



Citation for published version:

Sammy, N, Anstiss, P, Moore, L, Freeman, P, Wilson, M & Vine, S 2017, 'The effects of arousal reappraisal on stress responses, performance, and attention', *Anxiety Stress and Coping*, vol. 30, pp. 1-20.
<https://doi.org/10.1080/10615806.2017.1330952>

DOI:

[10.1080/10615806.2017.1330952](https://doi.org/10.1080/10615806.2017.1330952)

Publication date:

2017

Document Version

Peer reviewed version

[Link to publication](#)

University of Bath

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

Take down policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

1

2 **The Effects of Arousal Reappraisal on Stress Responses, Performance and Attention.**

3

4 Nadine Sammy¹, Paul A. Anstiss², Lee J. Moore³, Paul Freeman⁴, Mark R. Wilson¹ &
5 Samuel J. Vine¹.

6 **1. College of Life & Environmental Sciences, University of Exeter, UK.**

7 **2. School of Sport & Exercise Sciences, University of Kent, UK.**

8 **3. School of Sport & Exercise, University of Gloucestershire, UK.**

9 **4. School of Biological Sciences, University of Essex, UK.**

10

11 **Corresponding Author:** Samuel J Vine, College of Life and Environmental Sciences,
12 University of Exeter, St Luke's Campus, Exeter, Devon, UK, EX1 2LU. Tel: +44 1392
13 722891. Fax: +44 1392 724726. Email; s.j.vine@exeter.ac.uk.

14

15 **Running Title:** AROUSAL REAPPRAISAL AND ADAPTIVE STRESS RESPONSES

16

17 **Conflicts of Interest:** No conflicts of interest to declare.

18

19 **Word count: 4694**

20

21

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25

Abstract

Background and Objectives: This study examined the effects of arousal reappraisal on cardiovascular responses, demand and resource evaluations, self-confidence, performance and attention under pressurized conditions. A recent study by Moore et al. (2015) suggested that arousal reappraisal is beneficial to the promotion of challenge states and leads to improvements in single-trial performance. This study aimed to further the work of Moore and colleagues (2015) by examining the effects of arousal reappraisal on cardiovascular responses, demand and resource evaluations, self-confidence, performance and attention in a multi-trial pressurized performance situation. **Design and Methods:** Fifty-four university students were randomly assigned to either an arousal reappraisal intervention or control condition, and completed a pressurized dart throwing task. The intervention encouraged participants to view their physiological arousal as facilitative rather than debilitating to performance. Measures of cardiovascular reactivity, demand and resource evaluations, self-confidence, task performance and attention were recorded. **Results:** The reappraisal group displayed more favourable cardiovascular reactivity and reported higher resource evaluations and higher self-confidence than the control group but no task performance or attention effects were detected. **Conclusion:** These findings demonstrate the strength of arousal reappraisal in promoting adaptive stress responses, perceptions of resources and self-confidence.

Key words: challenge, threat, psychophysiology, cardiovascular, attention

1 **Introduction**

2 Individual responses to pressure situations vary considerably which, according to the
3 Biopsychosocial Model (BPSM; Blascovich, 2008) of challenge and threat, may be explained
4 by individuals' evaluations of their personal coping resources and the situational demands
5 (e.g. skills, uncertainty, psychological danger). The BPSM postulates that when individuals
6 are engaged in a task, as evidenced through an increased heart rate (Seery, 2011), and are
7 motivated to perform well, they enter into conscious, unconscious and dynamic demand and
8 resource evaluation processes. When task demands are deemed to outweigh personal coping
9 resources, a threat state occurs, whereas when coping resources are judged to match or
10 outweigh demands a challenge state occurs; these states do not act as two dichotomous
11 entities but are instead two ends of a bipolar spectrum (Blascovich, 2008).

12 A crucial component of the BPSM is that the demand and resource evaluation process
13 results in distinct neuroendocrine and cardiovascular responses. Catecholamines (adrenaline
14 and noradrenaline) are released in both challenge and threat states which results in an
15 increase in sympathetic-adrenomedullary (SAM) activation. This, in turn, causes increased
16 blood flow to the brain and muscles due to increased cardiac activity and vasodilation of
17 blood vessels. However, a threat state is proposed to also cause a release of cortisol, resulting
18 in pituitary-adrenocortical (HPA) activation, which causes a dampening of cardiac activation.
19 A challenge state in comparison to a threat state is therefore characterized by relatively higher
20 cardiac output (CO) and lower total peripheral resistance (TPR) (Blascovich & Tomaka,
21 1996). These indices suggest that challenge is characterized by more efficient mobilization
22 and transportation of energy as compared with threat (Scheepers, de Wit, Ellemers, &
23 Sassenberg, 2012).

24 The relationship between challenge and threat evaluations and the aforementioned
25 physiological markers has been demonstrated in past research (Seery, 2011). For instance,

AROUSAL REAPPRAISAL AND ADAPTIVE STRESS RESPONSES

1 challenge and threat evaluations were experimentally manipulated via instructional sets in the
2 first of a three part study by Tomaka and colleagues (1997). The physiological responses
3 described above were consistent with each state. Parts two and three of this research tested
4 whether challenge and threat evaluations would follow on from the distinct physiological
5 responses described above. As hypothesized, physiological manipulations did not result in the
6 corresponding cognitive evaluations (Tomaka, Blascovich, Kibler, & Ernst, 1997). This
7 reinforces that cognitive processes may result in physiological responses which underpins the
8 idea that changing such processes can thus influence physiological outcomes.

