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Challenge and Threat States: Cardiovascular, Affective and Cognitive Responses to a Sports-Related Speech Task

Carla Meijen[1], Marc V. Jones[2], David Sheffield[3], and Paul J. McCarthy[4]

[1]School of Sport and Exercise Sciences, University of Kent

[2]Centre for Sport, Health and Exercise Research, Staffordshire University

[3]Centre for Psychological Research, University of Derby

[4]Department of Psychology, Glasgow Caledonian University

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Abstract

This study examined the relationship among cardiovascular responses indicative of challenge and threat states, self-efficacy, perceived control and emotions before an upcoming competition. Using a repeated-measures design, 48 collegiate athletes talked about an upcoming competition (sport-specific speech task) and the topic of friendship (control speech task), whilst cardiovascular responses (heart rate, preejection period, cardiac output, and total peripheral resistance) were collected and self-report measures of self-efficacy, perceived control, and emotions completed. Findings showed that participants with a physiological threat response reported higher levels of self-efficacy and excitement. Further, none of the other emotions or the cognitive appraisals of challenge and threat predicted cardiovascular patterns indicative of either a challenge or threat state. Thus, cardiovascular responses and self-report measures of self-efficacy, perceived control, and emotions did not correlate in the manner predicted by the theory of challenge and threat states in athletes. This finding may reflect methodological aspects, or that perhaps highly efficacious individuals believe they can perform well and so the task itself is more threatening because failure would indicate under-performance.

Keywords: cardiovascular responses, self-efficacy, control, emotion, cognitive appraisal

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Understanding why some individuals perform well under pressure is important in various situations: examinations, job interviews, performing arts, and athletic competition. These are all examples of motivated performance situations in which an individual must exert effort to achieve a goal, or goals, that are self-relevant or important (Seery, 2011). From the stuttering presentation in a job interview to a world record performance at the Olympics, it can be observed that some individuals will rise to the demands and perform well, whereas others will wilt and perform poorly; for some people a motivated performance situation is viewed as a challenge, and for others it is seen as a threat.

Challenge and threat states are motivational states that reflect how an individual engages in a personally meaningful situation and includes cognitive, affective, and physiological components (Blascovich & Mendes, 2000). People experience a challenge state when they perceive they have sufficient, or nearly sufficient, resources to meet the demands of a situation, whereas a threat state is experienced when insufficient resources to meet the demands of situation are perceived (Blascovich & Mendes, 2000; Blascovich & Tomaka, 1996). Competitive sport provides the context for the present study and is a good example of a motivated performance context because the outcome usually matters greatly to the individual involved, there is often a perception of danger (injury or humiliation), there is uncertainty about the outcome (e.g., how will the opponent perform), and it usually requires much physical and mental effort to succeed.

Challenge and threat states can be identified by two distinct cardiovascular reactivity patterns, this notion has been supported by a consistent body of research that has emerged identifying cardiovascular indices of challenge and threat states in motivated-performance situations (Blascovich, Mendes, Vanman, & Dickerson, 2011; Seery, 2011). The biopsychosocial (BPS) model of challenge and threat (Blascovich & Mendes, 2000; Blascovich & Tomaka, 1996) explains the two distinct cardiovascular patterns. These two patterns are proposed to reflect activity in the sympathetic adrenal medullary (SAM) and pituitary adrenal cortical (PAC) axes. Both challenge and threat states result in increased SAM activation, a threat state also results in increased PAC activation (Blascovich & Tomaka, 1996; Dienstbier, 1989). In a threat state increased PAC activation inhibits vasodilation that would otherwise take place in the challenge state (Blascovich & Mendes, 2000). Using impedance cardiography (Sherwood et al., 1990), a threat state can be inferred from increases in total peripheral resistance (TPR), indicating vasodilation, with no change or a slight increase in cardiac output (CO) and a challenge state is observed by an increase from baseline in CO and a decrease in TPR (Blascovich & Mendes, 2000). Challenge and threat states only occur when individuals are engaged with the task, that is, it must be a motivated performance situation. Therefore, heart rate (HR) and preejection period (PEP) are also measured, with an increase from baseline in HR and a decrease in PEP indicating task engagement (Blascovich & Mendes, 2000). PEP is an index of isovolumic contraction time directly related to the degree of cardiac contractile force, this can be the heart beating or inotropic performance. The cardiovascular patterns that index challenge and threat proposed in the BPS model have been empirically validated numerous times (see Blascovich et al., 2011; Seery, 2011 for reviews).

Challenge and Threat States in Athletes

Research on challenge and threat states in a competitive sport setting is in its early stages. Blascovich, Seery, Mugridge, Norris, and Weisbuch (2004) examined the influence of cardiovascular reactivity patterns on sport performance in baseball and softball. It was found that athletes who displayed cardiovascular reactivity indicative of a challenge when imagining and talking about a hypothetical sports scenario performed better during the subsequent season than those who displayed a threat pattern. It was suggested that better players were more challenged during the sports-related speech because they had higher self-efficacy (Blascovich et al., 2004), however self-efficacy was not assessed in their study. More recent research has explored the relationship among self-efficacy and cardiovascular indices of challenge and threat in sport. For example, Williams, Cumming, and Balanos (2010) were unable to find consistent differences in cardiac output between participants when using challenge or threat imagery about a sport competition. The challenge imagery script was related to higher levels of self-efficacy compared to the threat script, providing some support for the cognitive component of the TCTSA. Self-efficacy was not related to cardiovascular reactivity indicative of either challenge or threat in a netball task (Turner, Jones, Sheffield, & Cross, 2012). In sum, despite Blascovich et al.'s (2004) proposition, the research from athletic settings does not suggest an association among self-efficacy and cardiovascular indices of challenge and threat states.

