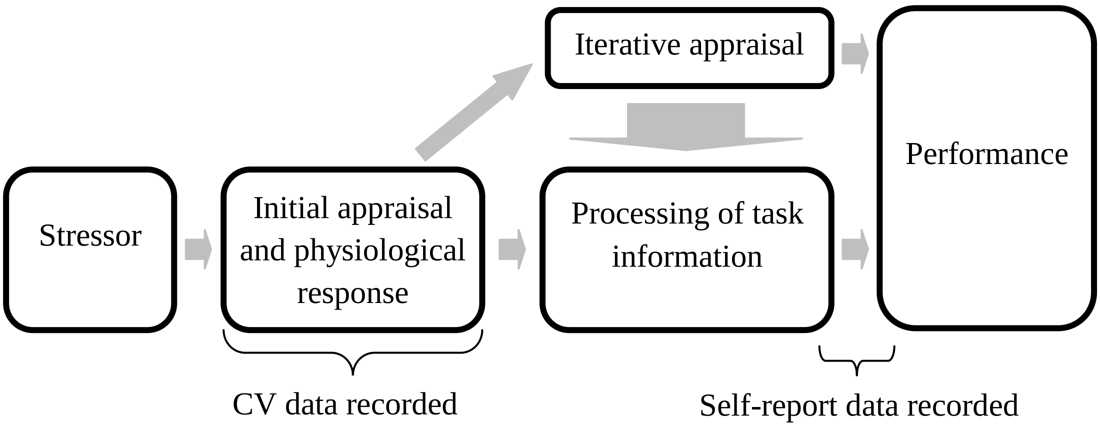

Figure 5.1. A non-linear model of the stress-performance process in the context of this thesis.

Second, Bandura (1994) recognized that self-efficacy and perceptions of physiological arousal interrelate to influence performance. For example, when an individual becomes aware of unpleasant physiological arousal, they are more likely to doubt their competence than if their physiological state was pleasant or neutral. Likewise, comfortable physiological sensations are likely to lead to feelings of confidence in the ability to succeed in the situation at hand (Maddux, 2000). This is important because it may be that individuals cannot tell the difference between challenge and threat CV reactivity at a physiological level, and therefore could perceive their arousal as facilitative regardless of underlying CV changes. In other words, it may be that some individuals, such as those in chapter three who performed well despite exhibiting threat CV reactivity, perceived their arousal as facilitative and therefore reported higher levels of self-efficacy. Indeed, these athletes reported a more positive perception of emotional states compared to the other athletes, albeit non-significantly.

Third, the self-report results of chapter three may of course be chance findings. There were after all only five participants who exhibited threat CV reactivity but performed well and only six participants who exhibited challenge CV reactivity but performed poorly. However, given the evidence that challenge CV reactivity is related to superior performance, individuals who perform contrary to their CV reactivity may be rare, especially in studies where challenge and threat states are not artificially manipulated. Indeed, only one participant emerged in chapter two who exhibited threat CV reactivity but managed to maintain performance (in Study 1). It may be that the elite athletes used in chapter three are more accustomed to competing in stressful situations and are therefore more likely to be able to produce skilled performance under pressure despite exhibiting a threat state. Indeed, some individuals may be more resilient to threat CV reactivity due to a robust level of self-efficacy, which is typically high in elite athletes (DeVenzio, 1997) who have years of prior skill knowledge and pressured situation experiences to draw from. Similarly, in elite athletes performing in such an ego-involving environment as the national academy (Barker et al., 2011), those who adopt particularly strong performance avoidance goals may suffer performance disruption regardless of the initial threat appraisal indicated by threat CV reactivity. Overall, these interesting findings warrant further research to elucidate what it is that distinguishes individuals that can perform well despite exhibiting threat CV reactivity from those that cannot.

Physiological. An alternate explanation for the relationship between CV reactivity and performance is that CV reactivity exerted an influence on cognitive and motor performance via physiological mechanisms. Challenge reactivity reflects an adaptive physiological response marked by the efficient release and delivery of energy (glucose) via increase blood flow to the muscles and brain in motivated performance situations (Blascovich & Tomaka, 1996; Jones et al., 2009). The TCTSA suggests that the physiological efficiency accompanied by catecholamine release that characterizes challenge reactivity, may facilitate psychological factors such as decision making and attention to relevant cues, while providing the muscles with sufficient energy to perform effectively (Jones et al., 2009).

There is much evidence that the release of catecholamines (epinephrine and norepinephrine), which occurs in a challenge state, can enhance cognitive abilities (e.g., selective attention: Frankenhaeuser et al., 1967; decision making, McMorris, Myers, MacGillivary, Sexsmith, Fallowfield, & Graydonr, 1999; hypothesis formulation and testing, Sothmann, Barbara, Hart, & Horn, 1988) and gross motor skill performance such as parachuting (Ursin et al., 1978). Dienstbier (1989, 1992) brought evidence together from endocrine studies and suggested possible mechanisms for the positive relationship between catecholamine release and performance. Principally, in a challenge state epinephrine facilitates energy release into the blood and efficient delivery of this energy to the brain and muscles through decreased vascular resistance and enhanced blood flow (e.g., Williams, 1986). Conversely, threat reactivity is characterized by a less efficient physiological response accompanied by PAC activity, which tempers SAM activity and inhibits the facilitative effects of catecholamines on decision making and may lead to a focus on task irrelevant cues (Dienstbier, 1989, 1992). PAC activation and the release of cortisol are consistently found to have a deleterious influence on performance (Harvey et al., 2010). For example, elevated cortisol responses to stressful events are associated with performance impairments on tasks of memory, attention, decision making, and clinical performance (Harvey et al., 2010). The performance effects related to cortisol release are thought to be a result of the short term effects of stress on endocrine feedback from the pre-frontal cortex (e.g., working memory) to the amygdala (which controls emotional responding; Lovallo, 2005). For example, in many studies, participants with the highest cortisol secretion have the worst performance in mental arithmetic tasks (e.g., al'Absi, Hugdahl, & Lovallo, 2002; al'Absi, Lovallo, McKey, & Pincomb, 1994).

Fundamentally, CV reactivity reflects underlying physiological changes brought about by an initial (and often unconscious) appraisal of the situation. The TCTSA suggests that these physiological reactions may have an influence on the delivery and use of energy to the brain and the muscles, thus affecting cognitive processes and motor skill execution. This hypothesis is most plausibly evidenced in chapter two Study 1 where CV reactivity was recorded immediately before the performance of a cognitive task. As performance occurred immediately after CV recording, the likelihood of physiological mechanisms being responsible for observed performance effects is increased. However, it is important to recognise that the performance disruption associated with a threat state observed chapter two Study 1 is unlikely to be directly related to levels of cortisol. To explain, as performance took place immediately after CV data recording, cortisol would not have had an opportunity to effect neural activity and subsequent performance as this can take up to ten minutes (Mendes & Jamieson, 2011). It is more plausible that PAC activity blunts SAM activity therefore preventing the facilitative effects of catecholamines from having a positive effect on performance (Seery, 2011).

In contrast, chapter two Study 2 and chapter three suggest alternative mechanisms as performance was completed at a later stage, 24 hours after CV recording in chapter two Study 2 and 30 minutes after CV recording in chapter three. These mechanisms are more likely to be psychological as already discussed, although this thesis cannot support this proposal based on self-report data collected across all studies. For example, it is reasonable to suggest that the way an individual responds to the stressor (description of the upcoming task) is likely to be replicated when faced with the task itself. However, temporal factors may cause some disparity between the initial response to a stressor and the response exhibited immediately prior to performing the task (e.g., Epstein & Fenz, 1965; Giacobbi Jr, Tuccitto, & Frye, 2007).

In addition, although the BPS model and the TCTSA suggest that endocrinal mechanisms cause different CO and TPR reactivity in challenge and threat states, there are alternative mechanisms that could cause these key CV changes. For example, muscle activity may be able to distinguish between challenge and threat (Cacioppo, Tassinary, & Fridlund, 1990), following the notion that when approaching a motivated performance situation, a threat state may be associated with increased muscular tension (Wright & Kirby, 2003). This muscular tension may inhibit vessel dilation reflected in TPR increases. For example, it has long been established that emotional responses have concomitant patterns of skeletal muscular activity (Ax, 1952) and symptoms of muscular tension (Holmes & Wolff, 1952; Jacobson, 1938; Wolff, 1948). Further, more anxious individuals show greater muscle activity than less anxious individuals (Sainsbury & Gibson, 1954). Measured using electromyography (EMG), muscular activity reflects central nervous system arousal (Hoehn-Saric, Hazlett, McLeod, & Pourmotabbed, 1997), generated by psychologically relevant stimuli (such as task performance). Indeed, it has also been suggested that EMG responses can be highly localised and can often occur in muscles needed for the overt responses necessary for motor performance (Davis, 1938; Jacobson, 1932). Recently Moore et al. (2012) found that a threat state was related to greater muscle activity in the muscles needed for motor performance, compared to a challenge state, which resulted in poorer subsequent motor performance. In sum, the physiological reactions to motivated performance situations activated via the central nervous system may be reflected in muscular activity and subsequent muscular tension, which may plausibly have an influence on TPR. Whether increased muscle tension and increased TPR happen simultaneously, or whether one drives the other (e.g., increased TPR helps to increase tension, or increased tension helps to increase TPR) as part of a threat response is yet to be established, but would be a fruitful area for future research. Only one research study has linked challenge and threat CV reactivity to actual neuroendocrine release (Jamieson et al., 2012) showing that participants rejected by an individual of the same race displayed greater threat CV reactivity and greater cortisol reactivity, compared to participants rejected by an individual of a different race. However, the authors do not report correlations between CV reactivity and cortisol.

While the psychological and physiological explanations discussed are theoretically plausible, this thesis contains no direct evidence of the underpinning mechanisms by which challenge and threat CV reactivity are produced in the body, or exactly how challenge and threat CV reactivity influences cognitive and motor performance. In other words, it is not known exactly how challenge CV reactivity facilitates performance, or how threat CV reactivity directly, if at all, disrupts performance.

5.2.2 The Manipulation of Challenge and Threat CV Reactivity

Chapter four extended previous research (e.g., Tomaka et al., 1997) by showing that challenge and threat CV reactivity can be manipulated by task instructions using only the resource appraisals, without altering task importance between challenge and threat instructions. That task instructions could influence CV reactivity is based on the notion that CV reactivity follows cognitive appraisal and is supported by research showing that challenge and threat cognitive appraisals lead to challenge and threat CV reactivity respectively (e.g., Schneider, 2008; Tomaka et al., 1997). Therefore, by influencing the psychological components of challenge and threat states as proposed in the TCTSA, CV reactivity can be manipulated (e.g., Williams & Cumming, 2012).

