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Abstract

Competitive situations often hinge on one pressurized moment. In these situations, individuals' psychophysiological states determine performance, with a challenge state associated with better performance than a threat state. But what can be done if an individual experiences a threat state? This study examined one potential solution: arousal reappraisal. Fifty participants received either arousal reappraisal or control instructions before performing a pressurized, single-trial, motor task. While both groups initially displayed cardiovascular responses consistent with a threat state, the reappraisal group displayed a cardiovascular response more reflective of a challenge state (relatively higher cardiac output and/or lower total peripheral resistance) after the reappraisal manipulation. Furthermore, despite performing similarly at baseline, the reappraisal group outperformed the control group during the pressurized task. The results demonstrate that encouraging individuals to interpret heightened physiological arousal as a tool that can help maximize performance can result in more adaptive cardiovascular responses and motor performance under pressure.

Keywords: Cardiovascular reactivity, arousal reappraisal, challenge/threat states, motor performance, pressure

Reappraising threat: How to optimize performance under pressure

Competitive situations often hinge on a single pressurized moment, from responding to the first question in a job interview to performing the final putt to win a golf tournament. According to the biopsychosocial model of challenge and threat (Blascovich, 2008), individuals' performances in these crucial moments are determined by their psychophysiological response to the stressor. Individuals who exhibit a challenge state (indexed by increased heart rate and cardiac output, and decreased total peripheral resistance) outperform individuals who display a threat state (marked by increased heart rate, and no or small fluctuations in cardiac output and total peripheral resistance; Seery, 2011). Compared to a threat state, a challenge state is also associated with more adaptive cognitive (favorable demand/resource evaluations), affective (less negative emotions), and behavioral (approach-related behavior) outcomes (Blascovich, 2008). While empirical evidence supporting these assertions is gathering (e.g., Moore, Wilson, Vine, Coussens, & Freeman, 2013), limited research has identified interventions that help individuals overcome a threat state and perform more optimally. This is surprising given that challenge and threat states can be manipulated before meaningful tasks using verbal instructions (e.g., Moore, Vine, Wilson, & Freeman, 2014).

One strategy that might help individuals tackle a threat state is arousal reappraisal, which encourages individuals to view pressure-induced elevations in physiological arousal (e.g., racing heart) as a tool that can aid performance (Jamieson, Mendes, & Nock, 2013a). This strategy emanates from theories such as Schachter's two-factor theory of emotion (see Cotton, 1981 for a review), and is similar to the notion of re-interpreting competitive anxiety symptoms (Jones, 1995). However, arousal reappraisal is distinct from cognitive reappraisal, which stems from emotion-regulation models and typically involves altering individuals' emotional responses by reframing the way a pressurized situation is construed (Gross, 2002).

Recently, arousal reappraisal has been shown to stimulate a challenge state and better mathematical performance (Jamieson, Mendes, Blackstock, & Schmader, 2010; Jamieson, Nock, & Mendes, 2012; Jamieson, Nock, & Mendes, 2013b). By promoting a challenge state, arousal reappraisal is predicted to increase sympathetic-adrenomedullary activation and oxygenated blood flow to the brain and muscles, thereby improving performance (Jamieson et al., 2013a). To date, no studies have investigated if arousal reappraisal can help individuals escape a threat state and benefit the performance of motor skills under pressure. The present study, therefore, examined if an arousal reappraisal manipulation positively influenced cardiovascular responses and performance during a pressurized, single-trial, motor task.

Method

Participants

Fifty participants (28 males, 22 females; $M_{\text{age}} = 20.24$ years, $SD = 4.27$) with no prior golf putting experience were recruited to take part in the study that received institutional ethical approval. All participants provided written informed consent before participation.