9 The BPSM further asserts that a challenge state is associated with improved
10 performance in comparison to a threat state (e.g. Moore, Vine, Wilson, & Freeman, 2012;
11 Vine, Freeman, Moore, Chandra-Ramanan, & Wilson, 2013). **However, challenge/threat and**
12 **closed skill task performance is still relatively under researched. This is surprising**
13 **considering the number of instances in which such skills are performed particularly in**
14 **competitive settings; they range from taking a basketball free throw to performing a tennis**
15 **serve. Not only did this research aim to illustrate the performance benefits of being**
16 **challenged but aimed to do so under pressure conditions. The mechanisms behind these**
17 **proposed performance benefits have yet to be fully identified however, it is hypothesized that**
18 **attentional control could be a key component (Blascovich, Seery, Mugridge, Norris, &**
19 **Weisbuch, 2004; Turner, Jones, Sheffield, & Cross, 2012; Vine et al., 2013). Vine et al.**
20 (2013) investigated the effects of challenge and threat states on attentional control in a novel
21 surgical task. Their findings showed that evaluating the task as a challenge, at both baseline
22 and pressurized stages, was associated with superior attentional control and improved
23 performance. Further support for challenge and threat states resulting in differential attention
24 control was demonstrated by Moore and colleagues (2012). They found that challenged
25 individuals reported more favourable attentional focus than threatened individuals as

AROUSAL REAPPRAISAL AND ADAPTIVE STRESS RESPONSES

1 evidenced by an increase in their quiet eye (QE) duration (Moore et al., 2012). The quiet eye
2 is the final fixation or tracking gaze that occurs prior to the final movement of a task and a
3 longer QE duration has been associated with higher levels of performance in numerous tasks
4 (Vickers, 2009). **Indeed, it is proposed to represent the time period in which critical visual**
5 **information is processed (Vickers, 2009).**

6 Limited research has explicitly tested interventions aimed at promoting challenge
7 from a state of threat **with even fewer examining such in high pressure sporting scenarios or**
8 **the mechanisms behind why they might work.** One promising line of research has indicated
9 that arousal reappraisal may be an effective intervention in promoting challenge states,
10 particularly in such pressure situations. The process of arousal reappraisal focuses on
11 reinterpreting bodily signals such as increased heart rate, ‘butterflies’ in the stomach, and
12 tense muscles as being facilitative rather than debilitating. This reappraisal has been
13 consistently linked to a more adaptive stress response, more favourable emotions, more
14 favourable interpretation of emotions, and superior task performance (Jamieson, Peters,
15 Greenwood, & Altose, 2016). An important factor in arousal reappraisal is that it promotes
16 the reconceptualization of stress as a coping mechanism (Jamieson et al., 2016). By
17 increasing perceptions of coping resources, individuals may experience elevations in their
18 situational self-confidence regarding performance. Increases in self-confidence may therefore
19 be a direct effect of arousal reappraisal as well as a possible mediating factor in the challenge
20 and performance relationship.

21 Additional support for arousal reappraisal comes from a recent study by Moore and
22 colleagues (2015) who investigated the effects of arousal reappraisal on pressurized golf
23 putting performance. They found that following a pressure manipulation, those who received
24 the reappraisal intervention reported more favourable cardiovascular responses, a more
25 favourable interpretation of physiological arousal and also performed better on a pressurized

1 single-trial golf putting task (Moore, Vine, Wilson, & Freeman, 2015). The abovementioned
2 is the only study so far to investigate an arousal reappraisal intervention as an aid to motor
3 performance. However, though the cardiovascular response equated to a medium effect size,
4 it was not statistically significant. Additionally, performance was assessed via only one putt
5 following the intervention limiting the generalizability of the performance finding among
6 other motor tasks that may require several trials in a row such as in darts and snooker. Recent
7 debate by authors about the replicability crisis in social psychology (e.g. Earp & Trafimow,
8 2015; Ioannidis, 2005; Loken & Gelman, 2017) highlights the importance of direct and
9 conceptual replication of studies in the discipline. It is therefore of importance to test the
10 robustness of current findings on arousal reappraisal interventions.

11 Furthermore possible underlying mechanisms such as self-confidence and attention
12 were not examined in Moore and colleagues' aforementioned research. Our study therefore
13 extends their research in a novel way by examining why arousal reappraisal may facilitate
14 and even enhance motor performance specifically under pressure conditions. Indeed, such
15 research is not only important in academia but in applied settings as well, particularly for
16 practitioners who may employ such interventions to enhance sporting performance. The
17 bolstering and extension of current theory not only affects the likelihood of use but the
18 delivery of such interventions as well.

19 *Aims and Hypotheses*

20 The aims of the present study were to examine the influence of arousal reappraisal on
21 challenge and threat states and pressurized motor performance as well as to identify the
22 potential mechanisms through which these states operate (self-confidence and attention). We
23 predicted that the intervention group would display cardiovascular measures more akin to a
24 challenge state and report more favourable resource evaluations and higher self-confidence as

1 compared with the control group. Further, the intervention group was predicted to outperform
2 and display longer QE durations than the control group on the pressurized task. Finally, to
3 explore if differences in self-confidence and quiet eye duration mediated any between-group
4 differences in performance, mediation analyses were conducted (Hayes, Preacher, & Myers,
5 2011).

