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The present study investigated whether imagery could manipulate athletes' appraisal of stress-evoking situations (i.e., challenge or threat) and whether psychological and cardiovascular responses and interpretations varied according to cognitive appraisal of three imagery scripts: challenge, neutral, and threat. Twenty athletes (M_{age} = 20.85; *SD* = 1.76; 10 female, 10 male) imaged each script while heart rate, stroke volume, and cardiac output were obtained using Doppler echocardiography. State anxiety and self-confidence were assessed following each script using the Immediate Anxiety Measures Scale. During the imagery, a significant increase in heart rate, stroke volume, and cardiac output occurred for the challenge and threat scripts ($p < .05$). Although there were no differences in physiological response intensities for both stress-evoking scripts, these responses, along with anxiety symptoms, were interpreted as facilitative during the challenge script and debilitative during the threat script. Results support using imagery to facilitate adaptive stress appraisal.

Keywords: anxiety interpretation, coping, sport psychology, stress

By its very nature, the sporting environment evokes a stress response by placing many demands on competing athletes (Jones, 1995). How individuals appraise stress as a challenge or threat provides insight into why some athletes excel in performance situations whereas others fail or underperform (Cerin, Szabo, Hunt, & Williams, 2000). Challenge and threat are motivational states reflecting how an individual engages in a meaningful situation. Whereas a challenge appraisal is characterized by a more adaptive approach to coping, a threat appraisal is more maladaptive (Blascovich & Mendes, 2000). Moreover, appraising a situation as a challenge can lead to better performance over individuals appraising the same situation as a threat (Blascovich, Seery, Mugridge, Norris, & Weisbuch, 2004). Together with research investigating personal and situational characteristics that dictate challenge and threat appraisals, these findings have led to theories and models describing similarities and differences between the two states, including the

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biopsychosocial model of challenge and threat (BPS; Blascovich & Tomaka, 1996), the model of *adaptive approaches to competition* (Skinner & Brewer, 2004), and the more recent *theory of challenge and threat states in athletes* (TCTSA; Jones, Meijen, McCarthy, & Sheffield, 2009).

The TCTSA is specific to athletes in competitive sport environments, and not only amalgamates and extends previous models of challenge and threat (Blascovich & Tomaka, 1996; Skinner & Brewer, 2004), but also includes Jones's (1995) model of debilitative and facilitative state anxiety. It attempts to explain (1) why athletes may appraise an encounter as a challenge or as a threat, (2) how athletes respond physiologically and psychologically to challenge and threat states, and (3) how the appraised state (i.e., challenge or threat) influences subsequent sporting performance. Self-efficacy beliefs, perceptions of control, and goal orientations are proposed as three interrelated antecedents to challenge and threat appraisals. It is predicted that athletes who feel efficacious and in control, and focus on approach goals in achievement situations will experience a challenge state. By comparison, a threat state is thought to occur when individuals possess low levels of self-efficacy and perceived control, and focus on avoidance goals.

When experiencing a stress-evoking situation, the TCTSA proposes athletes will experience variations in physiological responses depending on how the situation is appraised. A challenge-appraised situation is thought to be characterized by increases in sympathetic-adreno-medullary (SAM) activity, producing an increase in heart rate (HR) and stroke volume (SV), which combined produce an increase in cardiac output (CO). SAM activity also causes vasodilatation (widening of the blood vessels), thus reducing total peripheral resistance (TPR). A threat-appraised situation also elicits an increase in SAM activity, but is also characterized by an increase in pituitary-adreno-cortical (PAC) activity. This PAC activation releases the adrenocorticotrophic hormone, which results in corticosteroids secreted by the adrenal cortex into the bloodstream. Combined SAM and PAC activation is thought to produce changes (i.e., increases in HR, SV, and resulting CO) similar—albeit smaller—to those experienced during a challenge-appraised state (Blascovich, Mendes, Hunter, & Salomon, 1999). TPR is thought to remain unchanged or increase and be accompanied by the release of cortisol during a threat-appraised situation (Jones et al., 2009). In addition, the TCTSA proposes that emotions (e.g., anxiety) experienced in the situation will be differently interpreted depending on its appraisal.

Although higher anxiety levels have traditionally been associated with poorer performance (e.g., Spielberger, 1989), recent work has indicated that the directional perceptions of anxiety symptoms experienced (i.e., whether symptoms are considered to be facilitative or debilitative to subsequent performance) is more influential (e.g., Hanton & Jones, 1999a). Thomas, Maynard, and Hanton (2007) demonstrated that facilitative interpretations of anxiety symptoms associated with higher levels of self-confidence produced greater performance standards compared with more debilitative interpretations. In addition, Hanton and Jones (1999b) used a mental skills intervention to alter athletes' interpretation of their anxiety symptoms from debilitative to facilitative, which resulted in an improvement in performance for the athletes. The TCTSA suggests that facilitative interpretations of anxiety symptoms will occur when individuals appraise a situation as a challenge whereas a threat appraisal will result in more debilitative interpretations.

The TCTSA suggests a challenge state is developed by targeting self-efficacy, perceived control, and approach goals. Jones et al. (2009) explain that by manipulating an athlete's perceptions of situational characteristics previously evaluated to be a threat, the athlete can reappraise the situation as a challenge. This would lead to more adaptive behavioral tendencies associated with successful performance (Blascovich et al., 2004).

A strategy to modify cognitions and to change undesirable emotional responses is the use of imagery (for reviews, see Cumming & Ramsey, 2008; Martin, Moritz, & Hall, 1999). Athletes have described using imagery to overcome negative interpretations of anxiety symptoms both directly, by viewing them as controllable and facilitative to performance, and indirectly through confidence enhancement (e.g., Hanton, Mellalieu, & Hall, 2004; Thomas et al., 2007). Jones, Mace, Bray, MacRae, and Stockbridge (2002) found that imagery, with an emphasis on remaining in control of emotions and feeling confident and focused, led to lower perceived stress and higher levels of self-efficacy during a climbing task. Specifically using imagery to manipulate cognitive appraisals, Hale and Whitehouse (1998) instructed participants to observe a video and then image themselves experiencing the same scenario of taking a soccer penalty kick. The observed video was identical in both instances apart from the accompanying caption "pressure situation" or "challenge situation." Despite the intensity of HR and self-reported anxiety symptoms being similar in both instances, symptoms were perceived as facilitative for the challenge situation and debilitative for the pressure situation. Although participants were explicitly informed of which stress appraisal to adopt, the results indicate that cognitive appraisal can be altered by manipulating the imagery's meaning. Consequently, imagery appears to be a viable strategy for promoting a challenge appraised state in athletes.