Measures

Cardiovascular. A non-invasive impedance cardiograph device (PF05L1, Manatec Biomedical, Paris, France) estimated heart rate, cardiac output, and total peripheral resistance. Following procedures described previously (Moore, Vine, Wilson, & Freeman, 2012), cardiovascular data was recorded during baseline (5 minutes), post-pressure instruction (1 minute), and post-reappraisal/control instruction (1 minute) periods. Reactivity, the difference between the final minute of baseline and either the minute post-pressure instruction or the minute post-reappraisal/control instruction, was examined for all cardiovascular variables. Heart rate reactivity (difference between baseline and post-pressure instruction) was used to assess if participants were actively engaged in the pressurized task (a pre-requisite for challenge and threat states; Seery, 2011). Furthermore, cardiac output

reactivity and total peripheral resistance reactivity were used to assess challenge and threat states after the pressure instructions (difference between baseline and post-pressure instruction) and following the reappraisal/control instruction (difference between baseline and post-reappraisal/control instruction). Both heart rate and cardiac output were estimated directly by the Physioflow, whereas total peripheral resistance was calculated (see Moore et al., 2012).

Arousal Interpretation. Interpretations of physiological arousal were assessed using the somatic anxiety direction item of the immediate anxiety measurement scale (IAMS; Thomas, Hanton, & Jones, 2002). After receiving a definition of somatic anxiety, participants responded to the question ‘What effect do you think somatic anxiety will have on your performance of the upcoming task?’ on a 7-point Likert scale anchored between *very negative* (-3) and *very positive* (+3).¹

Performance. Task performance was recorded during the baseline and pressurized golf putts in terms of radial error: the distance the ball finished from the hole in centimeters (as Moore et al., 2012; 2013). A mean value from each condition was calculated.

Procedure

After arriving at the laboratory, participants were randomly assigned to a reappraisal or control group. The participants were then fitted with the impedance cardiograph device and performed six baseline golf putts from a distance of six feet (1.83 m) to a regulation hole (diameter = 10.8 cm) on a flat artificial putting green (length = 6 m, width = 2.5 m, Stimpmeter reading = 3.28 m). Next, five minutes of baseline cardiovascular data were recorded while participants sat still and quietly. Participants then received instructions about the pressurized task (see pressure manipulation instructions below). These instructions took

¹ Somatic anxiety intensity was also assessed with an IAMS item that asked, ‘To what extent are you experiencing somatic anxiety right now?’ on a 7-point scale anchored between *not at all* (1) and *extremely* (7).

60 seconds to deliver and no cardiovascular data were recorded during this time. Next, one minute of cardiovascular data were recorded while participants sat quietly and reflected on these instructions. The reappraisal group were then given the reappraisal manipulation and the control group received instructions about the non-demanding cognitive task (see arousal reappraisal manipulation instructions below). These instructions also took 60 seconds to deliver and no cardiovascular data were recorded during this time. Next, one minute of cardiovascular data were recorded while participants sat still and either reflected on the instructions (reappraisal), or silently performed the cognitive task (control). Subsequently, after completing the arousal interpretation measure, all participants performed the pressurized task, which consisted of a single golf putt. Finally, participants were debriefed, had the impedance cardiograph device removed, and thanked for their participation.

Pressure Manipulation Instructions

To elevate pressure, participants received instructions emphasizing the comparative and evaluative nature of the task (Baumeister & Showers, 1986). Participants were informed that their performance would be entered into a competition, with the top five performers awarded prizes and the worst five performers being interviewed. Participants were also told that their performance would be published on a leaderboard and video footage of their performance may be used in future presentations to peers. Finally, non-contingent feedback was used, whereby participants were told that their performance in the baseline putts positioned them in the bottom 30% compared to those who had already taken part. They were instructed to improve their performance or their data could not be used in the study.

Arousal Reappraisal Manipulation Instructions

The reappraisal group received instructions adapted from previous research that encouraged any elevations in arousal to be viewed as beneficial for performance (Jamieson et al., 2013b). Specifically, participants were told,

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

In contrast, the control group received neutral instructions that informed the participants about a non-demanding cognitive task in which they had to think about capital cities for one minute. Participants were informed that their performance on this task would not be evaluated. These instructions and the subsequent cognitive task were employed in order to control for experimenter contact, and time engaged in a cognitive task; important considerations arising from previous arousal reappraisal research (Jamieson et al., 2013b).