6 **Methods**

7 *Participants*

8 Fifty-four undergraduate students (33 male, 21 female) with a mean age of 21.72
9 years (*SD* 3.31) agreed to take part in the study. A required sample size of 50 was calculated
10 using G*power 3.1 software, setting power ($1-\beta$ err prob.) at .8, alpha (α err prob.) at $p = .05$,
11 and using the effect size ($d = .46$) from Moore and colleagues (2015). All participants were
12 self-reported novice darts players, who had had no prior formal coaching or playing
13 experience. In addition, all participants were right handed, non-smokers, had normal or
14 corrected vision and had not performed vigorous exercise or ingested alcohol 24 hours before
15 testing.

16 *Measures*

17 *Arousal intensity and interpretation:* The Immediate Anxiety Measurement Scale
18 (IAMS; Thomas, Hanton, & Jones, 2002) was used to measure the intensity and direction of
19 somatic anxiety. After a definition was provided, participants completed two items on a 7
20 point Likert scale to assess intensity (1 = not at all, 7 = extremely) and again to assess
21 direction (-3 = a very negative effect on performance, +3 = a very positive effect on
22 performance).

23 *Cardiovascular:* A morphology-based impedance cardiology device (Physioflow,
24 PF05L1, Manatec Biomedical, Paris, France) was used to collect cardiovascular data during

AROUSAL REAPPRAISAL AND ADAPTIVE STRESS RESPONSES

1 the experiment while blood pressure measurements were taken using an automatic blood
2 pressure monitor (A&D Medical, UA-767PC, California, USA). Heart rate has been found to
3 be a strong indicator of task engagement and both CO and TPR have been found to be viable
4 indicators of challenge and threat states (Moore, Wilson, Vine, Coussens, & Freeman, 2013;
5 Seery, 2011). Unlike CO values, which were taken directly from the Physioflow, TPR values
6 were derived by using the formula: mean arterial pressure/CO * 80 (Sherwood, Dolan, &
7 Light, 1990). Mean arterial pressure was calculated using the formula [(2 * diastolic blood
8 pressure) + systolic blood pressure/3] (Cywinski & Tardieu, 1980). To differentiate challenge
9 and threat states, an index was created by converting each participant's CO and TPR
10 residualized change scores into *z* scores and summing them (as in Seery, 2009). Residualized
11 change scores were calculated in order to control for baseline values. TPR was assigned a
12 weight of -1 and CO a weight of +1, such that a larger value corresponded with greater
13 challenge (Moore et al., 2015).

14 *Demand and resource evaluations:* The cognitive appraisal ratio (Tomaka,
15 Blascovich, Kelsey, & Leitten, 1993) was used to assess demand and resource evaluations.
16 Participants answered two separate questions, “How demanding do you expect the upcoming
17 dart throwing task to be?” and “How able are you to deal with the demands of the dart
18 throwing task?” For each question, participants rated their responses on a 6 point Likert scale
19 (1 = not at all, 6 = extremely).

20 *Self-Confidence:* The IAMS (Thomas et al., 2002) was also used to measure the
21 intensity of self-confidence following the same procedure as the measurement of arousal
22 intensity.

23 *Performance (mean radial error):* Mean radial error (the average distance that the
24 dart finished from the bullseye in cm) was recorded as a measure of performance. **All throws**

AROUSAL REAPPRAISAL AND ADAPTIVE STRESS RESPONSES

1 were performed from the regulation distance (236cm) to the facing wall where the dartboard
2 was fixed at the regulation height (172cm). A dart which landed in the bullseye was given a
3 score of 0 cm. For any attempts that missed the dartboard, a maximum score of 22.5 cm (the
4 radius of the dartboard) was recorded.

5 *Attention:* An Applied Science Laboratories (ASL; Bedford, Massachusetts, USA)
6 mobile eye tracker was used to collect gaze data during the study. This particular make and
7 model of mobile eye tracker has previously been used in the challenge and threat literature
8 (Moore et al., 2013; Vine et al., 2013). The system utilizes two features: the pupil and corneal
9 reflection (determined by the reflection of an infrared light source from the surface of the
10 cornea) to calculate a point of gaze (at 30 Hz) relative to the eye and scene cameras. A
11 circular cursor, representing 1° of visual angle with a 4.5 – mm lens, indicating the location of
12 gaze in a video image of the scene, was viewed by the co-experimenter in real time on a
13 laptop screen.

14 The *quiet eye duration* (QE) was operationally defined as the final fixation on the
15 dartboard's bullseye prior to the initiation of elbow extension (Vickers, Rodrigues, &
16 Edworthy, 2000). Quiet eye onset occurred before this extension and quiet eye offset
17 occurred when the gaze deviated off the bullseye by 1° or more for longer than 100ms. Each
18 dart thrown was analyzed using Quiet Eye Solutions software (www.QuietEyeSolutions.com)
19 which allows frame-by-frame analysis to occur. Unfortunately, due to calibration issues
20 (related to inadequate recording speed of the motor camera), gaze data could only be
21 collected for 26 participants (intervention = 13, control = 13).