Chapter four extends past research by maintaining perceptions of task importance between challenge and threat conditions. Previous research (e.g., Alter et al., 2010; Feinberg & Aiello, 2010; Tomaka et al., 1997) has promoted challenge states by devaluing an upcoming task, a strategy that may not be effective in real world motivated performance settings such as competitive contexts or personally relevant events such as an interview or exam. By keeping constant the importance of the tasks it was possible to manipulate challenge and threat states using only the resource appraisals as put forth in the TCTSA. In both Studies 1 and 2 in chapter four, challenge instructions promoted perceptions of high self-efficacy, high perceived control, and a focus on approach goals, while threat instructions promoted perceptions of low self-efficacy, low perceived control, and a focus on avoidance goals.

Studies 1 and 2 in chapter four were differentiated by the use of contrasting motor tasks; Study 1 used a competitive short motor task (throwing bean-bags) whereas Study 2 used a physically demanding motor task (climbing). The different tasks were proposed to have different demand characteristics, and therefore would have different implications for resource appraisals and subsequent CV reactivity. To explain, in Study 1 the demands of the throwing task included danger to esteem, required effort to produce accurate arm motor movements, and the uncertainty of competition. Whereas in Study 2, the demands of the climbing task included physical danger, required sustained effort to produce coordinated gross motor movements, and given the novice status of participants, the novel nature of the climbing task itself. Therefore, under differing demand characteristics, it was possible to examine whether manipulating resource appraisals in the same way in both studies could influence challenge and threat states. Results showed that in both studies CV reactivity was exhibited in line with the instructions. Specifically, challenge instructions led to challenge CV reactivity and threat instructions led to threat CV reactivity.

Alongside CV reactivity, participants' self-reported psychological states were measured prior to completing the tasks. Intriguingly, and in line with chapters two and three, self-reported psychological states were not related to CV reactivity, and there were no between conditions differences in self-reported resource appraisals. This finding is even more perplexing in chapter four than in previous chapters because the resource appraisals were purposely manipulated using the task instructions. In other words, even though participants in the challenge instructions condition were encouraged to be highly self-efficacious, to perceive high control, and to focus on approach goals, they did not report feeling this way on the questionnaires, despite exhibiting challenge CV reactivity. Similarly, participants in the threat instructions condition were encouraged to have low self-efficacy, low perceived control, and to focus on avoidance approach goals, but did not report feeling so on the questionnaires, despite exhibiting threat CV reactivity.

The lack of self-report findings could be interpreted as being an indicator that the task instructions manipulation did not work. Indeed, had CV reactivity not been measured the conclusion to chapter four would have been that the instructions did not successfully alter resource appraisals in the desired directions. However, given that CV reactivity was in line with the manipulation and conformed with theoretical postulations (TCTSA; Jones et al., 2009) and that CV reactivity is a more objective and potentially more reliable measure of challenge and threat states (Chalabaev et al., 2009), the effectiveness of the manipulation is difficult to dispute. Also, Blascovich and Mendes (2000) suggested that appraisals are an iterative process in that a situation may be initially interpreted as a threat, thus triggering threat CV reactivity, but may become less threatened or even interpreted as a challenge over time. Therefore, in chapter four it is possible that CV reactivity indicated a participant's initial appraisal of the situation, which was later modified as reflected in the self-report measures (Schneider, 2008). This echoes previously discussed notions of a non-linear appraisal process (see figure 5.1) posited in past research (Blascovich & Mendes, 2000; Lerner & Keltner, 2000; Schneider, 2008).

5.2.3 The Lack of Associations Between CV Reactivity and Self-Reports Measures

The lack of self-report findings documented in this thesis is remarkably consistent across chapters and studies, and can be explained using three key methods of reasoning. The first is that there may have been flaws in the measures used, and flaws in the method by which self-report data were collected. The second reason stems from the notion of self-presentation (e.g., Paunonen & LeBel, 2012) in which participants provided biased responses to questionnaires across the studies. The third, and most likely, is that self-report measures requiring introspection into the appraisal mechanisms driving CV reactivity to a stressor are a poor window into processes that may occur unconsciously (e.g., Frijda, 1993; LeDoux, 1998; Quigley et al, 2002). Each method of reasoning will be discussed separately.

Measurement flaws. It is appropriate to first acknowledge potential flaws in the self-report measures and data collection methods used in this thesis. Principally, the studies in this thesis may have been underpowered to detect a relationship between psychological states and

CV measures. Specifically, the studies required a sample of 70 participants to achieve a power of .8 for significant medium effects (r = .3, p < .05) to emerge via correlation analyses (Clark-Carter, 2010). Related to the issue of power, given that the resource appraisals are proposed by the TCTSA to interact to determine challenge and threat states, a more detailed analysis concerning the nature of this interaction is needed, but was not possible in this thesis due to low participant numbers; also, this was also not the main aim of the chapters comprising the thesis. For example, mediation analyses (e.g., Baron & Kenney, 1986; Chalabaev et al., 2009) may be necessary in order to elucidate interactions between each resource appraisal, and between resource appraisals and other psychophysiological factors.

In addition, while most of the measures used in the present study are validated measures, some are not (e.g., perceived helpfulness of emotional state), and some valid measures were shortened to suit the context in which data was collected. For example, in chapter three the SEQ was reduced from 22 items to 5 items, one for each subscale, which may have altered its reliability and limited participant responses to one opportunity to express their emotional experiences. Similarly, cognitive appraisals are measured inconsistently throughout the thesis; sometimes asking participants to respond on to two separate Likert scale items, one for challenge and one for threat, and sometimes asking them to indicate challenge or threat on one continuous scale. This is a reflection of uncertainty in the literature as to how cognitive appraisals should be measured (Peacock & Wong, 1990), and also reflects that in this thesis it was consistently found that there were no relationships between appraisals and CV reactivity, and so different and equally valid (or invalid) measurement techniques were used.

Self-presentation. Blascovich and Mendes (2000) suggested that one of the contributing factors dictating whether individuals can articulate their appraisals is the extent to which self-presentation concerns predominate. In other words, and in the context of motivated performance, if individuals wish to present themselves as capable of succeeding in a given task, they may report thinking and feeling in ways that indicate their coping potential, regardless of whether they actually harbour these psychological states (Wiechman, Smith, Smoll, & Ptacek, 2000). Especially in chapter two Study 2 and chapter three where athletes were used, it is unlikely that participants would record accurate responses on such transparent constructs as self-efficacy, perceived control, and goal achievement. That is, it is unlikely for an athlete to report being low in confidence, low in control, and focused on avoidance, given that many athletes understand these terms and their relevance to performance. Admitting to low levels of resource appraisals may be akin to admitting defeat for many athletes. In fact, one research study considered CV reactivity data alongside facial expression and vocalisation data (Weisbuch, Seery, Ambady, & Blascovich, 2009). Results showed that participants who exhibit threat reactivity sounded less confident but looked more confident than participants who exhibited challenge reactivity. Therefore, similar to responding with bias on questionnaires, individuals may also attempt to mask their thoughts and feelings behaviourally.

Paunonen and LeBel (2012) recognised that individuals may consciously engage in a deliberate strategy of misrepresentation to make a good impression, or may misrepresent unconsciously, motivated by an implicit need for self-enhancement and ego maintenance. It is easy to see how both of these self-presentation strategies could be fostered in motivated performance contexts. For example, in all chapters of this thesis participants are given ego-threatening task instructions outlining the evaluative nature of the upcoming task. Consciously a participant could have chosen to respond with bias towards answers that preserved their threatened ego, selecting high values for resource appraisals. Alternatively, self-presentational biased responses could be an implicit and learned response especially for athlete participants, for whom self-presentation may be key to their success (in part because psychometrics may sometimes be used to help select squad members).

It would be understandable for athletes to respond favourably on self-report measures with little conscious thought about doing so, especially in response to questions about self-confidence and anxiety (e.g., Williams & Krane, 1992). Indeed, in chapter two and three where instructions were standardised for all participants, participants reported average self-efficacy, control, and anxiety scores of 3.61, 3.87, and 1.45 respectively on a five-point likert scale, indicating high feelings of confidence and control, but little anxiety. In sum, self-report measures have long been criticised for their susceptibility to response distortion (e.g., Paunonen & LeBel, 2012) and the lack of self-report findings amongst such convincing CV findings in this thesis may be symptomatic of the use of easily biased self-report questionnaire items.

Unconscious appraisal processes. Perhaps the findings that self-reported psychological states were not related to specific patterns of CV reactivity is not so surprising. Blascovich and Mendes (2000) in a modification of the BPS model recognise that individuals "may make nonconscious demand or resource appraisals, or both, arriving at a state of challenge or threat without any awareness of the appraisals themselves" (p. 64). In effect, neither demand nor resource appraisals need be conscious, and it is also possible that appraisals that are conscious can be made without the individual being aware that they are engaging in the appraisal process (Blascovich & Mendes, 2000). Therefore, introspective self-reports concerning appraisal, such as those used in this thesis to measure resource appraisals, have obvious drawbacks that have been highlighted many times particularly in criticisms of cognitive appraisal research (e.g., Ellsworth & Scherer, 2003; Fridja, 1993; LeDoux, 1998; Parkinson, 1996).

The notion that appraisals happen unconsciously is widely recognised in stress and emotion literature (Lovallo, 2005), and an understanding of the processes involved in appraisal and the production of CV patterns may shed some light on why this thesis failed to find any consistent findings for self-reported appraisals. LeDoux (1998) suggested that appraisals are unconscious and must be the first step in the production of emotional responses. In line with the work of Robert Zajonc (1980; 1984) and Paul Ekman (1992; 1999), LeDoux recognised that emotions can arise extraordinarily quickly without cognition or conscious access to processes underlying appraisals. Indeed, research has shown that emotions are more easily influenced when individuals are unaware of the manipulation, such as in Zajonc's (1980) mere exposure experiments, and Robert Bornstein's (Bornstein & D'Agostino, 1992) subliminal stimuli research. So, the stressor may be appraised unconsciously allowing the significance of the event to be determined quickly. LeDoux supported this notion by proposing that perception and appraisal are processed separately in the brain, which the appraisal system begins automatically before the perceptual system has fully interpreted the stimuli, and that the appraisal systems connect directly to systems involved in the control of emotional responses.

Using studies of the brain and evolutionary reasoning, LeDoux reported a body of research indicating that appraisal can occur in the absence of areas of the brain important for conscious processing, and that these absent areas developed late in the span of evolution. Therefore, appraisal is programmed by evolution to detect important stimuli unconsciously giving rise to physiological reactivity that has proved useful in past encounters. This rapid appraisal mechanism is likely to occur in motivated performance situations where there is a potential for physical and or psychological (esteem) harm. LeDoux attributed the appraisal process to the amygdala that receives inputs from sensory regions of the thalamus, higher level information from sensory specific cortex, and even higher level information from the hippocampus (e.g., memory). The amygdala is critically involved in the activation of the pituitary and adrenal glands, involved in the bodily responses to stress included in challenge and threat reactivity. During this process, conscious awareness of the stimulus and conscious control of physiological responses are not required, so introspection won't be possible. Further, even if an individual does have introspective access, the conscious content is not likely to be what triggered the emotional response.