In support of the TCTSA, both imagery scenarios from Hale and Whitehouse's (1998) study were characterized by elevations in HR. However, it is unclear whether the increased cardiac activity was due to imaging the stressful nature of the imagery or the action of taking a penalty kick. Imaging physical activity can induce physiological responses reflective of actual performance (e.g., Wuyam et al., 1995). Thus inclusion of a control imagery condition is necessary for clarification. In addition, instructing participants to adopt a particular appraisal does not permit conclusions to be drawn as to whether they can appraise the same scenario as a challenge or threat depending on the manipulation of the imagery content's meaning. In sum, research is needed to investigate whether imagery can manipulate antecedents of challenge and threat appraisals within the same individual resulting in physiological activity reflective of those appraisals.

A recent within-subject designed study conducted by Cumming, Olphin, and Law (2007) investigated HR and anxiety responses (intensity and direction) of different imagery scenarios describing the moments before competition. Scenarios were developed based on bioinformational theory's (Lang, 1979) proposal that imagery is composed of stimulus, response, and meaning propositions. Stimulus propositions describe the characteristics of the imagery scenario (e.g., specific details about the competition venue). Response propositions describe the physiological responses an athlete would experience when exposed to the real-life stimulus (e.g., an increase in HR). Finally, meaning propositions explain the relationship between the stimulus and response propositions to the athlete. For example, entering the competition venue may elevate HR in an athlete who interprets this as excitement and anticipation associated with competing. Studies demonstrate response propositions within imagery scenarios can induce actual physiological responses, thereby supporting bioinformational theory (Bakker, Boschker, & Chung, 1996). However, most neglect the meaning of the stimulus and response propositions to the participant. Cumming et al. (2007) investigated whether the interpretation of imagery scenarios containing the same response propositions could differ depending on their meanings to the athlete. Scripts contained identical stimulus information determined by the individual based on a past competitive experience. As expected, HR and anxiety responses reflected imagery response propositions with increases from baseline found only for scripts describing elevated physiological responses. Although two scripts contained an identical description of anxiety symptoms, one included additional information of feeling efficacious and in control of the situation. As expected, anxiety symptoms were perceived as more facilitative to the upcoming performance during this scenario. The absence of imaged physical activity more conclusively supports Hale and Whitehouse's (1998) findings that a challenge- or threat-appraised state will elicit increased HR (Jones et al., 2009). Increased HR during the scenarios describing elevated physiological responses supports Lang's (1979) assumption that responses will reflect the actual situation. Interestingly, when Cumming et al., (2007) manipulated challenge/threat appraisal antecedents (i.e., self-efficacy and perceived control) through imagery, it altered an individual's perceptions of physiological and psychological responses experienced. By altering the meaning of a stress-evoking image's stimulus and response propositions through manipulation of the characteristics proposed to influence how a situation is appraised, an athlete could learn to reappraise the stressful scenario as a challenge rather than a threat.

Although Cumming et al. (2007) identified an increase in HR as a result of anxiety inducing imagery, the TCTSA suggests additional cardiovascular responses will be elicited. As previously mentioned, both appraisals are characterized by an increase in HR and SV, producing an increase in calculated CO, although to a lesser extent during a threat-appraised state (Jones et al., 2009). Research has supported these predicted cardiovascular patterns (e.g., Blascovich et al., 2004; Blascovich & Tomaka, 1996), but limited research has investigated these responses to stress-evoking situations elicited through imagery beyond that of HR. Additional measures have primarily investigated cardiovascular responses to imaged physical activity (e.g., Wuyam et al., 1995). To fill this gap, research should more comprehensively investigate cardiovascular responses to stress-inducing imagery exploring whether elicited responses are reflective of the actual scenario and in accordance with the TCTSA during challenging and threatening imagery situations (i.e., increases in HR and SV but overall discrepancies in CO).

The primary aim of our study was to investigate whether imagery could be used to manipulate antecedents proposed by the TCTSA to produce a challenge- or threat-appraised state as reflected by self-reported psychological responses compared with a neutral script (i.e., a script that describes feeling calm and relaxed before competition). By including a more in-depth assessment of cardiovascular responses to different imagery scenarios (HR, SV, and calculation of CO) than previously done (Cumming et al., 2007; Hale & Whitehouse, 1998), a second aim was to examine whether psychological and cardiovascular responses and their interpretations vary according to the cognitive appraisal of three imagery scripts.

It was hypothesized that both stress-evoking scripts would elicit psychological and cardiovascular responses reflective of the imagery content and in accordance to the TCTSA predictions. Specifically, it was hypothesized that although both scripts would elicit increases in symptoms associated with anxiety, HR, SV, and CO, a threat-appraised script would produce a smaller CO increase compared with a challenge-appraised script due to variations in SAM and PAC activation. Moreover, it was hypothesized that elicited responses would be interpreted differently depending on the appraisal of each imagery script. When athletes image a script describing a combination of challenge appraisal characteristics (i.e., having the resources to meet the demands of the situation by feeling efficacious and in control of the situation, and focusing on approach goals), it was expected that they would perceive the physiological and anxiety symptoms experienced as more facilitative to a hypothetical competition. Conversely, imaging a script describing a combination of threat appraisal characteristics (i.e., not having the resources to meet the demands of the situation by not feeling efficacious and in control, and focusing on avoidance goals) would result in athletes perceiving the same symptoms as debilitative to performance. It was predicted that imaging a neutral script would result in no changes in physiological and anxiety-level responses.