22 ***Procedure***

23 The method was approved by the university ethics committee, and written informed
24 consent was obtained from each participant prior to testing. Participants were randomly

AROUSAL REAPPRAISAL AND ADAPTIVE STRESS RESPONSES

1 assigned to either a control ($n=26$) or arousal reappraisal intervention ($n=28$) group prior to
2 entering the laboratory using an online research randomizer tool
3 (<https://www.randomizer.org>). Height, weight and blood pressure measurements were
4 recorded, after which participants were instrumented to the non-invasive cardiovascular and
5 eye tracking devices. Following another blood pressure measurement, participants performed
6 six baseline dart throws during which gaze measurements were recorded. Upon completion,
7 cardiovascular data was measured in one minute intervals during a five minute baseline
8 period (five minutes has been extensively used as a measure of true baseline in previous
9 challenge/threat research with the last minute of baseline used for reactivity calculations e.g.,
10 Blascovich et al., 2004; Turner, Jones, Sheffield, Slater, Barker, & Bell, 2013).
11 Cardiovascular data were measured while participants were seated in an upright position.
12 Measurements were not taken during the task due to possible movement artefacts
13 (Siebenmann, Rasmussen, Sorensen, Zaar, Hvidtfeldt, Pichon, Secher, & Lundby, 2015).
14 Blood pressure measurements were taken alongside self-report measures at each stage of
15 cardiovascular recordings. Following baseline recording, all participants received a pressure
16 manipulation followed by one minute of cardiovascular recording and self-report
17 measurements (arousal intensity and direction, demands and resources). The arousal
18 reappraisal group then received the reappraisal intervention while the control group
19 completed a non-demanding task designed to match for time. Another minute of
20 cardiovascular recordings and self-report measurements (arousal intensity and direction,
21 demands, resources and self-confidence) were taken followed by six pressurized dart throws
22 during which gaze measurements were also recorded. Following completion, all equipment
23 was removed and participants were thanked and debriefed about the study.

24 *Pressure Manipulation and Reappraisal Instructions*

AROUSAL REAPPRAISAL AND ADAPTIVE STRESS RESPONSES

1 All participants received the pressure manipulation following their baseline set of dart
2 throws. This manipulation was previously used by Moore et al. (2015) and was largely
3 adapted from the manipulations used by Moore et al. (2012). To ensure an increase in
4 pressure and task engagement, all participants were advised about the importance of the
5 experiment; that they were going to be compared against other individuals (through an online
6 leader board); that the top performers would be awarded prizes; and that very poor
7 performers would be interviewed about their performance. Participants were also instructed
8 that, following their previous six throws, they were in the bottom thirty percent of those
9 tested so far, and that if they were to perform the same way again, their data would not be
10 useable.

11 The control task consisted of reading a non-threatening nature article about birds
12 which was matched for time with the delivery of the reappraisal instructions. Participants
13 were informed that they would not be tested about the article. The reappraisal instructions
14 were the same as those used in Moore et al. (2015), adapted from previous studies
15 investigating arousal reappraisal (Jamieson, Mendes, Blackstock, & Schmader, 2010;
16 Jamieson, Mendes, & Nock, 2012) and are as follows:

17 “In stressful situations, like sporting competition, our bodies react in very specific
18 ways. The increase in arousal you may feel during stressful situations is not harmful.
19 In fact, recent research has shown that this response to stress can be beneficial and aid
20 performance in stressful situations. Indeed, this response evolved because it helped
21 our ancestors survive by delivering oxygen to where it was needed in the body to help
22 address stressors. Therefore, before and during the upcoming dart throwing task, we
23 encourage you to reinterpret your bodily signals and any increases in arousal as
24 beneficial and remind yourself that they could be helping you perform well.”

25 ***Statistical Analysis***

1 In order to check for task engagement, a dependent *t*-test was used to compare
2 heart rate reactivity at baseline and post-pressure manipulation, and show that across both
3 groups task engagement was present (Blascovich, 2008). To examine the effects of the
4 intervention, a 2 (time: post-pressure manipulation, post-intervention/control) x 2 (group:
5 control, intervention) mixed ANOVA was conducted with the challenge and threat index
6 (CTI) as the dependent variable. A further two 2 (time: baseline, pressurized) x 2 (group:
7 control, intervention) mixed ANOVAs were conducted with mean radial error and QE
8 duration as the dependent variables. A MANOVA was conducted on the self-report data:
9 arousal intensity, arousal interpretation, demands, resources and self-confidence. Effect sizes
10 were calculated using partial eta squared (η_p^2). Finally, to determine if differences in self-
11 confidence and QE duration mediated any between-group differences in performance,
12 mediation analyses were performed using the PROCESS add-on for SPSS (version 2.16)
13 (Hayes, 2013). **Recent developments in statistical analyses software, like PROCESS for**
14 **example, have allowed for the implementation of inferential tests of indirect effects of *X***
15 **(group) on *Y* (performance) without making unnecessary assumptions about the shape of its**
16 **sampling distribution (Hayes, 2013). Furthermore, this add-on allows for the testing of**
17 **indirect effects regardless of the significance for the individual paths in the mediation model**
18 **(Hayes, 2013).**

19 **Results**

20 ***Cardiovascular Responses***

21 The dependent *t*-test showed that both groups' heart rates significantly increased from
22 baseline, $t(51) = 6.04$, $p < .001$, $d = 1.18$, confirming task engagement and permitting the
23 subsequent investigation of challenge and threat states. The ANOVA on the CTI¹ data