However, there is theoretical support for Blascovich et al.'s proposition that self-efficacy may be associated with a challenge state in athletic competition. One approach that outlines how athletes may respond to a motivated performance situation, like a sports competition, is the theory of challenge and threat states in athletes (TCTSA, Jones, Meijen, McCarthy, & Sheffield, 2009). This theory builds on Lazarus and Folkman's (1984) work and the BPS model of challenge and threat (Blascovich & Mendes, 2000; Blascovich & Tomaka, 1996). The TCTSA proposes that self-efficacy, perceived control, and achievement goals comprise resource appraisals; these are referred to as the cognitive component of challenge and threat states, and are reflected in the cardiovascular indices of challenge and threat outlined. A challenge state will be experienced when an athlete has high levels of self-efficacy, a perception of control, and a focus on approach goals. A threat state is experienced with low self-efficacy, low perceived control, and a focus on avoidance goals (Jones et al., 2009). The present study is an initial exploration of the TCTSA, which was being refined when this study was conducted, and focuses on two of the determinants of challenge and threat states: self-efficacy and perceived control. We focus on self-efficacy because of Blascovich et al.'s (2004) proposition that athletes in a challenge state will have a higher level of self-efficacy and we also focus on perceived control, because individuals need to believe that they are in control, and can intentionally execute their actions, for self-efficacy to develop (Bandura, 1997).

Self-efficacy refers to an individual's judgment of his or her capability to successfully perform a task (Bandura, 1997) and as such contributes to a perception of being able to cope with the demands of a situation (cf. Lazarus, 1999). Control also forms a central component of the resource appraisals. Subjective (perceived) control influences physiological responses of challenge and threat states more than objective control (Dickerson & Kemeny, 2004). To illustrate, individuals who perceived an uncontrollable stressor as controllable showed less physiological changes, evidenced by smaller increases in cortisol responses, compared to individuals who appraised the stressor as uncontrollable in motivated performance tasks (Dickerson & Kemeny, 2004; Kemeny, 2003). A situation can be perceived as within (controllable) or outside one's personal control (uncontrollable) and influences the perception of the situation as a challenge or a threat. In a situation *perceived* as controllable, one is motivated to put more effort in a task and feel more self-efficacious, increasing the chances for success (Bandura & Wood, 1989).

The TCTSA also outlines the relationship among challenge and threat states and emotions. Positive emotions will typically be associated with a challenge response and negative emotions will typically be associated with a threat response (Jones et al., 2009). Although individuals typically experience more negative emotions in a threat compared to a challenge state (e.g., Schneider, 2008; Skinner & Brewer, 2002, 2004), challenge and threat are motivational states and therefore they are independent to the valence of the emotion experienced (Mendes, McCoy, Major, & Blascovich, 2008). For example, high-intensity emotions with a negative valence, like anger, that can serve motivational functions could therefore occur in a challenge state (e.g., Mendes et al., 2008). The interpretation of emotions as being helpful or unhelpful for performance has been recognised as an important aspect of how athletes approach competition, with athletes reporting a more positive perception of anxiety typically performing better (e.g., Jones, Swain, & Hardy, 1993). Collectively, both theory (Jones, 1995) and research (Hanton, Neil, & Mellalieu, 2008), suggest that in combination, a high perception of control and self-efficacy should, typically, be associated with emotional responses being perceived as helpful to performance regardless of the valence of the emotion. For example, Williams et al. (2010) found that anxiety experienced during a challenge script was perceived as more helpful for performance. Moore, Vine, Wilson, and Freeman (2012) manipulated challenge and threat states by giving participants different monetary incentives and found that the challenge group reported a more facilitative interpretation of cognitive anxiety.

The Present Research

The present study builds on the findings of Blascovich et al. (2004) and contributes to the literature by exploring the underlying psychological constructs of challenge and threat states using competitive sport as a naturalistic setting. Although demand and resource appraisals have been manipulated to induce challenge and threat states (e.g., Seery, Weisbuch, & Blascovich, 2009; Tomaka, Blascovich, Kibler, & Ernst, Study 1, 1997), comparatively little research has explored whether a person’s self-reported resource appraisals relate to the cardiovascular responses indicative of challenge and threat states. Whereas participants’ perceptions of their abilities to cope and whether the task is a challenge or a threat are routinely taken, few studies have examined psychological constructs, such as self-efficacy and control, which are proposed to underpin participants' ability to cope with a demanding sporting situation (cf. Jones et al., 2009). When this has been done in sport no significant associations (e.g., Turner et al., 2012; Williams et al., 2010) have been observed; however, research has either used laboratory-based tasks (Turner et al., 2012), or hypothetical competitive scenarios (Williams et al., 2010). We sought to add to this literature in line with a suggestion by Turner et al. (2012), that is, by collecting data in a task relating to a real-life competitive event. This will enable the relationship among CV responses and self-report measures, and CV responses and performance to be examined in a more ecologically valid manner. We specifically build on the research of Blascovich et al. (2004) by using a similar methodology and exploring the cognitive and emotional correlates of cardiovascular indicators of challenge and threat states in athletes using a sport-related speech task. To do this, we asked athletes to talk about an upcoming important competition and a neutral situation and measured cardiovascular response patterns along with cognitive and emotional responses (Blascovich et al., 2004). In line with the TCTSA it was hypothesised that higher levels of perceived control and self-efficacy would predict cardiovascular indicators of a challenge state, whereas lower levels of self-efficacy and perceived control would predict cardiovascular indicators of a threat state. A more positive emotional state, particularly if perceived as helpful to performance, was hypothesised to be associated with a cardiovascular pattern characterising a challenge state, and a more negative emotional state, perceived as unhelpful to performance associated with a cardiovascular pattern characterising a threat state.

Method

Participants

Forty-eight student athletes (31 men, 17 women, M_{age} = 20.56, *SD* = 2.02) participated in the study voluntarily, with the competitive standard ranging from international to regional level. Participants competed in soccer (*n* = 16), basketball, hockey (both *n* = 5), badminton, cricket (both *n* = 4), karate, swimming, rugby (all *n* = 2), kickboxing, lacrosse, rowing, volleyball, motorcycle trials, road cycling, running, and American football (all *n* = 1).

