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Examining the antecedents of challenge and threat states: The influence of perceived required effort and support availability

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ABSTRACT

To date, limited research has explicitly examined the antecedents of challenge and threat states proposed by the biopsychosocial model. Thus, the aim of the present study was to examine the influence of perceived required effort and support availability on demand/resource evaluations, challenge and threat states, and motor performance. A 2 (required effort; high, low) × 2 (support availability; available, not available) between-subjects design was used with one hundred and twenty participants randomly assigned to one of four experimental conditions. Participants received instructions designed to manipulate perceptions of required effort and support availability before demand/resource evaluations and cardiovascular responses were assessed. Participants then performed the novel motor task (laparoscopic surgery) while performance was recorded. Participants in the low perceived required effort condition evaluated the task as more of a challenge (i.e., resources outweighed demands), exhibited a cardiovascular response more indicative of a challenge state (i.e., higher cardiac output and lower total peripheral resistance), and performed the task better (i.e., quicker completion time) than those in the high perceived required effort condition. However, perceptions of support availability had no significant impact on participants' demand/resource evaluations, cardiovascular responses, or performance. Furthermore, there was no significant interaction effect between perceptions of required effort and support availability. The findings suggest that interventions aimed at promoting a challenge state should include instructions that help individuals perceive that the task is not difficult and requires little physical and mental effort to perform effectively.

1. Introduction

Individuals from a range of contexts (e.g., sport, surgery, military, and aviation) are often required to perform important tasks under extreme stress. As individuals do not respond to stress in a uniform manner, it is interesting to consider what factors cause these different stress responses. One theoretical framework that offers a vital insight into how individuals respond to stress is the biopsychosocial model (BPSM) of challenge and threat (Blascovich, 2008a). Despite recent research examining this model, particularly the consequences of challenge and threat states (e.g., Moore et al., 2012), limited research has explicitly examined the antecedents that are proposed by this model to influence these states. Thus, the present study examined the impact of two antecedents of challenge and threat states proposed by the BPSM; perceived required effort and support availability.

Rooted in the work of Lazarus and Folkman (1984) and Dienstbier (1989), the BPSM contends that an individual's stress response during a motivated performance situation (e.g., exam, speech, competitive task) is determined by their evaluations of situational demands and personal coping resources (Blascovich, 2008a). These evaluations are said to be dynamic, relatively automatic (i.e., unconscious), and only occur when an individual is actively engaged in a situation (indexed by increases in heart rate and decreases in the cardiac pre-ejection period; Seery, 2013). The BPSM specifies that when evaluated personal coping resources match or exceed situational demands, a challenge state occurs. Conversely, when evaluated situational demands outweigh personal coping resources, a threat state ensues (Blascovich, 2008a). Despite their discrete labels, challenge and threat are considered two anchors of a single bipolar continuum such that relative differences in challenge and threat (i.e., greater vs. lesser challenge or threat) are meaningful and commonly examined by researchers (Seery, 2011).

According to the BPSM, the demand/resource evaluation process triggers distinct neuroendocrine and cardiovascular responses (Blascovich, 2008a; Seery, 2011). During challenge and threat states, sympathetic–adrenomedullary activation is elevated. This activation increases blood flow to the brain and muscles due to higher cardiac activity and vasodilation of blood vessels via the release of catecholamines (epinephrine and norepinephrine). Importantly, during a threat state, pituitary–adrenocortical activation is also heightened. This dampens sympathetic–adrenomedullary activation and decreases blood flow due to reduced cardiac activity and diminished vasodilation (or even

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vasoconstriction). Consequently, compared to a threat state, a challenge state is characterized by relatively higher cardiac output and lower total peripheral resistance, a cardiovascular response considered more efficient for energy mobilization and action (Seery, 2011). These cardiovascular markers have been extensively validated in the literature (see Blascovich, 2008a for a review).

The BPSM suggests that a challenge state should lead to better task performance than a threat state (Blascovich, 2008a). Indeed, a number of predictive and empirical studies have offered support for this assumption using academic (e.g., Seery et al., 2010), cognitive (e.g., Gildea et al., 2007; Mendes et al., 2007; Turner et al., 2012), and motor (e.g., Blascovich et al., 2004; Moore et al., 2012, 2013; Turner et al., 2013) tasks. For example, Vine et al. found that evaluating a novel (surgical) motor task as more of a challenge was associated with a cardiovascular response more indicative of a challenge state and superior performance (i.e., quicker completion times) compared to evaluating the task as more of a threat. Furthermore, after being trained to proficiency, the participants performed the same motor task under stressful conditions. The results revealed that evaluating the task as more of a challenge was again associated with better performance than evaluating the task as more of a threat (Vine et al., 2013).