Statistical Analyses

Unfortunately, due to equipment problems, cardiovascular data from eight participants (4 reappraisal and 4 control) could not be analyzed. A dependent *t*-test on the heart rate reactivity data was used to assess task engagement and to establish that, in the sample as a whole, heart rate increased significantly from baseline following the pressure instructions (i.e., heart rate reactivity greater than zero; as Moore et al., 2012). To differentiate challenge and threat states after the pressure and reappraisal/control instructions, indexes were computed by converting each participant's cardiac output and total peripheral resistance residualized change scores into *z*-scores and summing them. Cardiac output was assigned a weight of +1 and total peripheral resistance a weight of -1, such that a larger index value corresponded with greater challenge (as Moore et al., 2012). A series of independent *t*-

tests were conducted on the baseline performance, challenge/threat index (pressure), challenge/threat index (reappraisal/control), arousal interpretation, and pressure performance data to examine any between-group differences. The degrees of freedom, t -statistic, and probability values were corrected for homogeneity of variance assumption violations using the Levene's test for equality of variances and effect sizes were calculated using Cohen's d .

Results

Both groups performed similarly during the baseline golf putts, $t(48) = -0.45$, $p = .658$, $d = 0.13$, suggesting that any subsequent differences could be attributed to the instructional sets. Furthermore, in the sample as a whole, heart rate increased from baseline ($M = 6.71$ bpm, $SD = 6.20$), $t(41) = -7.02$, $p < .001$, confirming task engagement.^{2,3} In addition, after the pressure instructions, both groups displayed comparable cardiovascular responses consistent with a threat state (small challenge/threat index values), $t(40) = -0.12$, $p = .909$, $d = 0.04$. However, following the arousal reappraisal and control instructions, the reappraisal group displayed a cardiovascular response more indicative of a challenge state (higher challenge/threat index value) than the control group, $t(40) = -1.39$, $p = .174$, $d = 0.44$. Although this difference was not statistically significant, it did equate to a medium effect size (Cohen, 1992).⁴ Moreover, following the reappraisal/control instructions, the reappraisal group interpreted the physiological arousal they experienced as facilitative for their performance while the control group interpreted it as debilitating, $t(48) = -2.29$, $p = .026$, $d =$

² The reappraisal ($M = 6.79$ bpm, $SD = 6.10$) and control ($M = 6.63$ bpm, $SD = 6.45$) groups exhibited similar heart rate reactivity from baseline following the pressure instructions, $t(40) = -0.08$, $p = .936$, $d = 0.03$.

³ Both groups displayed heart rate reactivity significantly greater than baseline after the arousal reappraisal/control instructions ($M = 3.66$ bpm, $SD = 4.50$), $t(41) = -5.28$, $p < .001$. The reappraisal ($M = 3.53$ bpm, $SD = 3.89$) and control ($M = 3.80$ bpm, $SD = 5.13$) groups displayed comparable heart rate reactivity from baseline following the arousal reappraisal/control instructions, $t(40) = 0.20$, $p = .846$, $d = 0.06$.

⁴ A similar result was found when change in challenge/threat index from pressure to reappraisal/control conditions was examined. The reappraisal group ($M = 0.30$, $SD = 2.20$) displayed a larger increase in challenge/threat index (i.e., more of a challenge state) from pressure to reappraisal/control than the control group ($M = -0.46$, $SD = 1.35$), $t(40) = -1.35$, $p = .185$, $d = 0.43$.

0.66, thus supporting the effectiveness of the arousal reappraisal manipulation.⁵ Finally, the reappraisal group performed the pressurized task more accurately than the control group, $t(28.67) = 2.48, p = .019, d = 0.93$. The data are presented in Table 1.