Method

Participants

Twenty healthy competitive athletes (10 males, 10 females) with a mean age of 20.85 (*SD* = 1.76) years participated in the study. Participants were all club-level athletes representing nine different sports with the majority recruited from rugby (*n* = 5), soccer (*n* = 4), lacrosse (*n* = 3), and swimming (*n* = 3), and had competed in their chosen sport for an average of 8.60 years (*SD* = 4.43). None of the participants smoked, had a known history of cardiovascular or respiratory diseases, and were currently experiencing illness or infection, nor were they taking prescribed medication other than taking oral contraception by female participants.

Self-Report Measures

Demographic Information. Participants provided information about their age, gender, sport played, competitive level, and years of playing experience. In addition, participants answered questions related to their general health to identify whether they suffered from any known cardiovascular or respiratory diseases or infections.

Cognitive and Somatic State Anxiety and Self-Confidence. Following each imagery scenario, the Immediate Anxiety Measurement Scale (IAMS; Thomas, Hanton & Jones, 2002) assessed the intensity and directional perception of anxiety symptoms and self-confidence experienced by participants. This questionnaire is composed of three items measuring the intensity and direction of cognitive anxiety, somatic anxiety, and self-confidence experienced by the athlete. The IAMS was reworded to assess how anxious and confident athletes felt during each imagery scenario. Participants rated each construct on a 7-point Likert-type scale from 1 (*not at all*) to 7 (*extremely*) for intensity and from –3 (*very debilitative/negative*) to +3 (*very facilitative/positive*) for direction. The IAMS provides definitions of each construct to enable individuals to fully understand the meaning of each one. Thomas et al., (2002) have identified the IAMS to be a valid and reliable measure to assess state cognitive and somatic anxiety and self confidence intensity and direction.

Imagery Manipulation Checks. Participants also filled in a post script evaluation (PSE) form comprised of four items rated on a 7-point Likert-type scale after each imagery script. The first two items, used by Cumming et al. (2007), assessed the ease participants could generate the imaged scenario and degree of emotion experienced during the imagery. The anchors for these items were 1 (*very hard/no emotion*) to 7 (*very easy/strong emotion*). The third item assessed how well athletes could relate to the scripts and how meaningful they were perceived to be, ranging from 1 (*not at all meaningful or able to relate*) to 7 (*completely meaningful and able to relate*). The fourth item assessed how helpful the script was in relation to a hypothetical performance, ranging from –3 (*very hurtful*) to +3 (*very helpful*).

Cognitive Appraisal of Imagery Scripts. To assess the extent participants perceived each imagery situation as challenging or threatening, six items were developed from items employed by McGregor and Elliot (2002). Each described how an individual may feel about an upcoming competition, with the wording modified so that participants appraised the previously heard competitive imagery scenario. The three items reflecting a challenge appraisal included, "I viewed the competition as a challenge," "the situation presented itself as a threat to me," and "I felt challenged by the situation." The three items representative of a threat appraisal were identical apart from inserting the word "threat" to replace the word "challenge" (e.g., "I viewed the competition as a threat"). Consequently two subscales were produced for the questionnaire. Participants rated the extent to which they agreed with each item ranging from 1 (*not at all true*) to 7 (*very true*). Adequate reliability for each subscale following each imagery script can be seen in Table 1, with Cronbach's alpha coefficient being .78 or above.

Postexperiment Manipulation Check. Following the experiment all participants selected the script they thought would be most helpful in preparing them for an actual competition. The final part of the questionnaire asked participants to indicate the extent the overall scanning procedure disrupted their imagery. Responses ranged from 0% (*not at all disruptive*) to 100% (*completely disruptive*).

Apparatus and Physiological Measurements

Heart Rate (HR). Heart rate was monitored continuously using a single lead electrocardiogram (Micromon, Charter-Kontron Ltd).

Stroke Volume (SV). Stroke volume was measured using Doppler echocardiography from an apical five-chamber view of the heart to identify systolic blood flow through the aortic valve. The velocity profile of aortic blood flow was obtained using a pulsed-wave spectral mode at a screen sweep speed of 100 $mm \cdot s^{-1}$. Doppler measurements of blood flow were taken immediately below the orifice of the aortic valve using a Philips Sonos 7500 ultrasound machine equipped with an S3 two-dimensional transducer (1–3 MHz). Continuously recorded digital spectral waveform images were obtained and used in later analysis for each minute. An additional measurement

Table 1 Cognitive Appraisal and Script Manipulation Checks for Each Imagery Script

		Scripts		
		Challenge	Neutral	Threat
Postintervention Imagery Evaluation				
Ease of imaging (1 = *very hard*, 7 = *very easy*)	*M*	5.55	5.35	5.25
	SD	1.00	0.99	0.85
Strength of emotion (1 = *very hard*, 7 = *very easy*)	*M*	5.25	4.70	5.05
	SD	1.02	1.49	1.23
Extent image was relatable and meaningful (1 = *not at all meaningful*, 7 = *very meaningful*)	*M*	5.25	4.65	4.65
	SD	1.07	1.38	0.81
Perceived helpfulness (–3 = *very hurtful*, +3 = *very helpful*)	*M*	1.75[a]	1.15[a]	–1.35
	SD	0.91	1.60	1.14
Cognitive Appraisal				
Challenge appraisal (1 = *not at all true*, 7 = *very true*)	*M*	4.88[b]	2.87	4.88[b]
	SD	0.94	1.30	1.02
	α	0.86	0.83	0.92
Threatening appraisal (1 = *not at all true*, 7 = *very true*)	*M*	2.78[b]	1.73	4.73[b,c]
	SD	1.06	0.53	1.29
	α	0.91	0.78	0.96

[a]Significantly greater than the threat script ($p < .001$).
[b]Significantly greater than the neutral script ($p < .001$).
[c]Significantly greater than the challenge script ($p < .001$).

of the aortic valve diameter was obtained from a parasternal long axis view during the second visit to calculate aortic valve area and subsequently SV.