¹ CO means for the control and intervention groups were $M=0.25$, $SD = 0.39$ and $M=0.14$, $SD = 0.44$ respectively while TPR was $M=-94.17$, $SD=119.88$ and $M=-33.5$, $SD=160.36$ respectively. Following the

AROUSAL REAPPRAISAL AND ADAPTIVE STRESS RESPONSES

1 revealed no significant effect for Time, $F(1,43) = .00, p = .98, \eta_p^2 = .00$, and no significant
2 effect for Group, $F(1,43) = .18, p = .66, \eta_p^2 = .00$. However, a significant interaction between
3 group and time was found, $F(1,43) = 5.63, p = .02, \eta_p^2 = .11$. Post hoc t -tests with a
4 Bonferroni correction to the alpha revealed that there was no significant difference between
5 groups following the pressure manipulation, $t(46) = 1.92, p = .06, d = 0.53$ but there was a
6 significant difference between groups following the intervention/control task, $t(44) = -3.08, p$
7 $< .025, d = 0.90$ with the intervention group displaying a significantly higher CTI than the
8 control group (see Table 1).

9 ***Self-report Data***

10 The multivariate result was significant for group, Wilks' Lambda = .78, $F(5, 48) =$
11 $2.72, p = .03, \eta_p^2 = .22$ indicating a difference in self-report data by group following the
12 intervention. The univariate F tests showed there was a significant difference between the
13 intervention and control groups for resource evaluations, $F(1,52) = 8.71, p = .01, \eta_p^2 = .14$ and
14 self-confidence, $F(1, 52) = 7.43, p = .01, \eta_p^2 = .13$ with the intervention group reporting both
15 higher resources and self-confidence than the control group (see Table 1).

16 [Table 1 near here]

17 ***Performance – Mean Radial Error***

18 The ANOVA revealed that there was a significant main effect for Time, $F(1,48) =$
19 $12.21, p = .001, \eta_p^2 = .20$, with participants performing better at the pressurized time point
20 (see Table 1.). There was also a significant main effect for Group, $F(1,48) = 5.02, p = .03, \eta_p^2$

intervention/control task, CO means for the control and intervention groups were $M = -0.45, SD = 0.98$ and
 $M = 0.01, SD = 0.66$ respectively while TPR was $M = 87.07, SD = 118.7$ and $M = 1.16, SD = 272.18$ in that order.

AROUSAL REAPPRAISAL AND ADAPTIVE STRESS RESPONSES

1 = .95, with the intervention group participants performing better at both time points.
2 However, there was no significant interaction effect, $F(1,48) = .12, p = .72, \eta_p^2 = .00$.

3 *Quiet Eye Duration*

4 The ANOVA, revealed that there was no significant effect for Time, $F(1,22) = 2.15, p$
5 $= .16, \eta_p^2 = .09$. There was also no significant effect for Group, $F(1,22) = 1.82, p = .19, \eta_p^2 =$
6 $.08$ and no significant interaction effect either, $F(1,22) = .002, p = .96, \eta_p^2 = .00$.

7 *Mediation*

8 A significant total effect of X (group) on Y (performance) is not a prerequisite for
9 examining the significance of indirect effects (Preacher & Hayes, 2004) permitting the testing
10 of such. In other words, the significance of the total effect of group on performance is not
11 pertinent to whether the indirect effect is significant. Therefore, to test if the effect of group
12 on performance was indirectly affected by any of the process variables, experimental group
13 (coded challenge = 1, threat = 0) was entered as the independent variable, mean radial error
14 was entered as the dependent variable, self-confidence and quiet eye duration were entered
15 separately. Based on a 10,000 sampling rate, the results from bootstrapping revealed no
16 significant indirect effects for self-confidence 95% CI = -3.44 to 0.65 or quiet eye duration,
17 95% CI = -5.34 to 0.71 (see Table 2).

18 [Table 2 near here]

19 **Discussion**

20 Facilitative stress responses, such as challenge states, have been consistently linked
21 with a number of positive physiological, psychological and performance outcomes
22 (Blascovich, 2008). Interventions which help to promote such responses are therefore highly

AROUSAL REAPPRAISAL AND ADAPTIVE STRESS RESPONSES

1 beneficial to performers across a range of situations and tasks. One such intervention which
2 has previously received support, arousal reappraisal, was investigated here. The current study
3 aimed to add to the robustness of previous findings which have supported the effectiveness of
4 this intervention (e.g. Moore et al., 2015). Further, this research is novel in its investigation of
5 why arousal reappraisal might positively influence performance through the examination of
6 potential underlying mechanisms namely, self-confidence and attention. Compared to a
7 control group, the arousal reappraisal group displayed cardiovascular markers indicative of a
8 challenge state and reported more favourable resource evaluations as well as higher self-
9 confidence. There were no effects of the intervention on performance or attention.
10 Furthermore, neither self-confidence nor attention mediated the group and performance
11 relationship.

12 Following the intervention, the arousal reappraisal group was significantly more
13 challenged than the control group. The arousal reappraisal intervention therefore resulted in a
14 more efficient and adaptive cardiovascular response for this group. Arousal reappraisal is
15 proposed to break the link between negative affective experiences and malignant
16 physiological responses by reframing the meaning of the physiological signals that
17 accompany stress (Jamieson et al., 2012). Interestingly, there were no differences between
18 groups in the interpretation of arousal following the intervention/control task. However,
19 resource evaluations were significantly higher for the intervention group than the control
20 group suggesting that arousal reappraisal's effectiveness in promoting challenge may be via
21 its positive consequences on coping. Indeed, research recent on arousal reappraisal in
22 educational settings has supported this conclusion (Jamieson et al., 2016).