Blascovich and Mendes (2000) asserted that the CV patterns of challenge and threat offer unambiguous and less error prone evidence of challenge and threat states. Taken into consideration alongside the unconscious process outlined by LeDoux, and the many criticisms by preeminent appraisal researchers such as Zajonc, and Ekman of introspective methods, perhaps we should rely more on techniques that do not depend on verbal reports (Scherer, 1993).

In summary, there are three broad reasons why this thesis may have failed to find any consistent results for self-reported psychological states. It may be possible to overcome measurement flaws, for example by conducting meaningful pilot studies or avoiding the significant modification and shortening of existing measures. It may also be possible to guard against self-presentation, for example by briefing participants more fully on honesty and confidentiality before data collection. In addition, the inclusion of a social desirability scale (Crowne & Marlowe, 1960) would allow for social desirability to be accounted for in data analysis thus reducing the effects of self-presentation on the results. However, the issue of unconscious appraisals is a more difficult issue to overcome or limit, and only when brain scanning is common place in psychology research might we be able to fully understand the role that conscious processes, if any, play in the appraisal of stressful stimuli and the production of challenge and threat CV reactivity. Future researchers are challenged to find inventories that can overcome the self-presentational tendencies of research participants, such as vocalisation as advocated by Weisbuch et al. (2009).

5.3 Implications

Overall, this thesis has many potential implications for both the measurement and management of individuals' responses to stressful situations. Taken together, it is possible to predict performance through the measurement of CV reactivity (chapters 2 and 3), and also possible to manipulate challenge and threat CV reactivity using instructional sets (chapter 4). All of the chapters in this thesis support the notion that the recording of CV reactivity to measure challenge and threat states may be preferable to self-report methods (e.g., Blascovich & Mendes, 2000; Chalabaev et al., 2009).

Chapters two and three advocate the measurement of CV reactivity in response to being exposed to a stressor; in this thesis being told about an upcoming motivated performance. The results support previous research showing that challenge CV reactivity predicts performance in both imminent (Moore et al., 2012) and later tasks (Blascovich et al., 2004; Seery et al., 2010). Because CV reactivity was able to predict performance in tasks occurring imminently, 30 minutes later, and 24 hours later, there appears to be value in measuring and understanding individuals' initial reactions to being informed about a given task. The finding that CV reactivity at this point can predict future performance could be used in many contexts to gauge individuals' approach to motivated performance situations. For example, how a student reacts to being informed about an assessed presentation they are required to give, or how a job seeker reacts to being informed that they have been selected for an interview, may provide important information about how these individuals may perform. This could then afford individuals an opportunity to take steps to alter their approach and or adopt stress management strategies in the lead up to the exam or interview. A benefit of using CV measures instead of, or alongside, self-reports to gather information regarding stress reactions, is that CV reactivity offers an objective indicator of how the individual feels about the upcoming event, bypassing risks of self-presentation or inventory flaws (Blascovich & Mendes, 2000).

Chapter three offers specific implications with regards to elite athletes, and in particular, the training and selecting of athletes for elite squads. With regards to training, the use of pressure testing as adopted in the Batting Test may be a useful way of introducing athletes to pressure in a training context. Desensitisation research suggests that repeated exposure to these types of activities could help athletes to adapt to stressful situations more easily (Wolpe, 1973), thus becoming better prepared for actual competitive pressure. To explain, as the athlete is subjected to stress regularly and systematically, they acclimatise to the experience of stress and develop or learn personal and often implicit resources for performing under pressured conditions. The athletes' progress through desensitisation could be measured using CV reactivity, and could be particularly useful for those who respond with threat reactivity on first exposure to the stressor. Hypothetically, one would expect repeated exposure to a stressor, and more importantly multiple experiences of successfully coping under pressure, to promote challenge CV reactivity as demand appraisals, particularly uncertainty, become weaker compared to resource appraisals, accelerated by the addition of stress management techniques. However, research needs to be conducted linking desensitisation to challenge and threat states before this type of strategy is implemented in an applied context.

With regard to athlete screening and selection, it is important to be clear that it would be inaccurate and inappropriate to suggest that athletes could be selected using CV reactivity screening data; this thesis indicates that it could be one of many important variables to take into account alongside physical, technical, social, behavioural, and psychological factors. Indeed, in chapter 2 baseline performance significantly predicted final task performance, thus athletes' previous performance and ability is a major factor to consider when selecting athletes. However, used properly CV reactivity data could offer important insights into whether an athlete is ready to perform in pressured situations. That is, psychologists and coaches could use CV reactivity data to form a more complete picture about an athlete's preparedness for an important performance situation, which may indicate how able the athlete is to fulfil their potential. In the event of a threat state prior to the event, an intervention can then be applied with the athlete to help promote a challenge state. As discussed in this thesis, the intervention could include reappraisal (Jamieson et al., 2010), imagery (Williams et al., 2010), or instructional sets, as examined in chapter four of this thesis.

The major implication of the findings from chapter four relate to the applied use of theoretical components of the TCTSA. Given the relationship between challenge CV reactivity and performance reported in chapters two and three, ways in which challenge states can be promoted are valuable. In chapter four the resource appraisals were used to manipulate challenge and threat states using instructional sets, which also maintained the perceived importance of the upcoming tasks. Importantly, the finding that a challenge state can be promoted using challenge instructions extended previous research (e.g., Tomaka et al., 1997) which devalued task importance in order to promote a challenge state. In this thesis, it is reasoned that it is unrealistic to devalue the importance of a task in any given motivated performance situation, especially in real world performance settings. That is, informing an athlete before a cup final that the match is not important and to just try her best is both false and potentially pointless. Indeed, it is not that the situation is important (or uncertain, or dangerous, or effortful) that causes performance disruptions; it is whether the athlete has the resources (self-efficacy, control, approach focus) to overcome the demands. For example, in this thesis self-reported task importance was not related to challenge or threat CV reactivity, or performance, and did not differ between challenge and threat task instruction conditions.

Therefore, it is possible to promote a challenge state in motivated performance situations using only the resource appraisals as put forth in the TCTSA.

In applied settings, the use of the resource appraisals to promote a challenge state can be operationalized in numerous ways. For example, previous research has used imagery scripts to manipulate challenge and threat appraisals and or CV reactivity (Williams & Cumming, 2012; Williams et al., 2010). Williams et al. adopted a challenge script, emphasising that the athlete's resources met the demands of the situation, that they could be confident (high self-efficacy), demonstrate competence (high perceived control), and had a lot to gain (approach goals). A threat script emphasised that the athlete's resources did not meet the demands of the situation, that they should doubt their abilities (low self-efficacy), may reveal their weaknesses (low perceived control), and had a lot to lose (avoidance goals). Results showed that compared to the threat script, the challenge script led athletes to feel that their emotional responses were more helpful for performance (in an upcoming competition in their sport), feel more confident, and appraise the situation as less threatening. CV data revealed no differences between challenge and threat imagery conditions. Williams and Cumming (2012) used similar imagery scripts and found that the challenge script led to challenge appraisals and the threat script led to threat appraisals. It was also found that those receiving the threat script reported their emotional responses as more debilitating for performance (in a dart throwing task) compared to those who received the challenge script. In sum, using the resource appraisals as outlined in the TCTSA to form challenge and threat imagery scripts it is possible to manipulate the psychological components that characterise challenge and threat states.

Imagery is a psychological skill that is best developed with practice and guidance from a practitioner (Hale & Whitehouse, 1998; Vealey & Greenleaf, 2006). In contrast chapter four used task instructions which require little skill other than for participants to be able to listen to a set of instructions for 1-2 minutes. In applied settings, instructional sets could be used by leaders, most feasibly managers, coaches, and captains within an athletic context. It is well established that leaders can have an important influence on their subordinates' responses to stressful situations (Baker et al., 2000; Lewthwaite & Scanlan, 1989; Smith et al., 1998). In team sports athletes frequently gather to hear the coach's final thoughts immediately prior to a competition, where effective leaders will attempt to use this unique and final opportunity to direct the athletes towards goal achievement (Vargas-Tonsing & Guan, 2007; Haslam, Reicher, & Platow, 2011). In this instance, a coach could laden her team talk with references to confidence, control and approach goals to promote a challenge state in her athletes, while retaining references to the importance of the occasion. Indeed, research suggests that speeches with high instructional content increase athletes' functional emotions (Vargas-Tonsing, 2009). In sum, the promotion of the resource appraisals using imagery could be used by sport psychologists and athletes to encourage challenge states in motivated performance situations. In addition, challenge instructions could be used by leaders to encourage challenge states in athletes prior to important competitive situations. The challenge for sport psychologists is convincing coaches to adopt the resource appraisals in their instructions, something that could be achieved in the event of more research and particularly research conducted in applied settings.

In summary, the findings in this thesis imply that CV reactivity could be adopted by psychology practitioners as a method of determining individuals' approach to motivated performance situations and as an indicator of stress management ability. Further, the resource appraisals could be used by practitioners and leaders to promote challenge states, validated by the measurement of CV reactivity.

5.4 Limitations

The limitations accompanying the studies in this thesis offer potential areas for future theoretical and research developments. Although validated many times (e.g., Blascovich et al., 2011) there is yet to be a research paper evidencing the exact mechanisms through which challenge and threat CV reactivity are activated. Research would need to report findings where CV reactivity, neurological, endocrine, and psychological factors are all measured to robustly support the notion of challenge and threat states. Although the findings in this thesis are important and reliable, this thesis contains no direct evidence of the underpinning neurological mechanisms through which challenge and threat CV reactivity patterns occur, and further, contains no direct evidence of how these CV reactivity patterns directly influence performance.

A further limitation regarding CV indicators of challenge and threat states in this thesis is that although participants exhibited HR and PEP reactivity consistent with task engagement, changes in HR and PEP were small when compared to other challenge and threat research (e.g., Blascovich et al., 2004). This may be because the tasks used in most of the studies in this thesis were deemed important artificially using ego-threatening instructions, rather than being genuinely relevant to the participants. In addition, similar research (e.g., Blascovich et al., 2004) has used a speech task to elicit CV reactivity, which is likely to engender high task engagement due to the stressful nature of public speaking. The use of a speech task may not be an ecologically valid way to elicit CV reactivity and therefore the use of real-life competitive events may engender clearer changes in HR and PEP.

Another limitation of this thesis is the self-report measurement strategies used. The findings of this thesis outline the drawbacks of using self-report measures, but also there were inconsistencies in how self-reports were attained. For example, in chapter two Study 1 self-reports were collected after performance in the task, whereas all other studies in this thesis attained self-reports before the tasks. Although the reasons for this were plausible (attempting to get CV reactivity as close as possible to performance), retrospective introspections may confound the limitations of self-reports already discussed. In addition, the studies may have been statistically underpowered to find significant correlations of medium effects (Clark-Carter, 2010). Therefore, investigations recruiting larger samples could be conducted to address this limitation, similar to Moore et al. (2012), who recruited 127 participants between challenge and threat conditions, but who did not report associations between CV reactivity with the diverse range of psychometrics reported in this thesis.