Physiological Calculations

Aortic blood flow was automatically quantified using the velocity time integral (VTI). This is the mean distance blood travels through the aortic valve during ventricular contraction. A VTI measurement for each minute was obtained by averaging three or more spectral waveforms recorded during that minute from the Doppler ultrasound machine. Similarly, HR for each minute was obtained by averaging the beats per minute provided with the same spectral waveforms used to calculate VTI. Aortic blood flow measurements and HR were therefore averaged across 60-s intervals. Aortic valve diameter was used to calculate aortic valve area (A) using the following formula: $A = \pi r^2$. Stroke volume was then calculated using the following formula: VTI × A. Finally, CO was calculated using the following formula: HR × SV. A value of HR, SV, and CO for the 9 min of each imagery trial was calculated. Following this procedure, the 3 min of baseline and 3 min of recovery were each averaged, providing a baseline and recovery value. Consequently, physiological data were statistically analyzed over five time points: baseline, 3 min of imagery, and recovery.

Procedures

Development and Pilot Testing of Imagery Scripts. Three imagery scripts describing the moments before a hypothetical competition were developed for the study. These were all devised based on the recommendations of Lang's (1979) bioinformational theory and available examples from the literature (e.g., Cumming et al., 2007). Content to specifically manipulate a challenge or a threat appraisal was based on characteristics proposed by the TCTSA (Jones et al., 2009). Before data collection, these scripts were first pilot tested with five competitive athletes and then slightly modified based on feedback received.

Scripts were designed to make the content personally meaningful for each athlete while keeping certain instructions consistent across participants. Similar to Cumming et al. (2007), individuals were asked to recall a previous competitive experience and base their imagery on this memory to create specific stimulus propositions within each script. Unlike the personalized stimulus propositions, response propositions were manipulated during the study, and with the exception of the neutral script, described a series of events creating a stress-evoking situation requiring a cognitive appraisal to be made (e.g., "you feel the adrenalin rush through your body reaching all your muscles"). The neutral script also described the moments before competition. However, its response propositions were not intended to be stress evoking but referred to feeling calm and confident before the competition (e.g., "any anxiety you previously experienced has completely evaporated from your body"). Stress-evoking scripts described disturbances in athlete preparation and emphasized the importance of the upcoming competition with the odds being against the athlete. Both contained the exact same characteristics and occurrence of events (stimulus) and the way the athlete physiologically responded to each of these (response propositions). Only the meaning of these responses differed between the challenge- and threat-appraised scripts. The challenge script emphasized a challenge appraisal by indicating the athlete's resources met demands of the situation, and included feelings of high efficacy (e.g., "you have confidence in your own ability to perform") and control (e.g., "demonstrating your sporting competence"), and emphasized a potential to gain (e.g., "there is real potential to achieve everything"; Jones et al., 2009). Conversely, the threat script emphasized a threat appraisal indicating that the athlete's resources did not meet demands of the imaged situation, which included feelings of low efficacy (e.g., "you cast doubts about your own ability to perform") and control (e.g., "concerned about revealing your weaknesses"), and emphasized a potential of loss (e.g., "there is real potential to lose everything"; Jones et al., 2009). A copy of all three scripts can be obtained from the lead author upon request.

During the first visit, participants imaged each script while attached to the equipment measuring physiological responses. This was to ensure a spectral trace was obtainable from all participants and they were able to image the different aspects of the scenarios. All scripts were delivered to participants in a counterbalanced order that remained consistent for both laboratory visits.

Recruitment. Following ethical approval of the study from the ethics committee at the university where the authors are based, participants were recruited from different sports clubs. Participation comprised two visits to the laboratory each 24 hr apart, with the first and second visits lasting approximately 90 and 60 min respectively. All participants were tested on an individual basis and refrained from consuming food and caffeine within 3 hr and consuming alcohol or partaking in exercise within 12 hr of each laboratory visit. All females participated within the first 14 days of their menstrual cycle or during a day when oral contraception was consumed.

Visit 1. The first visit was divided into two parts. Participants were first given an information sheet and explained the requirements of the study by an investigator. Those who agreed to participate understood it was voluntary and signed a written consent form. Participants then provided their demographic and general health information to ensure they were suitable to participate. A definition of mental imagery was then provided (White & Hardy, 1998) along with a training exercise based on the recommendations of Lang, Kozak, Miller, Levin, and McLean (1980) to show participants how they can maximize the effectiveness of imagery (i.e., stimulus and response training). Participants were made aware of specific stimulus details within an imagined scenario and then encouraged to consider how these details might make them respond physiologically and emotionally. They were then asked to re-create these feelings and responses in subsequent images of the described scenario. Finally, participants were introduced to the IAMS, PSE form, and script appraisal questionnaires and it was explained that all were to be completed following each script.

The second part of Visit 1 was to familiarize participants to the equipment used to record physiological responses. The ECG leads were attached to the participant to provide a HR value and a spectral trace of the participant's heart was obtained. Individuals reclined on a couch tilted to the left to provide an easily obtainable trace. Participants listened to the imagery scripts via headphones while physiological measurements were obtained to familiarize themselves with the process. All imagery scripts were prerecorded and played on a Samsung YP-U1 MP3 player through headphones.

Each imagery script's trial included a baseline, imagery, and recovery phase. Before the baseline, participants maintained the correct reclined position and were reminded of the stimulus and response training they received previously. They were instructed to image the scenario as clearly and vividly as possible from their preferred imagery perspective (Hall, 1997) with their eyes open or closed. During 3 min of baseline recording, participants were asked to breathe deeply and relax so stable baseline rates could be maintained and ensure that any changes during the imagined scenario would be more clearly detected (Lang et al., 1980). Following baseline, the imagery scripts began to play automatically and lasted 3 min in duration. After each script, a further 3 min of physiological recordings were obtained during the recovery phase, during which time the participant was instructed to relax and clear their mind of the imagery just experienced. Consequently, any changes in physiological responses during the imagery phase could be observed returning to baseline level. At the end of the recovery phase, physiological recording stopped and from a sitting position participants completed the IAMS, PSE form, and cognitive appraisal of the imagery script. The process was then repeated for the remaining two scripts. All data obtained in Visit 1 was to familiarize participants to the equipment and protocol of the study, consequently data were not included in the analysis.