Procedure

Following institutional ethical approval, athletes were recruited from university individual and team sports. Upon arrival in the lab, and after the participant provided informed consent, the researcher applied the sensors to obtain four cardiovascular (CV) measures using impedance cardiography (ZKG), electrocardiography (EKG) and blood pressure readings: heart rate (HR), preejection period (PEP), cardiac output (CO), and total peripheral resistance (TPR). An impedance cardiograph, model HIC-3000 (Bio-Impedance Technology, Inc.), with an external electrocardiographic lead was used to record ZKG and ECG signals in line with accepted protocols (Sherwood et al., 1990). A Critikon Dinamap Pro 100 blood pressure monitor was used to obtain systolic (SBP), diastolic (DBP) blood pressure, and mean arterial pressure (MAP) readings. CO was calculated by heart rate multiplied by stroke volume. TPR was calculated with the formula (MAP/CO) X 80. Four self-adhesive band electrodes (Instrumentation for Medicine Inc., Greenwich, CT) were placed on the participant’s body. Two electrode bands were placed around the base of the neck and at the level of the xiphisternal junction around the chest. Three self-adhesive gel spot ECG electrodes (Vermed Inc.) were used to record ECG signals. The electrodes were placed on the left and right wrist and the left lower inside leg (c.f. Berntson, Quigley, & Lozano, 2007).

After completing demographic questions, the participants were asked to sit on a comfortable chair. Next, the participants were introduced to one of two tasks and asked to talk for three minutes about their thoughts, feelings, and expectations immediately before an important competition they were about to face in their main sport (sport task) or talk about the topic of friendship for three minutes (control task). The order of the two tasks was counterbalanced. Five minutes of resting cardiovascular data were collected before the control task and the sport task. There was a 10-minute rest between the control task and sports task.

The use of a speech task about a motivated performance situation has been frequently used in similar research (e.g., Blascovich et al., 2004; Seery, Weisbuch, Hetenyi & Blascovich, 2010). It is the CV reactivity to talking about the upcoming competition that is the focus of the present study. The control task was identical to that used by Blascovich et al. (2004) and was included to control for the physiological responses to speaking.

In the control task, participants were asked to talk about the topic of friendship for three minutes. After the control task participants indicated the degree they experienced the task as a threat, challenge, and felt stressed. In the sport task, participants were asked to talk for three minutes about their thoughts, feelings, and expectations immediately before an important competition they were about to face in their main sport. After the sport task the participants completed measures of self-efficacy, emotion, perceived control, and challenge and threat appraisals in relation to the important competition they just talked about. In both tasks a standard list of prompts was used if participants became silent, to ensure they spoke for three minutes. The participant and the researcher were separated by a screen, which allowed the researcher to use the prompts when needed. This screen was used to prevent the effect non-verbal feedback could have on the participant's cardiovascular responses. After both tasks were completed the electrodes were removed and the participants debriefed and thanked.

Measures

Self-efficacy. The main sport varied across the participants; therefore a self-efficacy measure tailored towards a particular sport (Bandura, 2006) could not be used. Accordingly a generic sports related measure of self-efficacy was used that catered for various sports (Coffee & Rees, 2008). The participants were instructed to indicate with reference to the important competition they had just spoken about, to what extent they felt confident that they could cope with six statements on a five-point scale. An example statement is “mobilise all your resources for this performance”. The internal consistency reliability coefficient of the self-efficacy measure in the present study was α = .77.

Emotions. Emotions were measured using the Sport Emotion Questionnaire (SEQ, Jones, Lane, Bray, Uphill, & Catlin, 2005). The SEQ comprised three four-item and two five-item scales, measuring anger, anxiety, dejection, happiness, and excitement. The participants were asked to indicate on a five point Likert-scale, how they feel right now, at this moment for each of the items in the SEQ, in relation to the critical situation they have just talked about. The questionnaire has been validated by Jones et al. (2005), providing evidence of internal consistency reliability values for each subscale above α =.80, and further support from confirmatory factor analyses (Jones et al., 2005). The internal consistency reliability coefficients for each subscale were .86 for anxiety, .71 for dejection, .88 for excitement, .54 for anger, and .91 for happiness. Further exploration of the low internal consistency reliability coefficient for anger showed that deleting any of the items did not improve the internal consistency of the scale. Subsequently it was decided to not use this scale in further analyses.

Interpretation of emotions was measured by adding an extra rating scale for each item to the SEQ, where participants were asked to indicate whether they regarded this feeling as negative (debilitative) or positive (facilitative) in relation to their performance in the important competition they just talked about. The participants were asked to rate this on a 7-

point scale, ranging from -3 (*very debilitative*) to +3 (*very facilitative*), in line with the directional scale of the CSAI-2d (Jones & Swain, 1992).

Appraisals and control. To assess control participants indicated, in relation to the important competition they had just talked about, to what degree “I felt that I had control over the situation to demonstrate my skills to the best of my ability” on a 5 -point scale, ranging from 0 (*not at all)* to 4 (*extremely)*. Furthermore, participants indicated on a 5-point scale, ranging from 0 (*not at all)* to 4 (*extremely)* in relation to the sporting situation they had described how much they (a) “I experienced the situation as a threat” and (b) “I experienced the situation as a challenge”. They also rated their levels of stress (“I felt stressful about the important competition”) and to what extent they felt they could cope with the important competition (“I felt that I could cope with the important competition”). For the friendship control task participants indicated to what degree (a) “I experienced the task as a threat”, (b) “I experienced the task as a challenge”, (c) “I felt stressed during the task”, and (d) “I felt that I could cope with the task”. Responses were on a 5 -point scale, ranging from 0 (*not at all)* to 5 (*extremely)*. Participants who rated the control task as stressful or felt that were unable to cope with the control task were excluded from further analyses, as the aim of the control task was to control for the cardiovascular responses of a speech task and was not intended to be stressful.