23 The intervention group also reported higher self-confidence as compared with the
24 control group. This increase in self-confidence is in line with the predictions of the Theory of
25 Challenge and Threat states in Athletes (TCTSA; Jones, Meijen, McCarthy, & Sheffield,

AROUSAL REAPPRAISAL AND ADAPTIVE STRESS RESPONSES

1 2009) which suggests that self-efficacy, state self-confidence, is a critical determinant of
2 challenge and threat.

3 The arousal reappraisal intervention did not improve performance, above that
4 achieved by the control group. Indeed, both groups performed better during the pressurized
5 trials. According to the Attentional Control Theory (ACT; Eysenck, Derakshan, Santos, &
6 Calvo, 2007), anxiety may not impair quality of performance when it leads to the use of
7 compensatory strategies. Such strategies may range from increased effort to the increased use
8 of processing resources (Eysenck, et al., 2007). Therefore, both groups may have utilized
9 compensatory strategies in order to prevent performance decrements in the pressurized
10 performance situation. On the other hand, it may be that other factors, such as perceptions of
11 control and achievement goals, are more instrumental in the challenge/threat and athletic
12 performance relationship (as suggested in the TCTSA; Jones et al., 2009). Indeed, modifying
13 the pressure manipulation in order to manipulate goal orientations may yield differential
14 performance outcomes in future research. Additional future research should examine possible
15 compensatory strategies, employ another type of motor task or utilize different measurement
16 outcomes.

17 The ANOVA on QE duration revealed no significant effects for time, group or an
18 interaction. Though QE duration has been previously shown to be a gaze measure affected by
19 high levels of performance pressure and anxiety (e.g. Behan & Wilson, 2008; Wilson, Wood,
20 & Vine, 2009), it is probable that it is not a sensitive enough measure of attention in novices.
21 Standard deviations of QE durations were high in both groups indicating high variability
22 amongst participant measures across groups. **Furthermore, on a methodological note, post-**
23 **hoc power analyses indicated that the study was underpowered ($1-\beta$ err prob. = 0.3) to find**
24 **quiet eye effects meaning there is scope for future research to re-examine this avenue with a**
25 **larger sample.**

AROUSAL REAPPRAISAL AND ADAPTIVE STRESS RESPONSES

1 Mediation analyses revealed that neither levels of self-confidence nor QE duration
2 mediated the relationship between challenge/threat and performance. Therefore, while self-
3 confidence may be an antecedent of challenge and threat, it may not result in performance
4 consequences. While similar conclusions may also be made for QE duration, discounting
5 attention as an underlying mechanism of challenge/threat and performance would be ill-
6 advised. Utilizing a differential on-line attentional measure **such as target locking (e.g. Vine**
7 **et al., 2013)** may provide better evidence for these relationships.

8 The current study has several theoretical and practical implications. The reappraisal
9 intervention was successful in leading to more efficient cardiovascular adaptations. As
10 aforementioned, the proposed theoretical view that arousal reappraisal influences stress
11 responses via reframing physiological arousal may not fully explain this relationship. It may
12 however, be explained via an increase in the perception of an individual's coping resources
13 among other factors. This leaves scope for future research to assess possible moderators such
14 as social support; **validation for such has recently come from work by Slater and colleagues**
15 **(2016) who highlighted the importance of social support in promoting a positive reappraisal**
16 **of stress. The authors proposed that psychological factors such as social identity and social**
17 **support may enhance resource appraisals and/or reduce demand appraisals thereby increasing**
18 **the chances of evaluating stressful situations as challenge states rather than threat states**
19 **(Slater, Evans, & Turner, 2016).** From a practical viewpoint, our findings suggest that
20 arousal reappraisal could act as a low-resource intervention to help promote challenge states.
21 Arousal reappraisal can be incorporated into performer-focused cognitive behavioural
22 therapy to promote adaptive stress responses (Baron, Baron, & Foley, 2009). Finally, as the
23 cardiovascular responses associated with recurrent threat evaluations may be adverse to
24 health (Blascovich, 2008), arousal reappraisal may be a protective factor via its role in
25 promoting challenge.

AROUSAL REAPPRAISAL AND ADAPTIVE STRESS RESPONSES

1 Limitations of the current study include the lack of measures of compensatory
2 strategies which would have allowed for a better understanding of challenge/threat and
3 performance. Furthermore, additional measures of attention should have been recorded and
4 analyzed in order to more systematically assess whether attention is an underlying
5 mechanism of the challenge/threat-performance relationship.

6 To conclude, the current study demonstrated the benefits of arousal reappraisal in
7 leading to more facilitative cardiovascular responses, perceptions of resources and self-
8 confidence. Findings support the notion that arousal reappraisal is effective in promoting a
9 more adaptive stress response in pressurized motor performance situations. Future research
10 should examine the intricacies of how arousal reappraisal leads to challenge/threat and how
11 this subsequently affects motor-task performance in pressurized situations.

12 **References**

13 Baron, D. A., Baron, S. H., & Foley, T. (2009). Cognitive and behavioral therapy in
14 depressed athletes. *Advances In Psychiatry, 3*, 61-75.