Visit 2. The second visit was nearly identical to the second part of Visit 1. Upon arrival to the laboratory, participants were reintroduced and attached to the equipment used during the first visit, and reminded of the stimulus and response training received. Participants adopted the same reclined position, and baseline recordings were obtained. The procedures described for Visit 1 were followed for each imagery script. After the IAMS, PSE form, and imagery script appraisal were completed for the final script, participants were asked to complete the postexperimental manipulation check before their aortic valve diameter was measured to quantify aortic valve area and calculate SV. Finally, participants were debriefed about the study and thanked for their participation.

Results

Preliminary Analyses

Statistical Analyses. Repeated-measures ANOVAs and repeated-measures MANOVAs were used for the preliminary and main data analyses. Pillai's trace was always reported as it is considered the most robust of multivariate significance tests (Olson, 1976). When appropriate, Mauchly's test of sphericity was used to examine the equality of the within-subject factor. If data violated the assumption of homogeneity of the variance-covariance matrices ($p < .05$), the degrees of freedom of the subsequent univariate tests were reduced by reporting the Greenhouse–Geisser correction (Greenhouse & Geisser, 1959).

Imagery Manipulation Checks. Participants' ease of imaging was assessed following the challenge, neutral, and threat imagery scripts. Participants reported a mean score of 5.25 (5 = *somewhat easy to image*) or above for ease of imaging each imagery script and 4.70 (4 = *moderate emotion*) or above for how emotive the scripts were. A repeated-measures MANOVA revealed no significant differences between the three imagery scripts for ease of imaging or emotion produced (dependent variables; observed power = 66%). Athletes reported all scripts to be meaningful and they were able to relate to the content in each script with mean scores of 4.65 or above (4 = *moderately meaningful and able to relate*) for each script. A repeated-measures ANOVA revealed no significant differences in how meaningful and how well athletes could relate to the scripts (observed power = 45%). A repeated-measures ANOVA identified significant differences between imagery scripts in their perceived helpfulness in relation to a hypothetical performance, $F(2, 38) = 31.19$, $p < .001$, $\eta^2 = .62$, observed power = 100%. Post hoc analysis indicated the threat script was perceived as significantly less helpful than the challenge and neutral scripts. Means and standard deviations of the PSE form for each script are reported in Table 1.

Postexperimental Manipulation Checks. When indicating which script would be considered most helpful for performance, 70% of participants selected the challenge script and the remaining 30% of participants selected the neutral script. No participants chose the threat script to be most helpful. During the experiment, a mean score of 36% (40% = *somewhat disruptive*) indicated the extent participants felt the physiological equipment disrupted their imagery.

Cognitive Appraisal of Imagery Scripts. A repeated-measures MANOVA determined whether any differences existed in perceptions of how challenging or threatening the imagery scripts were to participants. Gender was included as a between-subject variable due to previous studies identifying differences in how males and females appraise situations (e.g., Folkman & Lazarus, 1980). Results revealed no significant difference due to gender (observed power = 62%) and no significant interaction between gender and imagery script (observed power = 52%). There was, however, a significant multivariate effect due to imagery script, Pillai's trace = 1.13, $F(4, 72) = 23.35$, $p < .001$, $\eta^2 = .57$, observed power = 100%. Results examined at the univariate level revealed a significant difference in challenge appraisal, $F(2, 36) = 23.28$, $p < .001$, $\eta^2 = .56$, observed power = 100%, and threat appraisal, $F(2, 36) = 65.77$, $p < .001$, $\eta^2 = .79$, observed power = 100%. As can be seen in Table 1, post hoc analysis revealed both challenge and threat scripts were perceived as more challenging compared with the neutral script. The threat script was also perceived to be more threatening than the challenge script, which in turn, was perceived to be more threatening than the neutral script.

Main Analyses

Three separate 3 (imagery script) × 5 (time points) repeated-measures ANOVAs were carried out to assess differences in HR, SV, and CO elicited as a result of the 3 imagery scripts. Because all three cardiovascular measures are correlated, to reduce the likelihood of a Type I error, a Bonferroni adjustment was performed to set a more conservative significance level of $p < .017$. Post hoc analysis on significant effects determined differences among the five time points: baseline, 3 min of imagery, and recovery. An additional 3 (imagery script) × 5 (IAMS subscales) repeated-measures MANOVA assessed differences in state cognitive and somatic anxiety intensity and direction and self-confidence following each script. For significant effects, post hoc analysis was again carried out between the three scripts.

HR Response. Results revealed a significant main effect for time, $F(2.63, 49.88) = 10.18$, $p < .001$, $\eta^2 = .35$, observed power = 99%. Although there was no main effect for script, there was a significant time by script interaction, $F(4.42, 84.01) = 6.09$, $p = .001$, $\eta^2 = .24$, observed power = 99%. Post hoc analysis comparing the imagery scripts at each time point (i.e., between scripts) revealed at Time Points 3 and 4 (2nd and 3rd minutes of imagery) HR was significantly higher during the challenge and threat scripts compared with the neutral script. In addition, post hoc analysis comparing both the challenge and threat script across all five time points (i.e., within script) revealed HR at Points 3 and 4 (2nd and 3rd minutes of imagery) was significantly higher than at Points 1 and 5 (baseline and recovery). Furthermore, HR at Time Point 2 of the threat script (1st minute of imagery) was significantly higher than at Point 5 (recovery). Finally, post hoc analysis for the neutral script revealed no significant differences across all five time points. Means and standard errors of HR can be seen in Figure 1.

SV Response. Results revealed a significant main effect for time, $F(2.10, 39.87) = 80.03$, $p < .001$, $\eta^2 = .81$, observed power = 100%, and a significant main effect for script, $F(2, 38) = 17.40$, $p < .001$, $\eta^2 = .48$, observed power = 100%. There was also a significant time × script interaction, $F(8, 152) = 19.42$, $p < .001$, $\eta^2 = .51$, observed power = 100%. Inspection of post hoc analysis comparing all three scripts at each time point (i.e., between script) revealed SV was significantly higher during the challenge and threat scripts compared with the neutral script during all three minutes of imagery (Time Points 2, 3, and 4). Post hoc analysis comparing SV of the each script across all time points (i.e., within script) revealed for the challenge and threat scripts, the three minutes of imagery (Time Points 2, 3, and 4) elicited a significantly higher SV compared with baseline (Minute 1) and recovery (Minute 5). In addition, the third minute of imagery (Time Point 4) during the challenge and threat script produced a significantly higher SV than the first minute of imagery (Time Point 2). No significant differences in SV were found across the five time points for the neutral script. Means and standard errors for SV can be seen in Figure 1.