Results

Preliminary Analyses

Four participants reported they felt threatened, stressed, or could not cope with the control task and were removed from further data analysis. There was one outlier (more than 3 SD away from the mean) on CO which was subsequently removed from further analysis, in addition four participants were deleted from further data analysis with missing cardiovascular data. This left 39 participants for the primary analysis. The reactivity scores for the cardiovascular data are presented in Table 1. The data indicated that participants engaged with both tasks. Measures of HR (reported in BPM) and PEP (reported in ms) were used to analyse engagement with the tasks. There was a statistically significant increase in HR between baseline and condition, for both the friendship control condition, t (38) = 9.41, p < .001, d = 0.93 (mean increase 11.54, SD = 7.66) and the sport competition condition, t (38) = 9.93, p <. 001, d = 0.99 (mean increase 13.38, SD = 8.42), none of the participants displayed a decrease in HR. There were decreases in PEP as expected between baseline and the speech tasks; these were not statistically significant in both the control task t (38) = 1.66, p =.11, d = 0.10 (mean decrease 2.62, SD = 9.84) and the sport task, t (38) = 1.78, p = .08, d = 0.10 (mean decrease 3.23, SD = 11.37). The data were examined for presentation-order effects for the cardiovascular responses. A repeated-measures 2x2 mixed ANOVA showed that the effect of presentation order of the task was not significant for HR, F (1, 37) = .09, p = .76, η_p^2 = .002, PEP, F (1, 37) = .65, p = .43, η_p^2 = .02, TPR, F (1, 37) = .05, p = .83, η_p^2 = .001 and CO, F (1, 37) = .18, p = .67, η_p^2 = .01. There was a consistent decrease for CO and an increase in TPR for both the baseline and the task, indicating that there were no presentation-order effects.

Paired sample t-tests showed that participants rated the sport task to be significantly more threatening, t (38) = 2.23, p < .05, d = 0.43, challenging, t (38) = 4.56, p < .001, d = 0.88, and stressful, t (38) = 2.23, p = .003, d = 0.65, than the control task. In sum the participants demonstrated that the sport task was psychologically more engaging than the control task.

*** INSERT TABLE 1 NEAR HERE ***

Primary Analysis

In line with Blascovich et al. (2004) a challenge and threat index was created based on changes in TPR and CO; cardiovascular reactivity scores were first calculated by deducting the first minute of the tasks by the last minute of the baseline for TPR and CO. Next, these reactivity scores were converted into z-scores and summed. TPR was assigned a weight of -1 and CO a weight of 1, such that higher scores correspond with a challenge pattern and lower scores with a threat pattern. Hierarchical regression analyses were conducted with the index for the sport task as the outcome variable predicted by the addition of the cognitive elements self-efficacy, perceived control, and challenge and threat appraisals and the addition of emotions. The index for the control task was entered in the first step of all hierarchical regression analysis to control for the individual's cardiovascular responses from the physical act of talking. The collinearity diagnostics for the regression analyses showed that variance inflation factors (VIF) were below the recommended value of 10.00 (Field, 2009). The means and correlations for the predictor variables are reported in Table 2.

*** INSERT TABLE 2 NEAR HERE ***

Cognitive components. A hierarchical regression analysis was performed to analyse the association between the cognitive component of challenge and threat states and cardiovascular reactivity. The findings are presented in Table 3. In the second level self-efficacy, perceived control, and challenge and threat appraisals were entered. Analysis showed that in the first step the friend index significantly predicted the index for the sport task. Step 2 revealed a statistically significant effect for the cognitive components of challenge and threat states F (4, 33) = 3.41, p = .02, ΔR^2 = .20, with self-efficacy as the only significant predictor of the sport index[1].

*** INSERT TABLE 3 NEAR HERE ***

Emotions. A hierarchical regression analysis was run for the challenge and threat index as the outcome variable and emotions as the predictor variables. The findings are presented in Table 4. Dejection (*M* = 0.09, *SD* = 0.20) and anger (*M* = 0.23, *SD* = 0.36) were not included in the analysis, because of their low mean scores, indicating that the participants did not feel dejected or angry. The addition of the remaining three emotions (anxiety, excitement, happiness) in Step 2 revealed a marginally significant effect, F (3, 34) = 2.53, $p = .07$, $\Delta R^2 = .13$. The results showed that there was a marginal negative effect for excitement predicting the challenge and threat index ($\beta = -.33$, $p = .08$).

*** INSERT TABLE 4 NEAR HERE***

Interpretation of emotions. Hierarchical regression analyses were run for the interpretation of anxiety, excitement and happiness as helpful or unhelpful for performance. The results for the challenge and threat index showed that there was no effect for interpretation of these three emotions in the Step 2, F (3, 33) = 1.38, $p = .27$, $\Delta R^2 = .08$.

Discussion

The present study is one of the first to use competitive sport as a setting to explore the relationship among cardiovascular responses indicative of challenge and threat states and cognitive and emotional responses. It was hypothesised, in line with suggestions made by Blascovich et al. (2004) and the TCTSA that higher levels of perceived control and self-efficacy would predict cardiovascular indicators of a challenge state. In addition, it was proposed that there would be a positive association between a challenge state and positive emotions. Findings showed that when talking about an upcoming important competition, participants who displayed a cardiovascular response indicative of a threat reported higher levels of self-efficacy and excitement. Perceived control, self-reported measures of challenge and threat, anxiety and happiness, and perception of emotional state did not relate to cardiovascular responses. There was, in line with expectations, a positive association between self-efficacy, perceived control, and coping perception.