15 Behan, M., & Wilson, M. (2008). State anxiety and visual attention: The role of the quiet
16 eye period in aiming to a far target. *Journal of Sports Sciences, 26*, 207-215. doi:
17 10.1080/02640410701446919.

18 Blascovich, J. (2008). Challenge, threat, and health. In J.Y. Shah & W.L. Gardner (eds.),
19 *Handbook of Motivation Science* (pp. 481-493). New York, NY: Guildford.

20 Blascovich, J., Seery, M. D., Mugridge, C. A., Norris, R. K., & Weisbuch, M. (2004).
21 Predicting athletic performance from cardiovascular indexes of challenge and threat.

22 *Journal of Experimental Social Psychology, 40*, 683-688. doi:10.1016/j.jesp.2003.10.007.

AROUSAL REAPPRAISAL AND ADAPTIVE STRESS RESPONSES

- 1 Blascovich, J., & Tomaka, J. (1996). The biopsychosocial model of arousal regulation.
2 *Advances in Experimental Social Psychology*, 28, 1-52.
- 3 Cywinski, J., & Tardieu, B. (1980). *The essentials in pressure monitoring: Blood and*
4 *other body fluids*: Martinus Nijhoff Medical Division.
- 5 Earp, B.D., & Trafimow, D. (2015). Replication, falsification, and the crisis of confidence
6 in social psychology. *Frontiers in Psychology*, 6, 1-11. doi: 10.3389/fpsyg.2015.00621.
- 7 Eysenck, M. W., Derakshan, N., Santos, R., & Calvo, M. G. (2007). Anxiety and
8 cognitive performance: attentional control theory. *Emotion*, 7, 336-353. doi:
9 10.1037/1528-3542.7.2.336.
- 10 Hayes, A.F. (2013). *Introduction to mediation, moderation, and conditional process*
11 *analysis: A regression-based approach*. New York, NY: The Guildford Press.
- 12 Hayes, A. F., Preacher, K. J., & Myers, T. A. (2011). Mediation and the estimation of
13 indirect effects in political communication research. *Sourcebook for Political*
14 *Communication Research: Methods, Measures, and Analytical Techniques*, 23, 434-465.
- 15 Ioannidis, J.P.A. (2005). Why Most Published Research Findings Are False. *PLOS*
16 *Medicine*, 2, e0696-e0701. doi: 10.1371/journal.pmed.0020124.
- 17 Jamieson, J. P., Mendes, W. B., Blackstock, E., & Schmader, T. (2010). Turning the
18 knots in your stomach into bows: Reappraising arousal improves performance on the
19 GRE. *Journal of Experimental Social Psychology*, 46, 208-212. doi:
20 10.1016/j.jesp.2009.08.015.

AROUSAL REAPPRAISAL AND ADAPTIVE STRESS RESPONSES

- 1 Jamieson, J. P., Mendes, W. B., & Nock, M. K. (2012). Improving acute stress responses:
2 The power of reappraisal. *Current Directions in Psychological Science*, *22*, 51-56.
3 doi: 10.1177/0963721412461500.
- 4 Jamieson, J. P., Peters, B. J., Greenwood, E. J., & Altose, A. J. (2016). Reappraising
5 stress arousal improves performance and reduces evaluation anxiety in classroom exam
6 situations. *Social Psychological and Personality Science*, *7*, 1-9. doi:
7 10.1177/1948550616644656.
- 8 Jones, M., Meijen, C., McCarthy, P. J., & Sheffield, D. (2009). A theory of challenge and
9 threat states in athletes. *International Review of Sport and Exercise Psychology*, *2*, 161-
10 180. doi: 10.1080/17509840902829331.
- 11 **Loken, E., & Gelman, A. (2017). Measurement error and the replication crisis. *Science*,**
12 **355, 584-585. doi: 10.1126/science.aal3618.**
- 13 Moore, L. J., Vine, S. J., Wilson, M. R., & Freeman, P. (2012). The effect of challenge
14 and threat states on performance: An examination of potential mechanisms.
15 *Psychophysiology*, *49*, 1417-1425. doi: 10.1111/j.1469-8986.2012.01449.x.
- 16 Moore, L. J., Vine, S. J., Wilson, M. R., & Freeman, P. (2015). Reappraising threat: how
17 to optimize performance under pressure. *Journal of Sport and Exercise Psychology*, *37*,
18 339-343. doi: 10.1123/jsep.2014-0186.
- 19 Moore, L. J., Wilson, M. R., Vine, S. J., Coussens, A. H., & Freeman, P. (2013). Champ
20 or chump? Challenge and threat states during pressurized competition. *Journal of Sport &*
21 *Exercise Psychology*, *35*, 551-562.