This thesis represents a significant step forward in the understanding of the relationship between challenge and threat states and performance and the manipulation of challenge and threat states that could be strengthened with the limitations detailed here addressed. Clearly, more research is needed to provide more detailed examinations into challenge and threat states and the resource appraisals, but this thesis offers a solid foundation for future research to build on and extend.

5.5 Future Research Directions

The findings of this thesis help to pose numerous questions that could be answered by future research. The most significant area for future research is the determination of the underlying neurological and endocrine mechanisms through which challenge and threat CV reactivity are exhibited. Neurological assessment methods and blood or urine sampling was beyond the scope of this thesis, but future research could employ these methods to form a more complete picture of what happens at a deeper level than CV reactivity when challenge and threat states emerge. Another significant area for further research concerns the nature and measurement of accompanying psychological states in challenge and threat states. More research is needed to identify the best way to measure psychological states to avoid bias, perhaps utilising non-verbal indictors such as innervations in the face muscles (e.g., Ekman, 1999) and variations in vocalisations (e.g., Weisbuch et al., 2009). Alternatively, psychological traits could be measured to explore the possibility of more implicit cognitive constructs influencing the experience of challenge and threat states. In addition, given the notion that appraisals most likely occur without conscious awareness (e.g., LeDoux, 1998), the use of subliminal manipulation could be investigated to align challenge and threat states more with the work of Zajonc and the implicit appraisal theorists and less with Lazarus and the cognitive theorists.

Research should also be conducted with a higher number of elite athletes, specifically in a sport setting. Chapter three in this thesis examined challenge and threat states and performance in elite athletes in the performance environment, with promising results. However, exploring challenge and threat states before actual competition, as opposed to an artificial one (e.g., the Batting Test), would be a more ecologically valid way to examine challenge and threat states in athletes. In addition, the intriguing findings of chapter 3 that athletes who exhibit threat reactivity performed well when highly confident, could be expanded and further explored using a variety of methodologies. Obviously, the comparison of individuals who exhibit threat reactivity and perform poorly with individuals who exhibit threat reactivity and perform well would benefit from a larger sample size than used in chapter 3 in order to provide sufficient power for more meaningful between-groups comparisons. Also, with sufficient power mediation analyses could be used to assess the impact of self-efficacy, and the other resource appraisals, on the relationship between CV reactivity and performance. Achieving greater statistical power could be difficult in naturalistic settings, such as that used in chapter 3, due the potential rarity (considering the strong relationship between CV reactivity and performance) of individuals who can perform well despite exhibiting threat reactivity. Therefore, between-groups methodologies could be employed where initially a threat state is promoted across two groups (as in chapter 4) after which, one group receives a self-efficacy enhancement strategy (e.g., imagery; Williams et al., 2010) and the other receives nothing. Hypothetically one would anticipate the self-efficacy enhancement group to perform better in competitive tasks than the group that received no such enhancement, based on the findings of chapter 3 and the postulations of the butterfly catastrophe model (Hardy, 1990). Similarly, the findings of chapter 3 that athletes who exhibit challenge reactivity performed poorly when adopting high avoidance goals, could be explored using the aforementioned methodologies. Specifically, initially a challenge state is promoted across two groups (as in chapter 4), after which one group receives an avoidance goal strategy, and the other receives nothing. Avoidance strategies could include the promotion of ironic thought processes such as "don't mess up," that have been linked to performance disruption many times in research literature (e.g., Janelle, 1999; Wegner, Ansfield, & Pilloff, 2008). Alternatively, the avoidance strategy could be based on the work of Worthy et al. (2009b) where participants are encouraged to adopt a global prevention focus (avoidance goals) by performing a task in which they are sensitised to potential losses rather than gains (successful performance results in fewer losses than unsuccessful performance). One could hypothesise that the avoidance strategy group would perform worse in competitive tasks than the group that received no such strategy, based on the findings of chapter 3 and previous research (Worthy et al., 2009a).

To further explore the application of the TCTSA in sport settings, sport psychology practitioners should employ single-case methods (e.g., Barker, McCarthy, Jones, & Moran, 2011) and examine the effectiveness of interventions that increase self-efficacy, perceived control, and approach goals in increasing a challenge state. This would entail the repeated measurement of CV reactivity and psychological variables across time, spanning pre- and post-intervention phases. It is important to validate the psychophysiological underpinnings of challenge and threat states as put forth in the TCTSA in applied settings, not just in the laboratory.

Finally, the concept of challenge and threat states adopted in this thesis assumes that reductions in TPR and increase in CO from zero indicate challenge and increases in TPR and reductions/stabilisation in CO from zero indicate threat. However, similar to the propositions of the catastrophe theory (Fazey & Hardy, 1988) there is a possibility that individuals can endure increases in TPR and still maintain performance to a point, after which performance is likely to suffer (i.e., hysteresis). To explain, it may be that TPR increases of 10 and CO decreases of .1 are not enough to indicate potential performance disruption, it may be when TPR increases by 15 and CO decreases by .2 that performance is negatively impacted. This of course is conjecture, but it is important to understand the sensitivity of performance in relation to CV reactivity and to realise the points at which CV reactivity cannot predict performance. For example, what are the performance implications, if any, of an increase in TPR of 15 compared to an increase of 25? Future research could explore not only patterns of CV reactivity against zero, but consider that there may be extents to which reactivity predicts performance and extents to which it does not.

5.6 Conclusion

This thesis makes a novel contribution to challenge and threat literature. For the first time, this thesis shows that challenge and threat reactivity can predict changes in performance from normal levels, and predict the performance of elite athletes. This thesis also shows that challenge and threat CV reactivity can be manipulated using instructional sets formed using the resource appraisals outlined in the TCTSA. The use of hemodynamic CV reactivity as a method of gaining a deeper understanding of how individuals' respond in motivated performance situations, which can ultimately indicate the likelihood of performance success, is advocated. In addition, the support for the resource appraisals in this thesis offers practitioners a framework through which challenge states can be promoted. In short, by using the resource appraisals it is possible to promote a challenge state, which is likely to lead to a performance maintenance or improvement under pressured circumstances. With the consistent lack of findings for self-report data despite consistent CV reactivity findings, this thesis also makes an important contribution to the debate surrounding conscious vs. unconscious appraisals. In light of the evidence in this thesis and of previous research, it may be that challenge and threat states are best measured using CV reactivity indicators instead of, or at least alongside, self-report measures. In addition, underpinned by much research showing that psychological states and challenge and threat CV reactivity states are not always related (Mendes et al., 2002), a key direction for future research is to elucidate other ways to measure challenge and threat states other than CV reactivity and self-reports. The key message delivered in this thesis is that challenge and threat is a valuable concept that has important implications for motivated performance, which using the TCTSA as a framework, can be used to help individuals to approach pressured situations in an adaptive psychological and physiological state. In summary, this thesis has made an original and significant contribution to the understanding of how stress influences human performance, and how adaptive responses to stressful situations can be promoted, by examining the cognitive, affective, and physiological components of the TCTSA.

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APPENDIX 1: RECRUITMENT INFORMATION, QUESTIONNAIRES, AND TASK INSTRUCTIONS CHAPTER 2 STUDY 1

Do you want to take part in a research project this summer?

I am a PhD Student looking for people to take part in a research project exploring individuals' psychological and physiological approach to performing a short test.

An innovative piece of equipment is used to measure how your cardiovascular system responds to an upcoming task. We will also collect data from self-report questionnaires.

Taking part in the study will involve 45 minutes of your time and data collection will take place in the observation suites in the Brindley Building.

If you are unable to use a laptop, are haemophiliac, bruise easily, have high blood pressure, or are allergic to electrode gel, unfortunately you cannot take part in this study.

Please email me on martin.turner@staffs.ac.uk and we can arrange a convenient time for you to take part.

Kind Regards

Martin Turner

UNIVERSITY of DERBY

STAFFORDSHIRE UNIVERSITY

STAFFORDSHIRE UNIVERSITY

UNIVERSITY of DERBY

INFORMATION FORM

Dear Participant

I am a PhD candidate under the supervision of Dr Marc Jones in the Faculty of Health at Staffordshire University, and Dr David Sheffield in the Psychology Department at the University of Derby. I am conducting a research study to assess psychological and cardiovascular responses in relation to a short test. Your participation in this study will involve completing questionnaires and being connected to an impedance cardiograph machine while you are instructed on how to complete the test. You will complete the test on a laptop computer using the keyboard, but specific instructions will be given to you prior to the test. You can withdraw at any point. Once the test is completed you will not be required for this study again.

The attachment of the cardiograph equipment to you will involve the use of a hypoallergenic electrode gel to enhance the signal we get from your skin. If you have a known allergy to this gel, unfortunately you are excluded from this study. In our experience, the use of the band electrodes and gel can sometimes leave red marks on the skin where the bands are placed. These normally disappear in under 24 hours but in a small number of cases can persist past 24 hours. If you do not have a known allergy and choose to participate, you are also informed that the removal of the impedance cardiograph equipment may cause minor hair removal and potentially a small amount of pain in relation to this.

Your participation in this study is voluntary. You are free to refuse to commence the testing or withdraw at any time in the proceedings. The results of the research study may be published, but your name will not be used and no individual identifying information will be provided. Your participation will contribute to a greater understanding of how individuals feel prior to a competitive situation.

If you have any questions concerning the research or your participation in this study, please contact me via email: m.turner@staffs.ac.uk, Dr Marc Jones on 01782 295985, or Dr David Sheffield via d.sheffield@derby.ac.uk.

Sincerely

Martin James Turner

-*-*-*-*-*-*-*-*-*-*-*-

CONSENT FORM

Approaching an Upcoming Test

Please tick the appropriate boxes. If you do not agree with any of the statements, unfortunately you are excluded from the study and are not required to complete the rest of the consent form:

	Agree
I do not bruise easily	
I am not a haemophiliac	
I have no known allergy to Signa electrode gel	
I do not have high blood pressure	

Please tick the following boxes:

I confirm that I have read and understood the information form for the project "Approaching an Upcoming Test" and have had the opportunity to withdraw participation and/or ask questions.	
I understand that my participation is voluntary and I understand that I may withdraw my consent and discontinue participation at any time, without further consequences.	
I agree that cardiovascular, psychological, and performance recordings will be taken and used for this project only. All data will be stored safely on a password protected computer.	
I agree to take part in the above study.	

....	....	....
Name of Participant	Signature	Date
....	....	....
Name of Researcher	Signature	Date

Date of birth (dd/mm/yy): ____________ Age: ______

Sex (M/F): _______

Height: _________ (cm)

Weight: _________ (kilograms)

Occupation: ____

SPORT EMOTION QUESTIONNAIRE

Below you will find a list of words that describe a range of feelings that individuals may experience while completing the Stroop Test. Please read each one carefully and indicate on the scale next to each item how you **felt immediately prior to the final Stroop Test**. There are no right or wrong answers. Do not spend too much time on any one item, but choose the answer which best described **your feelings prior to the competitive performance**.