Discussion

This study examined if a brief arousal reappraisal manipulation, given immediately before a single pressurized motor task, altered a threat state to a challenge state, and enhanced individuals' cardiovascular responses and performance. Despite both groups initially displaying a threat cardiovascular response (little change in cardiac output and/or total peripheral resistance), the arousal reappraisal intervention resulted in the reappraisal group interpreting their physiological arousal as more facilitative for their performance than the control group. Furthermore, a non-significant, but potentially meaningful descriptive trend, revealed that the intervention may have resulted in the reappraisal group exhibiting a more adaptive challenge cardiovascular response, consisting of relatively higher cardiac output and/or lower total peripheral resistance. However, this descriptive trend should be interpreted with caution. While it equated to a medium effect size, it was not statistically significant (even though no measures were taken to control for type 1 error inflation), possibly owing to reduced statistical power caused by the loss of cardiovascular data or attenuated cardiovascular reactivity caused by the baseline golf putts. Interestingly, the non-demanding cognitive task led the control group to display more of a threat cardiovascular response. It is possible that despite being told that their performance would not be evaluated, participants experienced uncertainty about the task's true purpose, triggering a threat response (Blascovich, 2008).

⁵ The reappraisal ($M = 2.92, SD = 1.22$) and control ($M = 3.36, SD = 1.41$) groups reported experiencing comparable somatic anxiety symptoms, $t(48) = 1.18, p = .244, d = 0.34$.

Although both groups performed comparably at baseline, the reappraisal manipulation led to the reappraisal group performing the pressurized golf putt better than the control group, leaving the ball closer to the hole. These findings are consistent with previous research examining the effectiveness of arousal reappraisal for cognitive performance (Jamieson et al., 2010; 2012; 2013b). The reappraisal manipulation may have benefitted performance by increasing sympathetic-adrenomedullary activation and oxygenated blood flow to the brain and muscles. However, future research is needed to examine this and other potential mechanisms (e.g., attentional; see Jamieson et al., 2013a). For example, evaluating a motor task as a challenge, rather than a threat, has been associated with better attentional control and performance under pressure (Vine, Freeman, Moore, Chandra-Ramana, & Wilson, 2013; Vine, Uiga, Lavric, Moore, Tsaneva-Atanasova, & Wilson, 2014). These authors suggested that closer links could be made between the biopsychosocial model of challenge and threat (Blascovich, 2008) and cognitive theories related to attentional control (e.g., attentional control theory; Eysenck, Derakshan, Santos, & Calvo, 2007).

Additionally, future work should investigate possible moderators such as interoceptive accuracy - ability to perceive one's bodily changes (Critchley, Wiens, Rotshtein, Ohman, & Dolan, 2004) - and if these variables influence the effectiveness of reappraisal interventions. Indeed, a limitation of the present study is that such variables were not assessed. Another limitation of the present study was that the control group did not receive a justification for completing the non-demanding cognitive task. As such, participants may have found the task irritating, as it prevented them from focusing on the primary task. Future work should ensure justifications accompany such control tasks (e.g., this task will serve as a distraction and help reduce pressure-induced arousal). Finally, although further research is needed with other motor skills, the findings suggest that individuals should be encouraged to interpret the heightened physiological arousal they experience before a crucial

pressurized moment as a tool that can help maximize performance, rather than an unwanted negative experience. In doing so, individuals will ensure that they respond to the pressure more adaptively, and perform at their best when it matters most.

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Table 1. Mean (*SD*) performance (cm), challenge/threat index, and arousal interpretation data for reappraisal and control groups.

Variable	Reappraisal		Control	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Baseline performance (cm)	37.00	11.71	35.03	18.82
Challenge/threat index (pressure)	0.03	1.29	-0.02	1.20
Challenge/threat index (reappraisal/control)	0.33	2.20	-0.48	1.50
Arousal interpretation (-3 to +3)	0.44*	1.33	-0.44	1.39
Pressure performance (cm)	8.64*	9.80	24.92	31.29

Note: Significantly different from the control group, * = $p < .05$.