The finding that athletes with high levels of self-efficacy displayed a threat response when talking about an upcoming competition is contrary to what might be expected based on the TCTSA and the BPS. Theoretically, a high level of self-efficacy should be associated with a perception of sufficient resources to cope with the demands of the situation (Jones et al., 2009). The findings revealed a positive association between perceptions of being able to cope with the situation and self-efficacy; however, the cardiovascular responses did not provide support for the notion that a challenge response is positively associated to self-efficacy. Although this finding was contrary to theory it is perhaps not unexpected, given that other studies have reported inconsistencies in cardiovascular responses and psychological responses and the underlying psychology of cardiovascular responses is not clear (for a review see Hilmert & Kvasnicka, 2010). The present study was a naturalistic study and it appears that only studies manipulating self-efficacy or challenge and threat states find an effect on cardiovascular responses (for example Gerin, Litt, Deich, & Pickering, 1996; Hilmert, Christenfeld, & Kulik, 2002). The non-significant relationships among control, self-reported challenge and threat, and cardiovascular reactivity have also been observed in previous sport studies (e.g., Turner, et al., 2012; Williams et al., 2010) albeit not in relation to a real-life competitive scenario.

In addition to the lack of consistent associations among cardiovascular responses and self-report measures, of particular note was the finding, contrary to the TCTSA that participants who displayed a cardiovascular response indicative of a threat reported higher levels of self-efficacy. First, it is possible that highly efficacious individuals are physiologically threatened by an upcoming task. There is empirical evidence in a non-sport setting that self-efficacy has been associated with cardiovascular responses associated with a *threat* response (Hoyt & Blascovich, 2010). Female participants were asked to complete a leadership task that comprised chairing a selection committee for a post for a fictitious company. The participants with high leadership self-efficacy responded with a cardiovascular pattern indicative of a threat response when asked to do this task after receiving information about male leaders and the gender gap in elite leadership positions. For women with a high level of self-efficacy in their leadership abilities, information that most men occupy leadership positions was threatening, because it could potentially confirm a negative stereotype that women do not make good leaders (Hoyt & Blascovich, 2010). So it may be that highly-efficacious individuals in our study believed that while they have the capability to perform well, the task itself is more threatening because failure would indicate under-performance. In contrast, for individuals with lower levels of self-efficacy the task may be less threatening because a good performance is not expected. In sum cardiovascular responses to an upcoming task may be more reflective of the potential opportunities for gain or failure and the high self-relevance of a task could make an individual with high self-efficacy more disposed to feelings of threat (e.g., Hoyt & Blascovich, 2010).

The findings may also represent the social desirability inherent in self-report measures. Higher scores on self-efficacy for individuals in a threat state may reflect an attempt to mask an underlying lack of self-efficacy. Indeed, individuals who exhibited cardiovascular responses indicative of threat during a social interaction with a stranger sounded less confident, but looked more confident (Weisbuch, Seery, Ambady, & Blascovich, 2009). To explain, participants who were threatened in a social interaction attempted to mask an underlying lack of confidence by controlling their facial display which is relatively controllable compared to vocal confidence. Even though the participants in the present study were unable to see the researcher, they were aware that the researcher was listening to their sport speech.

It is also possible that some of the methodological reasons outlined may account for the lack of a relationship between perceived control and cardiovascular reactivity. In particular, collecting data closer to the actual competition itself may help elucidate the relationship. The absence of a relationship between self-reported challenge and threat and cardiovascular reactivity is interesting. This is in contrast to previous studies (for example Williams et al., 2010) but may be unique to an actual competitive setting in that all the athletes in our sample typically reported the upcoming competition to be challenging, and not very threatening. This may reflect the vernacular in sport where upcoming competitions are typically described as challenging and infrequently would a competition be described as threatening (Meijen, Jones, McCarthy, Sheffield, & Allen, 2013). For these athletes, the context in which ‘challenging’ and ‘threatening’ (words) are used may not relate to the theoretical use of the terms and as such the self-report measures may not accurately reflect their psychological approach to competition. A similar argument could also be made for ‘stressed’ and athletes may not use the word in line with its theoretical definition (e.g., Fletcher, Hanton, & Mellalieu, 2006). In addition, whereas the cardiovascular reactivity responses are suggested to be two distinct states (Blascovich & Mendes, 2000), the challenge and threat *appraisals* might not be able to provide this distinction, and athletes might subjectively experience a competition as both a challenge and threat (Cerin, 2003; Meijen et al., 2013).

The non-significant relationships between anxiety, happiness, and cardiovascular reactivity were also surprising, given that both the BPS and the TCTSA suggest that in general participants displaying cardiovascular reactivity should report a more positive emotional state, and this has been demonstrated empirically (Schneider, 2008). Some of the methodological issues outlined above might have accounted for these findings, such as the time of data collection. It is well-reported that the intensity of emotions, particularly anxiety, increases closer to the competition (Cerin, Szabo, Hunt, & Williams, 2000). Future research can manipulate challenge and threat states to further explore the influence on emotional states in challenge and threat states in athletes.

There are further general issues relating to the method employed that may help explain the findings and provide a guide for future work. Specifically the procedure itself, which required participants to talk about an upcoming competition, may have influenced the relationship between self-report measures and cardiovascular reactivity. This procedure was chosen because cardiovascular responses to physical exertion can mask cardiovascular changes that differentiate challenge and threat states (Blascovich et al., 2004). Although previous similar studies have used a speech task (see Blascovich et al., 2004; Chalabaev, Major, Cury, & Sarrazin, 2009) it is possible that cardiovascular reactivity to the task may not have been solely a result of having to talk about, and therefore think and imagine, an upcoming situation. Some participants may have been preoccupied with the content of what was being said, rather than being solely focused on their thoughts and feelings in relation to the competition they were describing. Therefore, talking about something meaningful such as an upcoming important competition might be a different stressor to imagining partaking in the competition itself. Future research could explore what methodologies are best able to assess challenge and threat states in athletes. For example, future research could consider the temporal nature of challenge and threat states in the lead up to a real-life competitive event, as well the effect of this on performance. In addition, we suggest the use of a multi-item measure of control, as well as the inclusion of achievement goals. Finally, the use of an imagery task similar to that used in Williams et al. (2010) could be considered instead of a speech task.