	Not at all	A little	Moderately	Quite a bit	Extremely
Uneasy	0	1	2	3	4
Upset	0	1	2	3	4
Exhilarated	0	1	2	3	4
Irritated	0	1	2	3	4
Pleased	0	1	2	3	4
Tense	0	1	2	3	4
Sad	0	1	2	3	4
Excited	0	1	2	3	4
Furious	0	1	2	3	4
Joyful	0	1	2	3	4
Nervous	0	1	2	3	4
Unhappy	0	1	2	3	4
Enthusiastic	0	1	2	3	4
Annoyed	0	1	2	3	4
Cheerful	0	1	2	3	4
Apprehensive	0	1	2	3	4
Disappointed	0	1	2	3	4
Angry	0	1	2	3	4
Energetic	0	1	2	3	4
Happy	0	1	2	3	4
Anxious	0	1	2	3	4
Dejected	0	1	2	3	4

How helpful did you feel your emotional state was for your performance in the final Stroop Test?

Not at all helpful	A little bit	Moderately	Quite a bit	Extremely helpful
0	1	2	3	4

Pre-test Measures

Please consider your thoughts and feelings about the final Stroop Test you have just completed, and indicate the extent to which the following statements represent how you felt immediately before completing the final test:

	Not at all true						**Very true**
It is important to me to perform as well as I possibly can	1	2	3	4	5	6	7
I worry that I may not perform as well as I possibly can	1	2	3	4	5	6	7
It is important to me to do well compared to others	1	2	3	4	5	6	7
I just want to avoid performing worse than others	1	2	3	4	5	6	7
I want to perform as well as it is possible for me to perform	1	2	3	4	5	6	7
Sometimes I'm afraid that I may not perform as well as I'd like	1	2	3	4	5	6	7
It is important for me to perform better than others	1	2	3	4	5	6	7
My goal is to avoid performing worse than everyone else	1	2	3	4	5	6	7
It is important for me to master all aspects of my performance	1	2	3	4	5	6	7
I'm often concerned that I may not perform as well as I can perform	1	2	3	4	5	6	7
My goal is to do better than most other performers	1	2	3	4	5	6	7
It is important for me to avoid being one of the worst performers in the group	1	2	3	4	5	6	7

Recall how you felt <u>immediately before taking the final Stroop Test</u> and indicate to what extent you agree with the following statement?

The more effort I put into this test, the better I will do.

Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
1	2	3	4	5

How confident did you feel about performing to the best of your ability in the final Stroop Test?

Not at all	a little	moderately	quite a bit	completely
1	2	3	4	5

Please consider your thoughts and feelings about the final Stroop Test you have just completed, and indicate on the scale below how <u>you felt immediately prior to completing the final test</u>:

Threatened				Neither				Challenged
-4	-3	-2	-1	0	+1	+2	+3	+4

How important was doing well in this test for you?

Not at all	not so much	a little	moderately	quite a bit	very much so
0	1	2	3	4	5

Participant Debrief Sheet

In this research project we are interested in how you responded both psychologically (via questionnaires) and physiologically (via cardiovascular recordings), to the information you received about the Stroop Test prior to your performance. We are also interested in how you performed in the test. We would expect that if you responded with increased vascular resistance and decreased cardiac output (amount of blood pumped from heart per minute), you would perform poorly in the Stroop Test. Alternatively, if you responded with decreased vascular resistance and increase cardiac output, you would perform well in the Stroop Test. All Stroop Test performance scores will be collated, and a league table with all participants' scores in ranking order will be sent to all participants, when the research project has been completed. Thank you for taking part in this research project and please refrain from revealing the nature of the project to other members of staff and/or students, until you have received the league table, signifying the end of the project. Finally, in light of the information you have received, you can still withdraw from this study. If you wish to do so, please contact me via m.turner@staffs.ac.uk, and all of the data you provided will be excluded from the study (including your performance).

Stroop Test Instructions

Practice Instructions

You will now be given 4 practice trials at the Stroop Test to allow you to familiarise yourself with the program and to give you an opportunity to develop your skills. Try your best to score highly in the 4 trials. Each practice trial will last 60 seconds. After each trial, the experimenter will take the laptop from you, and you will then be given 60 seconds rest before the next trial. After the 4th trial, we will collect some cardiovascular data from you for about 8 minutes. You can begin when the experimenter tells you to.

Final Test Instructions

The Stroop Test is an accurate measure of attention and cognitive ability, both important contributors to intelligence. You are required to complete one more 60 second Stroop Test. It is this score on this single final trial that will be compared with the performance scores from all other participants involved in the study. Your score in this final upcoming test will be displayed on a league table at the end of this study, with all participants' scores in ranking order. This league table will be sent to all participants. Consequently, you will have to try very hard, and perform well, if you are to compare favourably with the other participants. You can of course withdraw from the test at anytime, but for the moment, please remain seated and as still as possible for about two minutes while you think about the task, prepare yourself to take part, and we collect some cardiovascular data.

APPENDIX 2: QUESTIONNAIRES AND TASK INSTRUCTIONS CHAPTER 2 STUDY 2

SPORT EMOTION QUESTIONNAIRE

Below you will find a list of words that describe a range of feelings that sport performers may experience. Please read each one carefully and indicate on the scale next to each item how you feel **right now, at this moment, in relation to the upcoming task**. There are no right or wrong answers. Do not spend too much time on any one item, but choose the answer which best describes your feelings right now in relation to the critical situation.

	Not at all	**A little**	**Moderately**	**Quite a bit**	**Extremely**
Uneasy	0	1	2	3	4
Upset	0	1	2	3	4
Exhilarated	0	1	2	3	4
Irritated	0	1	2	3	4
Pleased	0	1	2	3	4
Tense	0	1	2	3	4
Sad	0	1	2	3	4
Excited	0	1	2	3	4
Furious	0	1	2	3	4
Joyful	0	1	2	3	4
Nervous	0	1	2	3	4
Unhappy	0	1	2	3	4
Enthusiastic	0	1	2	3	4
Annoyed	0	1	2	3	4
Cheerful	0	1	2	3	4
Apprehensive	0	1	2	3	4
Disappointed	0	1	2	3	4
Angry	0	1	2	3	4
Energetic	0	1	2	3	4
Happy	0	1	2	3	4
Anxious	0	1	2	3	4
Dejected	0	1	2	3	4

Please consider your thoughts and feelings about the upcoming task and indicate the extent to which the following statements represent you:

	Not at all true						Very true
It is important to me to perform as well as I possibly can	1	2	3	4	5	6	7
I worry that I may not perform as well as I possibly can	1	2	3	4	5	6	7
It is important to me to do well compared to others	1	2	3	4	5	6	7
I just want to avoid performing worse than others	1	2	3	4	5	6	7
I want to perform as well as it is possible for me to perform	1	2	3	4	5	6	7
Sometimes I'm afraid that I may not perform as well as I'd like	1	2	3	4	5	6	7
It is important for me to perform better than others	1	2	3	4	5	6	7
My goal is to avoid performing worse than everyone else	1	2	3	4	5	6	7
It is important for me to master all aspects of my performance	1	2	3	4	5	6	7
I'm often concerned that I may not perform as well as I can perform	1	2	3	4	5	6	7
My goal is to do better than most other performers	1	2	3	4	5	6	7
It is important for me to avoid being one of the worst performers in the group	1	2	3	4	5	6	7

Taking the upcoming task into consideration, to what extent do you agree with the following statements?

The more effort I put into this test, the better I will do.

Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
1	2	3	4	5

With reference to today's performance, to what extent do you feel confident that you can get the ball on target and score highly in the upcoming task?

Not at all	a little	moderately	quite a bit	completely
1	2	3	4	5

With reference to today's performance, to what extent do you feel confident that you can stay focussed on the most important parts of your performance?

Not at all	a little	moderately	quite a bit	completely
1	2	3	4	5

With reference to today's performance, to what extent do you feel confident that you can mobilise all your resources for this performance?

Not at all	a little	moderately	quite a bit	completely
1	2	3	4	5

With reference to today's performance, to what extent do you feel confident that you can perform well even if things get tough?

Not at all	a little	moderately	quite a bit	completely
1	2	3	4	5

With reference to today's performance, to what extent do you feel confident that you can raise the level of your performance if you have to?

Not at all	a little	moderately	quite a bit	completely
1	2	3	4	5

With reference to today's performance, to what extent do you feel confident that you can stay motivated throughout your performance?

Not at all	a little	moderately	quite a bit	completely
1	2	3	4	5

With reference to today's performance, to what extent do you feel confident that you can shoot accurately in the task?

Not at all	a little	moderately	quite a bit	completely
1	2	3	4	5

How threatening do you expect the upcoming task to be?

Not at all	not so much	a little	moderately	quite a bit	very much so
0	1	2	3	4	5

How challenging do you expect the upcoming task to be?

Not at all	not so much	a little	moderately	quite a bit	very much so
0	1	2	3	4	5

Debrief

The purpose of this research was to investigate the cardiovascular responses of sports performers to stress and how they predicted performance on a netball shooting task.

The independent variable was the stressful situation imposed on each participant. There was a number of dependent variables, the first being performance on a netball shooting task rated using a scoring system. The second dependent variable was the physiological data recorded from the Impedance Cardiogram (ICG), ECG and blood pressure monitor. The answers from the questionnaires completed by participants about their general attitudes and beliefs, sport emotions, achievement goals, perception of control, self-efficacy and cognitive appraisal were also the dependent variables.

Any information obtained from you will not be identifiable and will enable me to complete my third year dissertation project for my undergraduate psychology degree.

Thank you very much for your participation.

Netball Shooting Task Instructions

You are about to complete a netball shooting task. It will involve taking 12 shots from three different positions in the D. Although you have already done this task before, it is your scores on this upcoming task that will be compared with performance scores from all the other participants involved in the study. Your score in this upcoming task will be displayed on a league table at the end of this study, with all scores in ranking order, and this will be sent to all participants. Consequently, you will have to try very hard if you are to perform well in comparison to the other participants. Also, your performance today will be video recorded and viewed by an England Netball Coach. At [time taking the task again] you will perform the task again in the sports hall. You can of course withdraw from the task at anytime, but for the moment please remain seated and as still as possible for about two minutes while you think about the task, and how you will perform, while we collect some cardiovascular data.

APPENDIX 3: RECRUITMENT INFORMATION, QUESTIONNAIRES, PERFORMANCE MEASURES, AND TASK INSTRUCTIONS CHAPTER 3

STAFFORDSHIRE UNIVERSITY

Letter to Athletes

Dear Athlete

I am a PhD scholar at Staffordshire University under the supervision of Dr Marc Jones (Staffordshire University), and I am conducting a research project with James Bell looking at cricketers' mental approach to performance, both psychologically and physiologically. A piece of innovative equipment is used to record cardiovascular data, and a series of short self-report questionnaires are used to record psychological data.

If you are haemophiliac, bruise easily, have high blood pressure, or have a known allergy to electrode gel, unfortunately you cannot take part in this study.

Data collection will take place at the National Cricket Centre tomorrow and will take 30 minutes of your time.

Please read the information sheet, and then complete the consent form overleaf.

Thank you for taking time to read this and I hope to see you soon at the National Cricket Centre.