CO Response. Results revealed a significant main effect for time, $F(2.16, 41.01) = 47.90$, $p < .001$, $\eta^2 = .72$, observed power = 100%, and a significant main effect for script, $F(2, 38) = 7.19$, $p = .002$, $\eta^2 = .27$, observed power = 91%. There was also a significant time × script interaction, $F(4.65, 88.31) = 22.60$, $p < .001$, $\eta^2 = .54$, observed power = 100%. Post hoc analysis comparing all three scripts at each time point (i.e., between scripts) revealed CO to be significantly higher for the challenge and threat scripts compared with the neutral script during Time Points 3 and 4 (2nd and 3rd minutes of imagery). Post hoc analysis comparing CO for each script across the five time points (i.e., within script) revealed that for the challenge and threat scripts, all three minutes of imagery (Time Points 2, 3, and 4) elicited a significantly higher CO compared with baseline and recovery. In addition, the second and third minute of imagery (Time Points 3 and 4) during the challenge script produced a significantly higher CO than the first minute of imagery (Time Point 2) and the second minute of imagery (Time Point 3) during the threat script produced a significantly higher CO compared with the first minute of imagery (Time Point 2). There were no differences across the time points with regards to the neutral script. Means and standard errors of CO are presented in Figure 1.

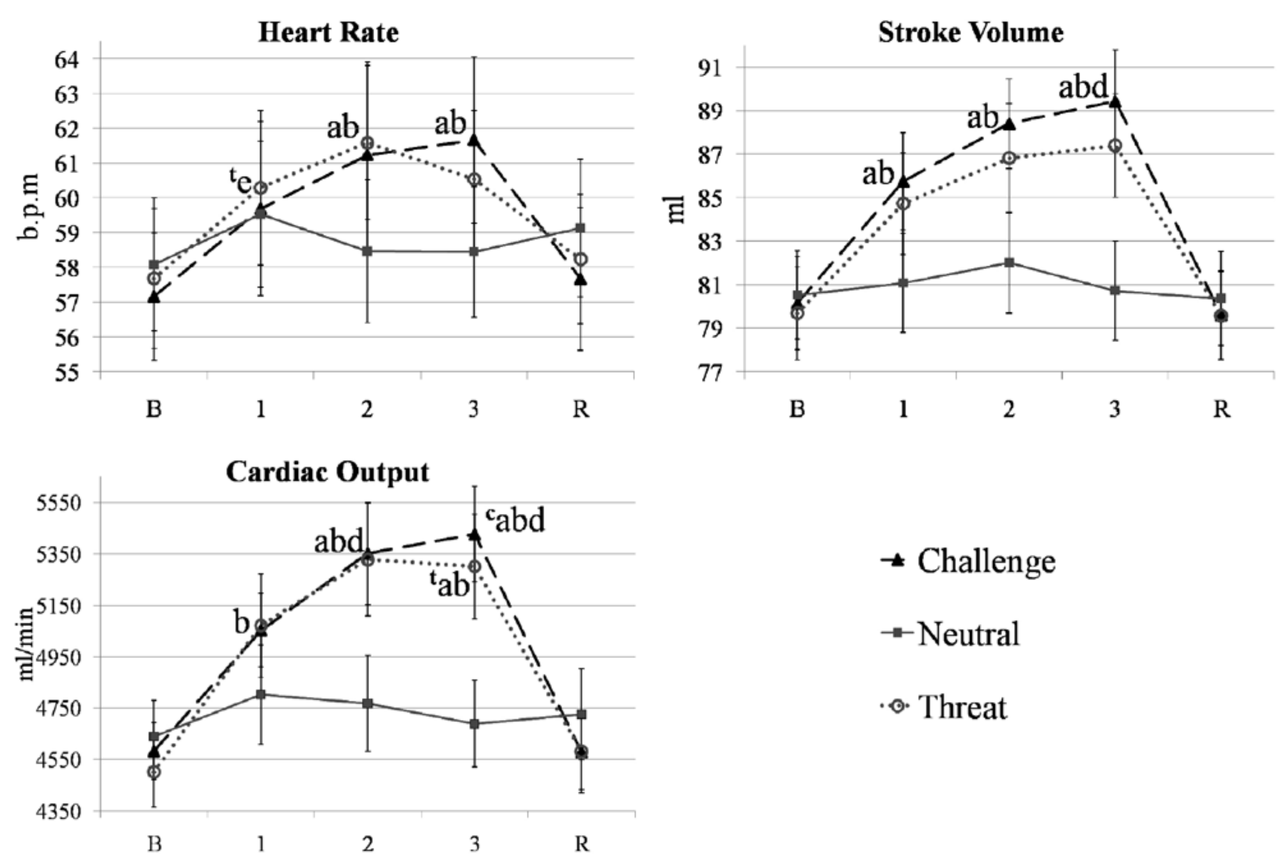

Figure 1 — Mean heart rate, stroke volume, and cardiac output values for each imagery script during the five time points. Letters represent the challenge and threat scripts significantly differing ($p < .05$) from the neutral script (a), baseline and recovery (b), 1st minute of imagery (d), and recovery only (e). Any differences for only one script are characterized by a preceding [c] or [t] to represent a challenge or threat script respectively. Error bars represent mean standard errors.

Table 2 Mean and Standard Deviations for Cognitive and Somatic Anxiety Symptoms Intensity and Direction and Self-Confidence Intensity

IAMS Dimensions	Script Scores					
	Challenge		Neutral		Threat	
	M	*SD*	*M*	*SD*	*M*	*SD*
Cognitive anxiety intensity	4.05[a]	1.00	2.15	0.99	5.15[a,b]	0.81
Somatic anxiety intensity	4.50[a]	1.36	2.30	0.98	4.70[a]	1.26
Self-confidence intensity	5.15[c]	0.75	5.05[c]	1.23	2.80	1.20
Cognitive anxiety direction	1.40[c]	0.88	1.25[c]	1.55	–0.55	1.57
Somatic anxiety direction	1.00[c]	1.30	0.65	1.53	–0.30	1.22

[a]Significantly greater than the neutral script ($p < .001$).
[b]Significantly greater than the challenge script ($p < .001$).
[c]Significantly greater than the threat script ($p < .01$).