Despite the limitations outlined, this study advances knowledge in the area by reporting data collected from participants who were asked to talk about an actual upcoming competition, in contrast to hypothetical scenarios or competitive laboratory based tasks. The present study is one of the first to explore the relationship between psychological and emotional measures and cardiovascular indices of challenge and threat states in relation to an upcoming real-life sports-related event. The results demonstrated that, contrary to expectations, athletes high in self-efficacy responded to an upcoming important competition with a cardiovascular pattern indicative of a threat response. These findings are contrary to that proposed in the TCTSA, and suggested by Blascovich et al. (2004), and may reflect methodological issues or a lack of congruence between self-report measures and physiological responses. Future research could explore the relationships between participants' self-reported approach to competition and cardiovascular reactivity, closer to the competition itself, using a methodology that does not require participants to talk about the upcoming task. In addition, future studies could manipulate challenge and threat states to examine changes in the correlates of challenge and threat states.

The findings of this study imply that there may be an inconsistency between what athletes think and their physiological responses. Using multiple methods of assessing athletes' responses to stressful situations may help elucidate the complex responses of athletes. For example, athletes who have high levels of self-efficacy might want to make sure that they do well (Hoyt & Blascovich, 2010) and this could influence physiological responses, whereas those who do not have high expectations might withdraw from the situation and consequently they do not demonstrate clear changes in physiological responses (Ennis, Kelly, & Lambert, 2001). Greater awareness of the physiological and psychological responses to an upcoming competition could help an athlete to prepare more effectively for competition. To conclude, before competition, our heart (i.e., physiological responses) might not always be in line with our head (i.e., cognitive resources).

References

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: Freeman.

Bandura, A. (2006). Guide for constructing self-efficacy scales. In F. Pajares & T. C. Urdan (Eds.), *Self-efficacy beliefs of adolescents* (pp. 307-337). Greenwich, CT: Information Age Publishing.

Bandura, A., & Wood, R. (1989). Effect of perceived controllability and performance standards on self-regulation of complex decision making. *Journal of Personality and Social Psychology, 56*(5), 805-814. doi: 10.1037/0022-3514.56.5.805

Beck, J. W., & Schmidt, A. M. (2012). Taken out of context? Cross-level effects of between-person self-efficacy and difficulty on the within-person relationship of self-efficacy with resource allocation and performance. *Organizational Behavior and Human Decision Processes, 119*(2), 195-208. doi: 10.1016/j.obhdp.2012.06.009

Berntson, G. G., Quigley, K. S., & Lozano, D. (2007). Cardiovascular psychophysiology. In J. T. Cacioppo, L. G. Tassinary, & G. G. Berntson (Eds.), *Handbook of Psychophysiology* (pp. 182-210). Cambridge: Cambridge University Press.

Blascovich, J., & Mendes, W. B. (2000). Challenge and threat appraisals: The role of affective cues. In J. P. Forgas (Ed.), *Feeling and thinking: The role of affect in social cognition* (pp. 59-82). Paris: Cambridge University Press.

Blascovich, J., Mendes, W. B., Vanman, E. & Dickerson, S. (2011). *Social psychophysiology for social and personality psychology*. London: SAGE Publications Ltd.

Blascovich, J., Seery, M. D., Mugridge, C. A., Norris, R. K., & Weisbuch, M. (2004). Predicting athletic performance from cardiovascular indexes of challenge and threat. *Journal of Experimental Social Psychology, 40*(5), 683-688. doi: 10.1016/j.jesp.2003.10.007

Blascovich, J., & Tomaka, J. (1996). The biopsychosocial model of arousal regulation. *Advances in Experimental Social Psychology, 28*, 1-51. doi:10.1016/S0065-2601(08)60235-X.

Cerin, E. (2003). Anxiety versus fundamental emotions as predictors of perceived functionality of pre-competitive emotional states, threat, and challenge in individual sports. *Journal of Applied Sport Psychology, 15*(3), 223-238. doi:10.1080/10413200305389

Cerin, E., Szabo, A., Hunt, N., & Williams, C. (2000). Temporal patterning of competitive emotions: A critical review. *Journal of Sports Sciences, 18*(8), 605-626. doi: 10.1080/02640410050082314

Chalabaev, A., Major, B., Cury, F., & Sarrazin, P. (2009). Physiological markers of challenge and threat mediate the effects of performance-based goals on performance. *Journal of Experimental Social Psychology, 45*(4), 991-994. doi:10.1016/j.jesp.2009.04.009

Coffee, P., & Rees, T. (2008). Main and interactive effects of controllability and generalisability attributions upon self-efficacy. *Psychology of Sport and Exercise, 9*(6), 775-785. doi: 10.1016/j.psychsport.2007.12.002

Dickerson, S. S., & Kemeny, M. E. (2004). Acute stressors and cortisol responses: A theoretical integration and synthesis of laboratory research. *Psychological Bulletin, 130*(3), 355-391. doi: 10.1037/0033-2909.130.3.355

Dienstbier, R. A. (1989). Arousal and physiological toughness: Implications for mental and physical health. *Psychological Review, 96*(1), 84-100. doi: 10.1037/0033-295X.96.1.84

Ennis, M., Kelly, K. S., & Lambert, P. L. (2001). Sex differences in cortisol excretion during anticipation of a psychological stressor. Possible support for the tend and-befriend hypothesis. *Stress and Health, 17*(4), 253-261. doi: 10.1002/smi.904

Field, A. (2009). *Discovering statistics using SPSS.* London: Sage.