Kind Regards

Martin Turner

INFORMATION FORM

Dear Athlete

I am a PhD scholar under the supervision of Dr Marc Jones in the Faculty of Health at Staffordshire University. I am conducting a research study with James Bell to assess cricketers' psychological and cardiovascular responses to performance. Your participation will involve completing questionnaires and being connected to an impedance cardiograph machine (assessing your cardiovascular responses) while you are instructed on how to complete a test. You will complete the test in the nets at the National Cricket Centre and specific instructions will be given to you prior to the test. If you are injured, or for any reason have restricted movement, you are unfortunately excluded from data collection, but may still be able to take the test. You can withdraw at any point. Once the test is completed you will not be required for this study again.

The attachment of the cardiograph equipment to you will involve the use of a hypoallergenic electrode gel to enhance the signal we get from your skin. If you have a known allergy to this gel, unfortunately you are excluded from this study. In our experience, the use of the band electrodes and gel can sometimes leave red marks on the skin where the bands are placed. These normally disappear in under 24 hours but in a small number of cases can persist past 24 hours. If you do not have a known allergy and choose to participate, you are also informed that the removal of the impedance cardiograph equipment may cause minor hair removal and potentially a small amount of pain in relation to this.

Your participation in this study is voluntary. You are free to refuse to commence the task or withdraw at any time in the proceedings. The results of the research study may be published, but your name will not be used and no individual identifying information will be provided. Your participation will contribute to a greater understanding of how individuals feel prior to a competitive situation.

If you have any questions concerning the research or your participation in this study, please contact me via email: m.turner@staffs.ac.uk or James Bell via j.j.bell@bangor.ac.uk.

Sincerely

Martin James Turner

-*-*-*-*-*-*-*-*-*-*-*-

STAFFORDSHIRE UNIVERSITY

CONSENT FORM

Approaching an Upcoming Test

Please tick the appropriate boxes. If you do not agree with any of the statements, unfortunately you are excluded from the study and are not required to complete the rest of the consent form:

	Agree
I do not bruise easily	
I am not a haemophiliac	
I have no known allergy to Signa electrode gel	
I do not have high blood pressure	

Please tick the following boxes:

I confirm that I have read and understood the information form for the project "Approaching an Upcoming Test" and have had the opportunity to withdraw participation and/or ask questions.	
I understand that my participation is voluntary and I understand that I may withdraw my consent and discontinue participation at any time, without further consequences.	
I agree that cardiovascular, psychological, and performance recordings will be taken and used for this project only. All data will be stored safely on a password protected computer.	
I agree to take part in the above study.	

....

Name of Participant Signature Date

....

Name of Researcher Signature Date

Please provide us with some brief details about yourself:

Name: ____

Date of birth (dd/mm/yy): ___________

Sex (M/F): _______ Age_______

Height: _________ (cm)

Weight: _________ (kilograms)

Please provide us with some brief details about yourself:

Main Sport: ____________________________________

Number of years experience playing your main sport: __________________________

Level of performance (please circle the most appropriate option below):

Club

County

Regional

National

International

Nationality: ____________________________________

Ethnicity: _____________________________________

Name: ____________________________________

SPORT EMOTION QUESTIONNAIRE

Below you will find a list of words that describe a range of feelings that individuals may experience in cricket performance. Please read each one carefully and indicate on the scale next to each item how you feel RIGHT NOW prior to the upcoming Batting Test. There are no right or wrong answers. Do not spend too much time on any one item, but choose the answer which best describes your feelings about the upcoming Batting Test.

	Not at all	**A little**	**Moderately**	**Quite a bit**	**Extremely**
Excited	0	1	2	3	4
Angry	0	1	2	3	4
Happy	0	1	2	3	4
Anxious	0	1	2	3	4
Dejected	0	1	2	3	4

How helpful do you feel your emotional state is for your performance in the Batting Test?

Not at all helpful	**A little bit**	**Moderately**	**Quite a bit**	**Extremely helpful**
0	1	2	3	4

Pre-test Measures

Please consider your thoughts and feelings about the upcoming Batting Test and indicate the extent to which the following statements represent you:

	Not at all true						**Very true**
It is important to me to perform as well as I possibly can	1	2	3	4	5	6	7
I worry that I may not perform as well as I possibly can	1	2	3	4	5	6	7
It is important to me to do well compared to others	1	2	3	4	5	6	7
I just want to avoid performing worse than others	1	2	3	4	5	6	7

Taking the Batting Test into consideration, to what extent do you agree with the following statements?

The more effort I put into this Batting Test, the better I will do.

Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
1	2	3	4	5

In doing the Batting Test...

...to what extent do you feel confident that you can score highly?

Not at all	a little	moderately	quite a bit	completely
1	2	3	4	5

...to what extent do you feel confident that you can make the right shot decisions/selections?

Not at all	a little	moderately	quite a bit	completely
1	2	3	4	5

How do you feel about your upcoming Batting Test performance?

Threatened				Neither				Challenged
-4	-3	-2	-1	0	+1	+2	+3	+4

How important is doing well in this Batting Test for you?

Not at all	not so much	a little	moderately	quite a bit	very much so
0	1	2	3	4	5

After the instructions you were just given, you were asked to think about the upcoming Batting Test for 2 minutes. Please describe in as much detail as possible what you were thinking about as you prepared for the Batting task:

Batting Test Scoring Sheet

Player Name:

Condition: Pace

Ball	**1st over**	**2nd over**	**3rd over**	**4th over**	**5th over**
1					
2					
3					
4					
5					
6					
Total					

Scoring: input runs awarded for each ball, and circle whether the shot was attacking (A) or defensive (D). Calculate total runs per over and insert in total box.

Indicate where a variation is bowled in the spin net by *

Also, if the player is given out, input -5 in the runs space.

At the end of each over, players are to be informed of how many overs left, and how many runs they need to reach 36.

Participant Debrief Sheet

In this research project we are interested in how you responded both psychologically (via questionnaires) and physiologically (via cardiovascular recordings), to the information you received about the Batting Task prior to your performance. We are also interested in how you performed in the task. We would expect that if you responded with increased vascular resistance and decreased cardiac output (amount of blood pumped from heart per minute), you would perform poorly in the Task. Alternatively, if you responded with decreased vascular resistance and increase cardiac output, you would perform well in the Task. All performance scores will be collated, and a league table with all participants' scores in ranking order will be sent to all participants, when the research project has been completed. Thank you for taking part in this research project and please refrain from revealing the nature of the project to other athletes/members of your team, until you have received the league table, signifying the end of the project. Finally, in light of the information you have received, you can still withdraw from this study. If you wish to do so, please contact me via m.turner@staffs.ac.uk, and all of the data you provided will be excluded from the study (including your performance).

Batting Test Instructions

The Batting Test is an accurate and important measure of your ability to perform under pressure in a competitive situation. As such, the coaches are very interested in how you perform in this test. You are required to face 30 balls, and chase a score of 36 runs. If you are dismissed (in any way), 5 runs will be deducted from your score, and you are required to continue the test until you have faced all 30 balls. Your score in the upcoming Batting Test will contribute to an assessment of the goals set at your performance review. It will also be considered when decisions about future program selection are being made. Finally, your batting test score will be displayed on a league table at the end of the program, with all players' scores in ranking order, which will be seen by the coaches, and allow them to make comparisons between you and all the other players. Consequently, you will have to perform well if you are to compare favourably to the other players. You can of course withdraw from the test at anytime, but for the moment, please remain seated and as still as possible for about two minutes while you think about the task, prepare yourself mentally to take part, and we collect some cardiovascular data.

APPENDIX 4: QUESTIONNAIRES AND TASK INSTRUCTIONS CHAPTER 4 STUDY 1

STAFFORDSHIRE UNIVERSITY

INFORMATION FORM

Dear Participant

I am a PhD student under the direction of Dr Marc Jones in the Faculty of Health at Staffordshire University. I am conducting a research study to assess psychological responses and cardiovascular activity before a motor task. Your participation in this study will involve being connected to an impedance cardiograph machine for 20 minutes while you are instructed on how to complete the task, a short motor task. Specific instructions of how to complete the task will be given to you prior to the task, but you can withdraw at any point if you wish. Once the task is completed you will not be required for this study again.

The attachment of the cardiograph equipment to you will involve the use of a hypoallergenic electrode gel to enhance the signal we get from your skin. If you have a known allergy to this gel, unfortunately you are excluded from this study. If you do not have a known allergy and choose to participate, you are also informed that the removal of the impedance cardiograph equipment may cause minor hair removal and potentially a small amount of pain in relation to this. Also, in our experience, the hypoallergenic electrode gel may cause red marks where placed that may persist over 24 hours in a small number of people. Also, the motor task will require arm movement and therefore if you have an arm injury, or have taken part in any heavy weight lifting in the past 24 hours, you are excluded from this study until you have rested. If this is the case, we can re-arrange your participation in this study for a later date, at a mutually convenient time and date.

Your participation in this study is voluntary. You are free to refuse to commence the testing or withdraw at any time in the proceedings. This study is completely independent from any course you are taking at this institution and has no influence on any of your grades. Therefore, if you do choose not to participate or to withdraw from the study at any time, it will not affect your grade. The results of the research study may be published, but your name will not be used and no individual identifying information will be provided.

The potential benefit for you participating in the study is the chance to win £10. Your participation will also contribute to a greater understanding of how individuals feel prior to a motor task.

If you have any questions concerning the research or your participation in this study, please contact me via email: m.turner@staffs.ac.uk or contact Dr Marc Jones on 01782 295985.

Sincerely

Martin James Turner

-*-*-*-*-*-*-*-*-*-*-

INFORMED CONSENT FORM

I have read the above information form. The nature, demands, risk, and benefits of the study have been explained to me. I knowingly assume the risks involved, and understand that I may withdraw my consent and discontinue participation at any time without penalty or loss of benefit to myself

Participant's signature ....Date.................................

If you have any questions about your rights as a participant in this research, or if you feel you have been placed at risk, please call 01782294515.

Please answer the following questions as accurately and as honestly as you can.

Have you participated in heavy exercise within the past eight hours?

Have you had any caffeine (coffee, tea, coke, pepsi, or chocolate) within the past 2 hours?

When did you complete your last meal?

Please list the items you ate in your last meal and the quantity.

Item	Quantity

Please list any medication you have taken in the past 3 days (this includes painkillers/Lemsip):

Medication	How often	Quantity

Please provide us with some brief details about yourself:

Email address: ____

Date of birth (dd/mm/yy): ___________

Sex (M/F): ______

Height: _________ (cm)

Weight: _________ (kilograms)

Occupation: ____

Main sport: ____

How long have you been competing in this sport: ______________ (years/months)

Please state what level you are currently competing at (e.g. club/county/university):

____

Other sport experience

____

____

____

____

How many hours a week do you play sport? Please specify for every sport separately.