IAMS. Results revealed a significant multivariate effect, Pillai's trace = 1.41, $F(12, 68) = 13.59$, $p < .001$, $\eta^2 = .71$, observed power = 100%. Inspection at the univariate level for anxiety symptom intensity revealed a significant effect for cognitive anxiety, $F(2, 38) = 58.61$, $p < .001$, $\eta^2 = .76$, observed power = 100%, and somatic anxiety, $F\ (2, 38) = 41.60$, $p < .001$, $\eta^2 = .69$, observed power = 100%. Post hoc analysis revealed the challenge and threat scripts produced significantly higher scores compared with the neutral script for the intensity of both cognitive and somatic anxiety symptoms. The threat script also produced a significantly higher cognitive anxiety score compared with the challenge script. Inspection of the univariate level findings for anxiety symptom direction revealed a significant effect for both cognitive direction, $F(2, 38) = 12.86$, $p < .001$, $\eta^2 = .40$, observed power = 100%, and somatic direction, $F(2, 38) = 5.22$, $p = .01$, $\eta^2 = .22$, observed power = 80%. Post hoc analysis indicated that symptoms associated with cognitive anxiety experienced after the challenge and neutral scripts was perceived as more facilitative to performance compared with the threat script anxiety symptoms. Furthermore, somatic anxiety experienced after the challenge script was perceived as more facilitative compared with the threat script symptoms. Lastly, inspection at the univariate level revealed a significant effect for self-confidence intensity, $F(2, 38) = 47.87$, $p < .001$, $\eta^2 = .72$, observed power = 100%. Post hoc analysis revealed participants felt significantly more confident following the challenge and neutral scripts compared with the threat script. Means and standard deviations are presented in Table 2.

Discussion

The aim of the study was to investigate whether imagery could be used to manipulate antecedents producing a challenge-and threat-appraised state as reflected in self-reported psychological responses. A second aim was to include an in-depth assessment of cardiovascular responses to investigate whether psychological and cardiovascular responses varied in magnitude and interpretation according to cognitive appraisal and in line with the TCTSA (Jones et al., 2009). It was hypothesized that in accordance to the TCTSA predictions, both stress-evoking imagery scripts would elicit increases in symptoms associated with anxiety, HR, SV, and CO. It was also proposed that calculated CO during the threat-appraised script would be lower than that calculated during a challenge appraised imagery scenario. Finally, it was hypothesized responses would be interpreted as facilitative and debilitative to performance following a challenge- and threat-appraised scenario, respectively.

Ease of imaging ratings for all three scripts revealed no significant differences, indicating that variations in physiological responses was not due to differences in the ability to image scripts—a factor previously identified as influencing physiological responses to imagery (e.g., Guillot et al., 2004). Script stimulus propositions were individualized to produce more meaningful imagery (Lang, 1979). Although response and meaning propositions were manipulated, manipulation checks revealed athletes could relate to all three scenarios identifying them to be meaningful and emotive. An interesting finding was that the neutral script was perceived to be as emotive and meaningful as the challenge and threat scripts. A somewhat low statistical power resulting from the analysis could mean that the sample size was small to detect statistical differences between scripts. However, previous research has suggested that imagery with personalized propositions can elicit more emotion from an individual (Lang, 1979). As all three scripts were equally personalized with individualized stimulus propositions, it is possible that these personally meaningful stimulus propositions were sufficient to enable participants to experience an emotive scenario to a similar extent in all three scripts.

In support of our hypothesis, the challenge and threat scripts caused an increase in anxiety intensity compared with the neutral script. Consistent with Hale and Whitehouse (1998), a greater intensity of cognitive anxiety was experienced during the threat script compared with the challenge script. It is suggested that a greater cognitive intensity was experienced during the threat scenario due to the script containing more thoughts of concern and worry (e.g., ". . . you are concerned about the possibility of revealing your weaknesses"). Such elements are described by the IAMS as symptoms of cognitive anxiety. Unlike Hale and Whitehouse (1998), results revealed a similar intensity of somatic anxiety symptoms for both the challenge and threat scripts. This finding, which is similar to previous studies using stress-evoking imagery (Cumming et al., 2007), is likely due to both scripts containing the same response propositions describing physiological activation being experienced. Such responses are described on the IAMS questionnaire as symptoms reflective of somatic anxiety. A more important finding is that the increased anxiety, similarly to the neutral script, was perceived as facilitative during the challenge script but debilitative during the threat script. These findings comply with previous studies investigating interpretation of anxiety symptoms in response to stress appraising imagery (Cumming et al., 2007; Hale & Whitehouse, 1998). Moreover, athletes perceived the challenge and neutral imagery scripts to be significantly more helpful to sporting performance compared with the threatening script. In addition, 14 athletes (70%) selected the challenge script as most helpful toward performance, indicating that although not all participants perceived a higher level of arousal and activation facilitative toward performance, the majority of athletes in this sample preferred it to a relaxed state (neutral script). In accordance with the TCTSA, results suggest negative emotions can be experienced during a challenge state but will facilitate performance (Jones et al., 2009). By comparison, the similar somatic anxiety intensity experienced during a threat appraised scenario is perceived as more debilitative to performance. Together, these findings further reinforce the interpretation of anxiety symptoms being an important factor in predicting successful performance (e.g., Hanton & Jones, 1999b; Thomas et al., 2007).

Differences in self-confidence between scripts indicated the challenge and neutral scripts produced higher levels compared with the threat scenario. This provides partial support to the TCTSA, which predicts a challenge appraisal is more likely if the athlete possesses high levels of self-efficacy—a more specific form of self-confidence (Bandura, 1977). Self-confidence differences are consistent with Cumming et al. (2007) and support Martin et al.'s (1999) suggestion that imagery can protect against debilitative interpretations of anxiety by maintaining high levels of self-confidence or allowing athletes to perceive symptoms as controllable and facilitative (also see Hanton, Mellalieu, & Hall, 2004; Thomas et al., 2007).