Fletcher, D., Hanton, S., & Mellalieu, S. D. (2006). An organizational stress review: Conceptual and theoretical issues in competitive sport. In S. Hanton & S. D. Mellalieu (Eds.), *Literature reviews in sport psychology* (pp. 321-374). Hauppauge, NY: Nova Science.

Gerin, W., Litt, M. D., Deich, J., & Pickering, T. G. (1996). Self-efficacy as a component of active coping: Effects on cardiovascular reactivity. *Journal of Psychosomatic Research, 40*(5), 485-493. doi: 10.1016/0022-3999(95)00642-7

Hanton, S., Neil, R., & Mellalieu, S. D. (2008). Recent developments in competitive anxiety direction and competition stress. *International Review of Sport and Exercise 1*(1), 45-57. doi: 10.1080/17509840701827445

Hilmert, C. J., Christenfeld, N., & Kulik, J. A. (2002). Audience status moderates the effects of social support and self-efficacy on cardiovascular reactivity during public speaking. *Annals of Behavioral Medicine, 24*(2), 122-131. doi: 10.1207/S15324796ABM2402_09

Hilmert, C., & Kvasnicka, L. (2010). Blood pressure and emotional responses to stress: Perspectives on cardiovascular reactivity. *Social and Personality Psychology Compass, 4*(7), 470-483. doi: 10.1111/j.1751-9004.2010.00275.x

Hoyt, C. L., & Blascovich, J. (2010). The role of leadership self-efficacy and stereotype activation on cardiovascular, behavioral and self-report responses in the leadership domain. *The Leadership Quarterly, 21*(1), 89-103. doi: 10.1016/j.leaqua.2009.10.007

Jones, G. (1995). More than just a game: Research developments and issues in competitive anxiety in sport. *British Journal of Psychology, 86*(4), 449-478. doi: 10.1111/j.2044-8295.1995.tb02565.x

Jones, G., & Swain, A. B. J. (1992). Intensity and direction dimensions of competitive state anxiety and relationships with competitiveness. *Perceptual and Motor Skills, 74,* 467-472. doi: 10.2466/pms.1992.74.2.467

Jones, G., Swain, A., & Hardy, L. (1993). Intensity and direction dimensions of competitive state anxiety and relationships with performance. *Journal of Sports Sciences, 11*(6), 525-532. doi: 10.1080/02640419308730023

Jones, M. V., Lane, A. M., Bray, S. R., Uphill, M., & Catlin, J. (2005). Development and validation of the sport emotion questionnaire. *Journal of Sport and Exercise Psychology, 27*(4), 407-431. Retrieved from http://journals.humankinetics.com/jsep

Jones, M. V., Meijen, C., McCarthy, P. J., & Sheffield, D. (2009). A theory of challenge and threat states in athletes. *International Review of Sport and Exercise Psychology, 2*(2), 161-180. doi: 10.1080/17509840902829331

Kemeny, M. E. (2003). The psychobiology of stress. *Current Directions in Psychological Science, 12,* 124-129. doi: 10.1111/1467-8721.01246

Lazarus, R. S. (1999). *Stress and emotion: A new synthesis.* New York: Springer Publishing Company.

Lazarus, R.S. & Folkman, S. (1984). *Stress, appraisal and coping.* New York: Springer.

Meijen, C., Jones, M., McCarthy, P. J., Sheffield, D., & Allen, M. S. (2013). Cognitive and affective components of challenge and threat states. *Journal of Sports Sciences, 31*(8), 847-855. doi: 10.1080/02640414.2012.753157

Mendes, W. B., McCoy, S., Major, B., & Blascovich, J. (2008). How attributional ambiguity shapes physiological and emotional responses to social rejection and acceptance. *Journal of Personality and Social Psychology, 94*(2), 278-291. doi: 10.1037/0022-3514.94.2.278

Moore, L. J., Vine, S. J., Wilson, M. R., & Freeman, P. (2012). The effects of challenge and threat states on performance: An examination of potential mechanisms. *Psychophysiology, 49*(10), 1417-1425. doi: 10.1111/j.1469-8986.2012.01449.x

Schneider, T. R. (2008). Evaluations of stressful transactions: What's in an appraisal? *Stress and Health, 24*(2), 151-158. doi: 10.1002/smi.1176

Seery, M. D. (2011). Challenge or threat? Cardiovascular indexes of resilience and vulnerability to potential stress in humans. *Neuroscience and Biobehavioral Reviews, 35*(7), 1603-1610. doi: 10.1016/j.neubiorev.2011.03.003

Seery, M. D., Weisbuch, M., & Blascovich, J. (2009). Something to gain, something to lose: The cardiovascular consequences of outcome framing. *International Journal of Psychophysiology, 73*(3), 308-312. doi: 10.1016/j.ijpsycho.2009.05.006

Seery, M. D., Weisbuch, M., Hetenyi, M. A., & Blascovich, J. (2010). Cardiovascular measures independently predict performance in a university course. *Psychophysiology, 47*(3), 535-539. doi: 10.1111/j.1469-8986.2009.00945.x

Sherwood, A., Allen, M. T., Fahrenberg, J., Kelsey, R. M., Lovallo, W. R., & Van Doornen, L. J. P. (1990). Methodological guidelines for impedance cardiography. *Psychophysiology, 27*(1), 1-23. doi: 10.1111/j.1469-8986.1990.tb02171.x

Skinner, N., & Brewer, N. (2002). The dynamics of threat and challenge appraisals prior to stressful achievement events. *Journal of Personality and Social Psychology, 83*(3), 678-692. doi: 10.1037//0022-3514.83.3.678

Skinner, N., & Brewer, N. (2004). Adaptive approaches to competition: Challenge appraisals and positive emotion. *Journal of Sport & Exercise Psychology, 26*(2), 283-305. Retrieved from http://journals.humankinetics.com/jsep