____

____

____

____

SPORT EMOTION QUESTIONNAIRE

Below you will find a list of words that describe a range of feelings that sport performers may experience. Please read each one carefully and indicate on the scale next to each item how you feel **right now, at this moment, in relation to the upcoming Bean Bag Throwing Test**. There are no right or wrong answers. Do not spend too much time on any one item, but choose the answer which best describes your feelings right now in relation to the critical situation.

	Not at all	**A little**	**Moderately**	**Quite a bit**	**Extremely**
Uneasy	0	1	2	3	4
Upset	0	1	2	3	4
Exhilarated	0	1	2	3	4
Irritated	0	1	2	3	4
Pleased	0	1	2	3	4
Tense	0	1	2	3	4
Sad	0	1	2	3	4
Excited	0	1	2	3	4
Furious	0	1	2	3	4
Joyful	0	1	2	3	4
Nervous	0	1	2	3	4
Unhappy	0	1	2	3	4
Enthusiastic	0	1	2	3	4
Annoyed	0	1	2	3	4
Cheerful	0	1	2	3	4
Apprehensive	0	1	2	3	4
Disappointed	0	1	2	3	4
Angry	0	1	2	3	4
Energetic	0	1	2	3	4
Happy	0	1	2	3	4
Anxious	0	1	2	3	4
Dejected	0	1	2	3	4

How helpful do you feel your emotional state is for the upcoming climbing task?

Not at all helpful	**A little bit**	**Moderately**	**Quite a bit**	**Extremely helpful**
0	1	2	3	4

Pre-test Measures

Please consider your thoughts and feelings about the upcoming Bean Bag Test and indicate the extent to which the following statements represent you:

	Not at all true						**Very true**
It is important to me to perform as well as I possibly can	1	2	3	4	5	6	7
I worry that I may not perform as well as I possibly can	1	2	3	4	5	6	7
It is important to me to do well compared to others	1	2	3	4	5	6	7
I just want to avoid performing worse than others	1	2	3	4	5	6	7
I want to perform as well as it is possible for me to perform	1	2	3	4	5	6	7
Sometimes I'm afraid that I may not perform as well as I'd like	1	2	3	4	5	6	7
It is important for me to perform better than others	1	2	3	4	5	6	7
My goal is to avoid performing worse than everyone else	1	2	3	4	5	6	7
It is important for me to master all aspects of my performance	1	2	3	4	5	6	7
I'm often concerned that I may not perform as well as I can perform	1	2	3	4	5	6	7
My goal is to do better than most other performers	1	2	3	4	5	6	7
It is important for me to avoid being one of the worst performers in the group	1	2	3	4	5	6	7

Taking the upcoming Bean Bag Test into consideration, to what extent do you agree with the following statements?

The more effort I put into this test, the better I will do.

Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
1	2	3	4	5

With reference to today's performance, to what extent do you feel confident that you can hit the centre of the target and score highly in the upcoming Bean Bag Throwing Test?

Not at all	a little	moderately	quite a bit	completely
1	2	3	4	5

With reference to today's performance, to what extent do you feel confident that you can stay focussed on the most important parts of your performance?

Not at all	a little	moderately	quite a bit	completely
1	2	3	4	5

With reference to today's performance, to what extent do you feel confident that you can mobilise all your resources for this performance?

Not at all	a little	moderately	quite a bit	completely
1	2	3	4	5

With reference to today's performance, to what extent do you feel confident that you can perform well even if things get tough?

Not at all	a little	moderately	quite a bit	completely
1	2	3	4	5

With reference to today's performance, to what extent do you feel confident that you can raise the level of your performance if you have to?

Not at all	a little	moderately	quite a bit	completely
1	2	3	4	5

With reference to today's performance, to what extent do you feel confident that you can stay motivated throughout your performance?

Not at all	a little	moderately	quite a bit	completely
1	2	3	4	5

With reference to today's performance, to what extent do you feel confident that you can throw the bean bag accurately in the Bean Bag Test?

Not at all	a little	moderately	quite a bit	completely
1	2	3	4	5

How threatening do you expect the upcoming Bean Bag Throwing Test to be?

Not at all	not so much	a little	moderately	quite a bit	very much so
0	1	2	3	4	5

How challenging do you expect the upcoming Bean Bag Throwing Test to be?

Not at all	not so much	a little	moderately	quite a bit	very much so
0	1	2	3	4	5

How important is doing well in this task for you?

Not at all	not so much	a little	moderately	quite a bit	very much so
0	1	2	3	4	5

Challenge Bean Bag Throwing Task Instructions

Your task is to complete a difficult throwing activity that assesses your judgment and accuracy, two very important aspects of human movement. You will complete this task as part of a team. In this task, you must throw ten bean bags at the target on the floor, 6 metres away, with your non-dominant hand. So if you are right handed, you will throw with your left hand and vice versa. The closer you get the bean bags to the centre of the target, the higher the score you will receive. Your score will be added to others on your team to form a team score, and all of your team mates and opponents will see your individual score at the end of the competition. You have been allocated to your team and there are 6 teams in total. The team with the best score at the end of the study will receive £10 per member, and as I mentioned before, each member's score will be on public display when the final scores are calculated. Members of the losing teams will receive nothing. The task will finish when you have thrown all of the bean bags.

It is unlikely that you will have done a task like this before, but you will have performed similar throwing tasks in the past. Because of this experience, you can feel confident that you will score highly in this task. Try your upmost to hit the centre of the target and treat this task as an opportunity to add to your team's overall score. Finally, the equipment is set up to allow you to complete the task without complications and to allow an accurate indication of your ability. Please begin when the experimenter asks you to begin and the task will end when you have thrown all bean bags. You can of course withdraw from the task at anytime, but for the moment please remain seated and as still as possible for about two minutes while you think about the task and we collect some cardiovascular data.

Threat Bean Bag Throwing Task Instructions

Your task is to complete a difficult throwing activity that assesses your judgment and accuracy, two very important aspects of human movement. You will complete this task as part of a team. In this task, you must throw ten bean bags at the target on the floor, 6 metres away, with your non-dominant hand. So if you are right handed, you will throw with your left hand and vice versa. The closer you get the bean bags to the centre of the target, the higher the score you will receive. Your score will be added to others on your team to form a team score, and all of your team mates and opponents will see your individual score at the end of the competition. You have been allocated to your team and there are 6 teams in total. The team with the best score at the end of the study will receive £10 per member, and as I mentioned before, each member's score will be on public display when the final scores are calculated. Members of the losing teams will receive nothing. The task will finish when you have thrown all of the bean bags.

It is unlikely that you will have done a task like this before, so you obviously can't be sure that you will perform well. Avoid the low scoring areas of the target as one poor performance can negatively impact the team score. Please note that the bean bags vary in weight which influences their flight, so it can be difficult to judge the power of your throw, especially with your non-dominant hand. Please begin this task when the experimenter asks you to begin and the task will end when you have thrown all bean bags. You can of course withdraw from the task at anytime, but for the moment please remain seated and remain as still as possible for about two minutes while you think about the task and we collect some cardiovascular data.

APPENDIX 5: RECRUITMENT INFORMATION, QUESTIONNAIRES, AND TASK INSTRUCTIONS CHAPTER 4 STUDY 2

Take Part in a Research Study this Semester

If you want to, or need to, take part in a research study between January and April 2012, you may be interested in participating in my study.

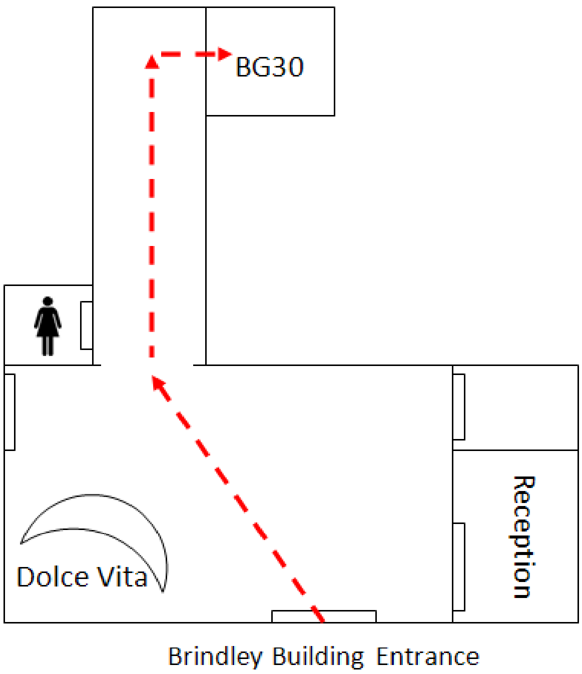
My name is Martin Turner I'm a PhD Scholar that teaches Level 5 Sport & Exercise Psychology.

I'm looking for students to take part in a project exploring psychological and physiological approaches to performing a physical task.

I will be collecting cardiovascular and self-report questionnaire data.

Taking part involves 60 minutes of your time and will take place in BG30 (see map below) in the Brindley Building.

Please email me on martin.turner@staffs.ac.uk and I can send you further information. We can then arrange a convenient time for you to take part. I look forward to hearing from you soon!



FAQ's

What are you researching?
I'm looking at how people respond physiologically to an upcoming task.

What will I have to do?
The study involves relaxing as we collect cardiovascular data from you using an innovative piece of equipment. I use an innovative piece of equipment to monitor your heart. You will also complete some questionnaires. Then you will be completing a short physical task. SO COME TO BG30 IN SPORTS GEAR! and *RESIST THE URGE* TO DRINK CAFFEINE FOR AT LEAST 2 HOURS BEFORE YOU COME TO THE LAB. Data collection takes place in BG30.

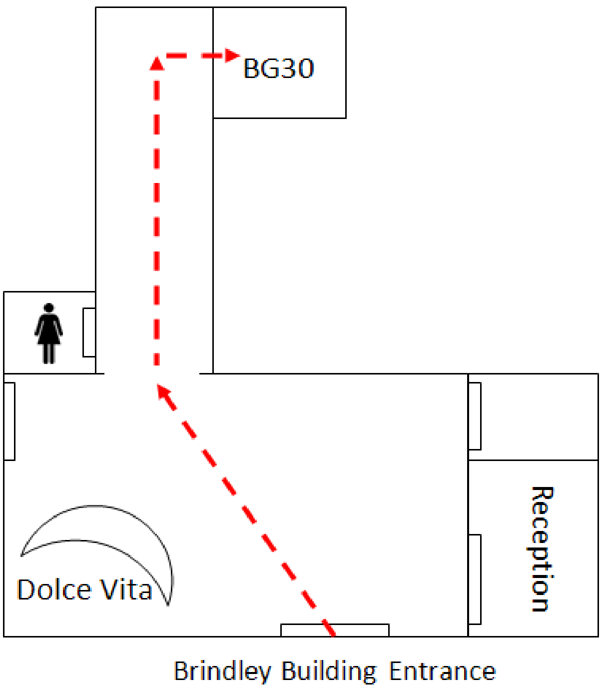
Are there exclusion criteria?
Yes. If you have high blood pressure or a heart condition, have a known allergy to electrode gel, or have injuries restricting motor movement of the arms and legs are you unfortunately unable to take part.

Where do I go to participate?
BG30 in the Brindley building. Please see map.