AROUSAL REAPPRAISAL AND ADAPTIVE STRESS RESPONSES

- 1 Neil, R., Hanton, S., Mellalieu, S. D., & Fletcher, D. (2011). Competition stress and
2 emotions in sport performers: The role of further appraisals. *Psychology of Sport and*
3 *Exercise, 12*, 460-470. doi:10.1016/j.psychsport.2011.02.001.
- 4 Preacher, K.J., & Hayes, A.F. (2004). SPSS and SAS procedures for estimating indirect
5 effects in simple mediation models. *Behavior Research Methods, Instruments and*
6 *Computers, 36*, 717-731. doi: 10.3758/BF03206553.
- 7 Scheepers, D., de Wit, F., Ellemers, N., & Sassenberg, K. (2012). Social power makes the
8 heart work more efficiently: Evidence from cardiovascular markers of challenge and
9 threat. *Journal of Experimental Social Psychology, 48*, 371-374.
10 doi:10.1016/j.jesp.2011.06.014.
- 11 Seery, M.D., Weisbuch, M., & Blascovich, J. (2009). Something to gain, something to
12 lose: The cardiovascular consequences of outcome framing. *International Journal of*
13 *Psychophysiology, 73*, 308-312. doi:10.1016/j.ijpsycho.2009.05.006.
- 14 Seery, M. D. (2011). Challenge or threat? Cardiovascular indexes of resilience and
15 vulnerability to potential stress in humans. *Neuroscience & Biobehavioral Reviews, 35*,
16 1603-1610. doi:10.1016/j.neubiorev.2011.03.003.
- 17 Sherwood, A., Dolan, C. A., & Light, K. C. (1990). Hemodynamics of blood pressure
18 responses during active and passive coping. *Psychophysiology, 27*, 656-668. doi:
19 10.1111/j.1469-8986.1990.tb03189.x.
- 20 Siebenmann, C., Rasmussen, P., Sørensen, H., Zaar, M., Hvidtfeldt, M., Pichon, A.,
21 Secher, N.H., & Lundby, C. (2015). Cardiac output during exercise: A comparison of four
22 methods. *Scandinavian Journal of Medicine and Science in Sports, 25*, e20-e27.
23 doi:10.1111/sms.12201.

AROUSAL REAPPRAISAL AND ADAPTIVE STRESS RESPONSES

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

4 Slater, M.J., Evans, A.L., & Turner, M.J. (2016). Implementing a social identity approach
5 for effective change management. *Journal of Change Management*, *16*, 18-37. doi:
6 dx.doi.org/10.1080/14697017.2015.1103774.

7 Thomas, O., Hanton, S., & Jones, G. (2002). An alternative approach to short-form self-
8 report assessment of competitive anxiety: a research note. *International Journal of Sport*
9 *Psychology*, *33*, 325-336.

10 Tomaka, J., Blascovich, J., Kelsey, R. M., & Leitten, C. L. (1993). Subjective,
11 physiological, and behavioral effects of threat and challenge appraisal. *Journal of*
12 *Personality and Social Psychology*, *65*, 248-260.

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

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

19 Turner, M., Jones, M., Sheffield, D., Slater, M., Barker, J., & Bell, J. (2013). Who thrives
20 under pressure? Predicting the performance of elite academy cricketers using the
21 cardiovascular indicators of challenge and threat states. *Journal of Sport and Exercise*
22 *Psychology*, *35*, 387-397.

AROUSAL REAPPRAISAL AND ADAPTIVE STRESS RESPONSES

1 Vickers, J.N. (2009). Advances in coupling perception and action: the quiet eye as a
2 bidirectional link between gaze, attention, and action. *Progress in Brain Research, 174*,
3 279-288. doi: 10.1016/S0079-6123(09)01322-3.

4 Vickers, J.N., Rodrigues, S.T., & Edworthy, G. (2000). Quiet eye and accuracy in the dart
5 throw. *International Journal of Sports Vision, 6*, 30-36.

6 Vine, S. J., Freeman, P., Moore, L. J., Chandra-Ramanan, R., & Wilson, M. R. (2013).
7 Evaluating stress as a challenge is associated with superior attentional control and motor
8 skill performance: testing the predictions of the biopsychosocial model of challenge and
9 threat. *Journal of Experimental Psychology: Applied, 19*, 185-194.

10 Wilson, M. R., Wood, G., & Vine, S. J. (2009). Anxiety, attentional control, and
11 performance impairment in penalty kicks. *Journal of Sport & Exercise Psychology, 31*,
12 152-168.

13

14

15

16

17

18

19

20

21

AROUSAL REAPPRAISAL AND ADAPTIVE STRESS RESPONSES

1 **Table 1:** Means and standard deviations of demands, resources, self-confidence,
 2 cardiovascular reactivity, performance and QE data for control and intervention groups.

	Control		Intervention	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Demand Evaluation	2.88	1.28	2.64	1.16
Resource Evaluation	3.92	1.02	4.68*	0.86
Self-confidence	3.23	1.45	4.21*	1.2
Post-Pressure Manipulation Challenge and Threat Index	0.44	1.63	-0.43	1.50
Post-Intervention/Control Challenge and Threat Index	-0.26	0.98	0.61**	0.91
Baseline Mean Performance (cm)	11.05	2.84	9.29	3.28
Pressurized Mean Performance (cm)	9.80	3.68	7.65	2.82
Baseline QE Duration (ms)	392.03	241.78	540.68	324.32
Pressurized QE Duration (ms)	638.52	511.57	687.75	350.33

3 *Note.* Significantly different from control group * $p < .05$; significantly different from control
 4 group ** $p < .01$

5
6
7
8
9
10
11
12
13
14
15
16

AROUSAL REAPPRAISAL AND ADAPTIVE STRESS RESPONSES

- 1 **Table 2:** Mediation Results for Self-Confidence and Quiet Eye Duration.

	Effect	SE	LL95% CI	UL 95% CI
Self-Confidence	-1.39	1.02	-3.44	0.65
Quiet Eye Duration	-2.31	1.46	-5.34	0.71

- 2 *Note.* LL: lower limit; CI: confidence interval; UL: upper limit.