Tomaka, J., Blascovich, J., Kibler, J., & Ernst, J. M. (1997). Cognitive and physiological antecedents of threat and challenge appraisal. *Journal of Personality and Social Psychology, 73*(1), 63-72. doi: 10.1037/0022-3514.73.1.63

Turner, M. J., Jones, M. V., Sheffield, D., & Cross, S. L. (2012). Cardiovascular indices of challenge and threat states predict performance. *International Journal of Psychophysiology, 86*(1), 48-57. doi: 10.1016/j.ijpsycho.2012.08.004

Weisbuch, M., Seery, M. D., Ambady, N., & Blascovich, J. (2009). On the correspondence between physiological and nonverbal responses: Nonverbal behaviour accompanying challenge and threat. *Journal of Nonverbal Behavior, 33*(2), 141-148. doi: 10.1007/s10919-008-0064-8

Williams, S. E., Cumming, J., & Balanos, G. M. (2010). The use of imagery to manipulate challenge and threat appraisal states in athletes. *Journal of Sport & Exercise Psychology, 32*(3), 339-358. Retrieved from http://journals.humankinetics.com/jsep

Footnotes

[1]We have explored the possibility of a non-linear relationship and are aware of research suggesting a non-linear relationship (i.e. Beck & Schmidt, 2012). To explore the possibility of a non-linear relationship we have looked at the scatterplot for the cardiovascular reactivity index for the sport task and self-efficacy, and the cardiovascular reactivity index for the sport task and excitement, as these were the two variables that significantly predicted cardiovascular reactivity. After looking at the scatterplot we created a squared version of the two independent variables (self-efficacy/excitement) and ran two separate multiple regression analyses (one for self-efficacy, one for excitement). We entered the cardiovascular reactivity index as the dependent variable, self-efficacy in step 1, and self-efficacy squared in step 2. This allowed us to look for a quadratic model. What the results showed was that there is no change in step 2, which indicated that there was no non-linear relationship. Because there was no change to the variance, it appears that the linear model works best.

Table 1

Means and Standard Deviations for Heart Rate, Cardiac Output, Preejection Period, and Total Peripheral Resistance in the Control Speech Task and Sport Speech Task

		Friend Speech		Sport Speech	
		Mean	*SD*	*Mean*	*SD*
HR	Baseline	70.33	11.50	70.82	11.22
	Task	81.87	13.31	84.21	13.25
	Reactivity	11.54	7.66	13.38	8.42
CO	Baseline	5.07	1.26	5.10	1.26
	Task	5.16	1.36	5.26	1.31
	Reactivity	0.08	0.64	0.16	0.52
PEP	Baseline	135.64	27.43	135.79	24.37
	Task	133.03	25.34	132.56	22.12
	Reactivity	-2.62	9.84	-3.23	11.37
TPR	Baseline	1340.18	416.17	1332.05	371.75
	Task	1539.64	432.94	1548.54	439.70
	Reactivity	199.46	215.01	216.49	171.75

Note: Baseline scores are based on the last minute of the baseline; task scores are based on the first minute of the task; reactivity is the difference between the first minute of the task and the last minute of the baseline. HR measured in BPM, CO in L/m, PEP in ms, and TPR in dyne seconds times cm^{-5}.

Table 2

Summary of Means, Standard Deviations and Correlations for Self-efficacy, Perceived Control, Challenge Appraisal, Threat Appraisal, Perceived Stress, Coping, Emotions, and Interpretation of Emotions

	M	*SD*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1 Self-efficacy	3.92	0.55	--														
2 Perceived Control	2.90	0.97	.55***	--													
3 Challenge Appraisal	2.64	1.20	.22	-.06	--												
4 Threat Appraisal	0.64	0.87	-.05	-.26	.33*	--											
5 Perceived Stress	1.21	0.95	-.02	-.26	.41**	.31	--										
6 Coping	2.92	0.87	.48**	.49**	-.13	-.14	-.27	--									
7 Anxiety	1.50	0.91	-.17	-.13	.23	.31	.46**	-.04	--								
8 Dejection	0.09	0.20	-.22	-.11	.22	.03	.26	-.23	.24	--							
9 Excitement	2.34	1.05	.39*	.33*	.27	-.06	.30	.28	.46**	-.13	--						
10 Anger	0.23	0.36	-.04	-.01	.46**	.15	.40*	-.18	.41**	.20	.39*	--					
11 Happiness	2.12	1.04	.28	.35*	.31	.11	-.13	.41*	.17	-.20	.62***	.15	--				
12 Interpretation Anxiety	-0.65	1.07	-.07	.10	.34*	.30	.16	-.03	.32*	.05	.04	.30	.11	--			
13 Interpretation Dejection	-1.45	1.49	-.10	.05	.09	.19	.22	-.30	-.06	.25	-.25	-.19	-.17	.38*	--		
14 Interpretation Excitement	1.96	0.61	.16	.38*	-.31	-.18	.12	.48**	.21	-.02	.41**	.16	.18	-.04	-.25	--	
15 Interpretation Anger	-0.94	1.79	.02	.10	.42**	.23	.40*	-.23	.30	.42**	.13	.27	.09	.54***	.64***	-.15	--
16 Interpretation Happiness	1.81	2.24	.06	.33*	.16	-.02	.05	.09	.21	-.10	.07	.32	.13	.23	-.12	.13	.05

* $p < .05$, ** $p < .01$, *** $p < .001$

Table 3

Summary Regression Analysis Cognitive Components

	b	*SE b*	β
Step 1			
Index friend	0.56	0.14	.56**
Step 2			
Index friend	0.64	0.13	.64**
Self-efficacy	-1.15	0.51	-.35*
Control	-0.31	0.30	-.17
Challenge appraisal	0.24	0.20	.16
Threat appraisal	-0.08	0.28	-.04

R^2 = .32, p < .001 for Step 1: ΔR^2 = .20, p = .02 for Step 2.

* p < .05, ** p < .001.