The demand/resource evaluation process is complex and thus challenge and threat states can be influenced by many interrelated factors (Blascovich, 2014). For example, psychological and physical danger, familiarity, uncertainty, required effort, skills, knowledge and abilities, and the availability of external support have all been proposed to impact upon demand and/or resource evaluations (Blascovich, 2008a; Frings et al., 2014). The cardiovascular indexes of challenge and threat states have been used to test various psychological theories including those related to inter-individual (e.g., social comparison; Mendes et al., 2001) and intra-individual (e.g., social power; Scheepers et al., 2012) processes. While the latter has inadvertently offered some potential antecedents, to date, no research has explicitly examined the effect of any of the antecedents proposed by the BPSM on demand/resource evaluations, challenge and threat states, and motor performance. This is surprising given the potential for such research to aid the development of the BPSM and help identify which factors are most crucial to target during interventions designed to facilitate challenge states in response to stressful tasks. Indeed, by promoting challenge states rather than threat states, these interventions are likely to have beneficial effects on performance and long-term cardiovascular and mental health (see Blascovich, 2008b).

Two of these potential antecedents, perceived required effort and support availability, have been discussed in recent reviews (McGrath et al., 2011; Seery, 2013). Although research has shown that expending greater effort during a task is characterized by increased heart rate and systolic blood pressure (see Wright and Kirby, 2001), no research has examined if perceptions relating to the effort required to successfully complete an upcoming task influence the cardiovascular indexes of challenge and threat. As perceptions of required effort have been proposed to contribute to demand/resource evaluations, with greater perceived required effort leading to higher demand evaluations and lower resource evaluations, greater perceived required effort could cause a cardiovascular response more reflective of a threat state (i.e., relatively lower cardiac output and higher total peripheral resistance; Blascovich and Mendes, 2000; Seery, 2013). Furthermore, despite research demonstrating that cardiovascular reactivity (i.e., systolic and diastolic blood pressure) is reduced when social support is perceived to be available during a stressful task (see Uchino and Garvey, 1997), limited research has investigated the influence perceived support has on the cardiovascular markers of challenge and threat. As perceptions of available support have been proposed to influence demand/resource evaluations, with perceived support availability leading to lower demand evaluations and higher resource evaluations, perceived available support might lead to a cardiovascular response more indicative of a challenge state (i.e., relatively higher cardiac output and lower total peripheral resistance; McGrath et al., 2011).

The aim of the present study was to examine the impact of perceived required effort and support availability on demand/resource evaluations, challenge and threat states, and motor task (laparoscopic surgery) performance. We hypothesized that, compared to participants in the high required effort condition, participants in the low required effort condition would have more favorable demand/resource evaluations (i.e., resources outweighed demands), a cardiovascular response more reflective of a challenge state (i.e., relatively higher cardiac output and lower total peripheral resistance), and superior task performance (i.e., quicker completion time). Furthermore, we hypothesized that, compared to participants in the no support available condition, participants in the support available condition would have more favorable demand/resource evaluations, a cardiovascular response more reflective of a challenge state, and superior task performance. Due to the absence of prior research investigating the antecedents of challenge and threat states, no predictions were made for the interaction effect of perceived required effort and support availability.

2. Methods

2.1. Participants

One hundred and twenty undergraduate students (59 women, 61 male; 109 right-handed, 11 left-handed) with a mean age of 21.57 (SD = 2.99) agreed to participate. All participants reported having no prior experience of laparoscopic surgery. Furthermore, all participants declared that they did not smoke, were free of illness or infection, and had normal or corrected vision, no known family history of cardiovascular or respiratory disease, had not performed vigorous exercise or ingested alcohol for 24 h prior to testing, and had not consumed food and/or caffeine for 1 h prior to testing. Participants were tested individually. The study was approved by the institutional ethics committee and written informed consent was obtained from all participants.

2.2. Measures

2.2.1. Manipulations checks (perceived required effort and support availability)

In order to assess perceptions of required effort and support availability, participants were asked "How much effort do you think will be required to complete the surgical task?" and "How much support do you think will be available during the surgical task?" respectively. Both items were rated using a 7-point Likert scale anchored between *no effort (=1)* and *extreme effort (=7)* for perceived required effort, and *no support (=1)* and *a lot of support (=7)* for perceived support availability.

2.2.2. Demand/resource evaluations

Two items from the cognitive appraisal ratio (Tomaka et al., 1993) were employed to measure demand/resource evaluations. One item assessed task demands ("How demanding do you expect the surgical task to be?") and another assessed personal coping resources ("How able are you to cope with the demands of the surgical task?"). Each item was rated using a 6-point Likert scale anchored between *not at all (=1)* and *extremely (=6)*. Although previous research has tended to calculate a ratio score by dividing evaluated demands by resources (e.g., Feinberg and Aiello, 2010), such a ratio is highly non-linear and is therefore inconsistent with the notion that challenge and threat states are two anchors of a single bipolar continuum (Seery, 2011). Thus, instead, a demand resource evaluation score was calculated by subtracting demands from resources (range: −5 to +5), with a more positive score reflecting a challenge state and a more negative score reflecting a threat state (see Moore et al., 2013; Vine et al., 2013).