I look forward to seeing you at BG30 soon!

Please email me on martin.turner@staffs.ac.uk if you have any questions or cannot make the time above. We can then arrange a convenient time for you to take part.

Martin Turner



STAFFORDSHIRE UNIVERSITY

INFORMATION FORM

Dear Participant

I am a PhD student under the direction of Dr Marc Jones in the Faculty of Health at Staffordshire University. I am conducting a research study to assess psychological responses and cardiovascular activity before a motor task. Your participation will require up to 1 hour of your time, part of which will involve being connected to an impedance cardiograph machine for 20 minutes while you are instructed on how to complete the task which will require strength and endurance (athletic clothing required), which may take place on a separate day depending on the participant group you are allocated to. Specific instructions of how to complete the task will be given to you prior to the task, but you can withdraw at any point if you wish. Once the task is completed you will not be required for this study again.

The attachment of the cardiograph equipment to you will involve the use of a hypoallergenic electrode gel to enhance the signal we get from your skin. If you have a known allergy to this gel, unfortunately you are excluded from this study. If you do not have a known allergy and choose to participate, you are also informed that the removal of the impedance cardiograph equipment may cause minor hair removal and potentially a small amount of pain in relation to this. Also, in our experience, the hypoallergenic electrode gel may cause red marks where placed that may persist over 24 hours in a small number of people. Also, the motor task will require gross motor movements of the arms and legs; therefore if you have any injuries, or have taken part in any heavy weight lifting in the past 24 hours, you are excluded from this study until you have rested. If this is the case, we can re-arrange your participation in this study for a later date, at a mutually convenient time and date.

Your participation in this study is voluntary. You are free to refuse to commence the testing or withdraw at any time in the proceedings. This study is completely independent from any course you are taking at this institution and has no influence on any of your grades. Therefore, if you do choose not to participate or to withdraw from the study at any time, it will not affect your grade. The results of the research study may be published, but your name will not be used and no individual identifying information will be provided.

The potential benefit for you participating in the study is that all participants will be entered into a prize draw to win £50 in high street vouchers. Your participation will also contribute to a greater understanding of how individuals feel prior to a motor task.

If you have any questions concerning the research or your participation in this study, please contact me via email: m.turner@staffs.ac.uk or contact Dr Marc Jones on 01782 295985.

Sincerely

Martin James Turner

CONSENT FORM

Approaching an Upcoming Task

As we will need to place impedance and blood pressure equipment on you, please tick the appropriate boxes below. If you do not agree with any of the statements, unfortunately you are excluded from the study and are not required to complete the rest of the consent form:

	Agree
I do not bruise easily	
I am not a haemophiliac	
I have no known allergy to Signa electrode gel	
I do not have high blood pressure	

Please tick the following boxes:

I confirm that I have read and understood the information form for the project "Approaching an Upcoming Task" and have had the opportunity to withdraw participation and/or ask questions.	
I understand that my participation is voluntary and I understand that I may withdraw my consent and discontinue participation at any time, without further consequences.	
I agree that cardiovascular, psychological, and performance recordings will be taken and used for this project only. All data will be stored safely on a password protected computer.	
I agree to take part in the above study.	

....	....	....
Name of Participant	Signature	Date
....	....	....
Name of Researcher	Signature	Date

Please answer the following questions as accurately and as honestly as you can.

Have you participated in heavy exercise within the past eight hours?

Have you had any caffeine (coffee, tea, coke, pepsi, or chocolate) within the past 2 hours?

When did you complete your last meal?

Please list the items you ate in your last meal and the quantity.

Item	Quantity

Please list any medication you have taken in the past 3 days (this includes painkillers/Lemsip):

Medication	How often	Quantity

Please provide us with some brief details about yourself:

Email address: ____

Date of birth (dd/mm/yy): ___________ Age: ___________

Sex (M/F): _______

Height: _________ (cm)

Weight: _________ (kilograms)

Occupation: ____

Main sport: ____

How long have you been competing in this sport: ______________ (years/months)

Please state what level you are currently competing at (e.g. club/county/university):
____

Other sport experience
____
____
____

How many hours a week do you play sport? Please specify for every sport separately.
____
____

SPORT EMOTION QUESTIONNAIRE

Below you will find a list of words that describe a range of feelings that sport performers may experience. Please read each one carefully and indicate on the scale next to each item how you feel **RIGHT NOW, at this moment, in relation to the upcoming Climbing Task**. There are no right or wrong answers. Do not spend too much time on any one item, but choose the answer which best describes your feelings right now in relation to the critical situation.

	Not at all	**A little**	**Moderately**	**Quite a bit**	**Extremely**
Uneasy	0	1	2	3	4
Exhilarated	0	1	2	3	4
Pleased	0	1	2	3	4
Tense	0	1	2	3	4
Excited	0	1	2	3	4
Joyful	0	1	2	3	4
Nervous	0	1	2	3	4
Enthusiastic	0	1	2	3	4
Cheerful	0	1	2	3	4
Apprehensive	0	1	2	3	4
Energetic	0	1	2	3	4
Happy	0	1	2	3	4
Anxious	0	1	2	3	4

How helpful do you feel your emotional state is for the upcoming climbing task?

Not at all helpful	**A little bit**	**Moderately**	**Quite a bit**	**Extremely helpful**
0	1	2	3	4

Pre-test Measures

Please consider your thoughts and feelings about the upcoming climbing task and indicate the extent to which the following statements represent you:

	Not at all true						**Very true**
It is important to me to climb as well as I possibly can	1	2	3	4	5	6	7
I worry that I may not climb as well as I possibly can	1	2	3	4	5	6	7
It is important to me to climb well compared to others	1	2	3	4	5	6	7
I just want to avoid climbing worse than others	1	2	3	4	5	6	7
I want to climb as well as it is possible for me to perform	1	2	3	4	5	6	7
Sometimes I'm afraid that I may not climb as well as I'd like	1	2	3	4	5	6	7
It is important for me to climb better than others	1	2	3	4	5	6	7
My goal is to avoid climbing worse than everyone else	1	2	3	4	5	6	7
It is important for me to master all aspects of my climbing performance	1	2	3	4	5	6	7
I'm often concerned that I may not climb as well as I can climb	1	2	3	4	5	6	7
My goal is to climb better than most other performers	1	2	3	4	5	6	7
It is important for me to avoid being one of the worst climbers in the group	1	2	3	4	5	6	7

Taking the upcoming climbing task into consideration, to what extent do you feel that you have control over the factors that will determine your climbing performance?

No Control			Moderate Control			Total Control
1	2	3	4	5	6	7

With reference to the upcoming climbing performance, to what extent do you feel confident that you can climb effectively in the upcoming climbing task?

Not at all				**Moder a-tely**				**Comple-tely**
1	2	3	4	5	6	7	8	9

How important is doing well in today's Climbing Task for you?

Not at all	not so much	a little	moderately	quite a bit	very much so
0	1	2	3	4	5

Overall, how do you feel about your upcoming Climbing Task performance?

Threatened				Neither				Challenged
-4	-3	-2	-1	0	+1	+2	+3	+4

After the video you just watched, you were asked to think about the upcoming Climbing task for 2 minutes. Please describe in as much detail as possible what you were thinking about as you prepared for the Climbing Task:

____

____

____

____

____

Participant Debrief Sheet 1 - Post-Lab Data Collection

In this research project we are interested in how you responded both psychologically (via questionnaires) and physiologically (via cardiovascular recordings), to the information you received about the climbing task prior to your performance. You have been allocated to a group that will not be performing the climbing task today, but you have been asked to attend a separate session in the near future where you will complete the task. The available times and dates of this session are:

Session	Please tick the one you can attend

Please attend the session in suitable clothing for the task e.g., lace-up training shoes, jogging bottoms, t-shirt, and refrain from wearing jewellery. You can of course choose not to attend the separate climbing session while also enabling us to use the data you have provided up to this point for our research. Thank you for taking part in this research project so far and please refrain from revealing the nature of the project to other students. Finally, in light of the information you have received, you can still withdraw from this study completely. If you wish to do so, please contact me via m.turner@staffs.ac.uk, and all of the data you have provided will be excluded from the study.

Participant Debrief Sheet 2 - Post-Climbing Task

In this research project we are interested in how you responded both psychologically (via questionnaires) and physiologically (via cardiovascular recordings), to the information you received about the climbing task prior to your performance. We are not so interested in how you performed in the task, only whether you got to the top, or indeed whether you attended the task day or not. We would expect that if you responded with increased vascular resistance and decreased cardiac output (amount of blood pumped from heart per minute), you would not complete the climb or would not take part at all. Alternatively, if you responded with decreased vascular resistance and increase cardiac output, you would complete the climb. Thank you for taking part in this research project and please refrain from revealing the nature of the project to other students. Finally, in light of the information you have received, you can still withdraw from this study. If you wish to do so, please contact me via m.turner@staffs.ac.uk, and all of the data you have provided will be excluded from the study.

Challenge Climbing Task Instructions

Your task is to climb a 10 meter climbing wall located in the sports hall. You will be given 5 minutes to complete this task. You will complete this task alone. You will be given climbing instructions before you start the task and will be provided with all equipment including a safety harness and rope. Your climb will be video recorded, and later viewed so your climbing ability and performance can be assessed. Try your best to stay on the wall and get as high as you can within the 5 minute time period. Although you may not have done a task exactly like this before, you will have seen or perhaps performed similar climbing tasks in the past so you can feel confident that you will be able to climb effectively. Because of this experience, you have control over the skills required to climb well. The experimenter will accompany you to the sports hall where the climbing task will take place, please begin climbing when the experimenter asks you to begin, and the task will end when you choose to stop climbing, or fall off. You can of course withdraw from the task at anytime, but for the moment please remain seated and remain as still as possible for about two minutes while you think about the climbing task, prepare yourself to climb, and we collect some cardiovascular data.

The challenge climbing task instructions video can be viewed via the following link: http://youtu.be/tW0UE8_hr6A or via the below QR code using a smart phone.

Threat Climbing Task Instructions

Your task is to climb a 10 meter climbing wall located in the sports hall. You will be given 5 minutes to complete this task. You will complete this task alone. You will be given climbing instructions before you start the task, and will be provided with all equipment including a safety harness and rope. Your climb will be video recorded, and later viewed so your climbing ability and performance can be assessed. Try your best not to fall off the wall at any point. It is unlikely that you will have done a task exactly like this before, so you obviously can’t be sure that you will climb the wall effectively. Because of this inexperience, how well you do on the task may be related to factors outside of your control, such as luck in choosing the right holds. The experimenter will accompany you to the sports hall where the climbing task will take place, you will begin climbing when the experimenter asks you to begin, and the task will end when you choose to stop climbing, or run out of time. You can of course withdraw from the task at anytime, but for the moment please remain seated and remain as still as possible for about two minutes while you think about the climbing task, prepare yourself to climb, and we collect some cardiovascular data.

The threat climbing task instructions video can be viewed via the following link: http://youtu.be/Sr6yCPzhRzM or via the below QR code using a smart phone.