An increase in HR, SV, and CO occurred during the challenge and threat scripts but not during the neutral script. This increase in cardiovascular responses during both stress-evoking scripts replicates previous findings (Hale & Whitehouse, 1998). The lack of measurable response during the neutral script is supportive of Lang's proposal (1979) that elicited responses will reflect the imagery script content as this script contained no response propositions referring to increases in physiological activation. The observed increases in SV and CO provide a more comprehensive insight into the physiological responses elicited through psychological stress-evoking imagery. Heart rate and SV increases support our hypothesis, aligning with the BPS model and TCTSA, that imagery appraised as a challenge or a threat will produce an increase in HR and SV, resulting in an overall increase in CO (Blascovich et al., 2004; Jones et al., 2009). Contrary to our hypothesis and predictions of the BPS model and TCTSA, we were unable to detect any discrepancies in CO between the challenge and threat scripts. According to both models, a challenge-appraised situation is thought to be characterized by a larger increase in CO compared with a threat-appraised state (Blascovich et al., 2004; Blascovich & Tomaka, 1996; Jones et al., 2009).

A possible explanation for a lack of distinguishable differences in CO could be due to the cognitive appraisal of the challenge and threat script. Although results of the cognitive appraisal revealed the threat script was appraised to be significantly more threatening than the challenge script, both were perceived to be equally challenging. The discrepancies in threat appraisal might have influenced different response interpretations, whereas the similar challenge appraisal may have led to indistinguishable cardiovascular responses (HR and SV), resulting in no CO discrepancies between threat and challenge scripts. A second explanation surrounds the nature of the stressor. Compared with active stressors which directly engage individuals in the situation, imagery is more suitably classed as a passive stressor. During imagery, the person is typically removed from the actual situation but still exposed to emotionally evocative stimulus materials. Because passive stressors may inhibit challenge appraisals, the physiological responses obtained may be explained by the nature of the stressor rather than the situation appraisal (Tomaka, Blascovich, Kelsey, & Leitten, 1993).

Despite no physiological distinction between both stress-evoking scenarios, the results nevertheless have applied implications. By attempting to manipulate self-efficacy, perceived control, and achievement goals through stress-evoking imagery, athletes varied in their cognitive appraisal of the upcoming hypothetical competition. Despite experiencing elevations in competitive anxiety, this was perceived as facilitative to performance when athletes imaged themselves feeling efficacious and in control of the situation, and sensed a potential to gain from the experience. Thus, athletes susceptible to a threat appraisal of stressful scenarios could use imagery to alter cognitive appraisals and associate experienced physiological and psychological responses as facilitative to performance. As a result of a more adaptive coping approach, improvements in performance might then occur.

Despite the contribution of novel findings, the study is not without its limitations. Although it is a strength that we incorporated a more sophisticated technique assessing cardiovascular indices to stress-evoking images, the procedure may be have been intrusive and distracting to the imagery process. The recorded physiological and psychological responses may have therefore been somewhat inhibited and not fully representative of those elicited through stress-evoking imagery. It should be noted, however, that the first visit to the laboratory was designed to acclimatize the participants to imaging under these conditions. Furthermore, participants rated that the scanning procedure on average only "somewhat" disturbed their imagery. In addition, to obtain a clear VTI trace, participants were required to adopt a supine position and roll slightly to their left side. Although this physical position is not equivalent to the position adopted by the individual in the real-life situation (e.g., Holmes & Collins, 2001), it was necessary in the current study to obtain such detailed cardiovascular responses. Despite this less-than-ideal physical position, discernable responses were found between the stress-evoking and neutral imagery scripts. Secondly, a somewhat small sample size may explain the slightly low observed power in some of the preliminary analysis. Despite this issue, the statistical power was more than sufficient for the main analysis. Finally, the similarity in challenge appraisals for the challenge and threat scripts suggests a possible lack of internal validity due to some overlap occurring. However, the significant difference in threat appraisal for both scripts indicates that participants did distinguish between the scripts. Future improvements could be made by attempting to more clearly distinguish the appraisal of stress-evoking imagery scenarios appraised as a challenge or threat.

Results from the study suggest possible avenues of future research. Other responses thought to discriminate between challenge and threat states includes TPR reduction due to SAM activity releasing epinephrine relaxing blood vessels during a challenge state, and the release of cortisol with unchanged or increased TPR due to increased PAC activity during a threat state (Jones et al., 2009). Future imagery research may expand the measurement of physical responses to include such measures to provide other objective indications of imagery content as well as how imagery scenarios are appraised. An additional next step would be to examine the effects of stress-evoking imagery on actual performance. When compared with a threat-appraised imagery scenario, our findings indicate that challenge-appraised imagery leads to more positive interpretations of responses and is considered more helpful toward an upcoming performance. Unknown is whether these interpretations will translate to a more successful performance. To our knowledge there is no direct evidence to demonstrate that challenge images can produce better performance. However, research suggests this might occur owing to the fact that imagery containing characteristics reflective of a challenge (e.g., facilitative perceptions of anxiety) can produce performance improvements. In conclusion, results from the current study indicate imagery to be effective in altering an athlete's appraisal of a stressful situation. By having athletes image a stressful scenario, we demonstrated that manipulating the meaning of stimulus and response propositions can alter an athlete's perception of a potentially stressful event, which may be harmful to psychological well-being and performance. A threat-appraised scenario produced debilitative interpretations, whereas a challenge appraisal led to facilitative interpretations of responses experienced. We identified stressful imagery, without reference to physical activity, to elicit increases in SV as well as HR, which supported assumptions of the TCTSA. However, indistinguishable differences in CO between a challenge and threat script opposes existing literature (Blascovich et al., 2004; Jones et al., 2009). Nevertheless, imagery can be used by athletes to alter their stress appraisal and produce more facilitative interpretations of responses resulting in more adaptive coping strategies.

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