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2.2.3. Cardiovascular responses

Cardiovascular data was estimated using a non-invasive impedance cardiograph device (Physioflow, PF05L1, Manatec Biomedical, Paris, France). The theoretical basis for this device and its validity has been published previously (e.g., Charloux et al., 2000). The Physioflow measures impedance changes in response to a high frequency (75 kHz) and low-amperage (3.8 mA) electrical current emitted via electrodes. Following preparation of the skin, six spot electrodes (Blue Sensor R, Ambu, Ballerup, Denmark) were positioned on the thorax; two on the supraclavicular fossa of the left lateral aspect of the neck, two near the xiphisternum at the midpoint of the thoracic region of the spine, one on the middle of the sternum, and one on the rib closest to V6. After entering the participants' details (height, weight etc.), the Physioflow was calibrated over 30 heart cycles while participants sat still and quiet in an upright position. Three resting systolic and diastolic blood pressure values were taken (one prior to the 30 heart cycles, one during this time period, and another immediately after this time period) manually by a trained experimenter using an aneroid sphygmomanometer (ACCOSON, London, UK) and stethoscope (Master Classic II, Littmann, 3M Health Care, St. Paul, USA). The mean blood pressure values were entered into the Physioflow to complete the calibration procedure.

Participants' cardiovascular responses were estimated continuously during baseline (5 min) and post-manipulation (1 min) time periods while they remained seated, still, and quiet (see Section 2.3.). It is important to note that while previous challenge and threat research have often measured cardiovascular data during tasks, this method was not employed in the present study due to concerns relating to movement artifacts (Blascovich and Mendes, 2000; Blascovich et al., 2004). Heart rate, the number of times the heart beats per minute, was estimated directly by the Physioflow. Heart rate reactivity (the difference between the final minute of baseline and the minute post-manipulation) was used to assess task engagement; with greater increases in heart rate reflecting greater task engagement (Seery, 2011). Cardiac output, the amount of blood in liters pumped by the heart per minute, was estimated directly by the Physioflow. Furthermore, total peripheral resistance, a measure of net constriction versus dilation in the arterial system, was calculated using the formula: [mean arterial pressure $\times$ 80 / cardiac output] (Sherwood et al., 1990). Mean arterial pressure was calculated using the formula: [(2 $\times$ diastolic blood pressure) + systolic blood pressure / 3] (Cywinski, 1980). Cardiac output and total peripheral resistance were used to differentiate challenge and threat states; with a challenge state characterized by higher cardiac output and lower total peripheral resistance (Seery, 2011).

2.2.4. Task performance

The laparoscopic surgery task was performed on a 3-Dmed (Franklin, OH) standard minimally invasive training system with a joystick SimScope (a manoeuvrable webcam). The scene inside the training box was viewed on a monitor (via the webcam). A surgical tool was inserted through a port on the box allowing objects to be moved inside the box. Participants completed a ball pick and drop task, in which they had to move 6 foam balls (diameter = 5 mm) from stems of varying heights into a cup, using a single tool (with their dominant hand). The balls had to be grasped and dropped into the cup individually and in a pre-specified order (see Vine et al., 2013 for a more detailed description and image of this system and task). Participants were informed to complete the task as quickly and as accurately (i.e., no dropped balls) as they could. Performance was assessed in terms of completion time, as this measure has been shown to differentiate varying levels of expertise in this task more precisely than other measures such as the number of balls knocked off or dropped (as Vine et al., 2013).

2.3. Procedure

Firstly, the participants were introduced to the experimenters (1 male aged 24 years and 2 females both aged 21 years) before providing written informed consent. Importantly, the experimenters were trained to ensure that their behaviors were consistent for all participants. The participants were then fitted with the Physioflow and Applied Science Laboratories (ASL) mobile eye tracker[1] by the two female experimenters who were blind to the participants' experimental condition until the manipulation instructions were given. Subsequently, 5 min of baseline cardiovascular data was recorded. Next, participants received their respective manipulation instructions from the male experimenter (see Section 2.4.). Cardiovascular data was then recorded for a 1 minute period while participants reflected on these instructions and anticipated the upcoming task. Afterward, participants completed the various self-report measures before carrying out the ball pick and drop task. Task performance and gaze data were continuously recorded throughout the surgical task. Finally, following the removal of the Physioflow and ASL mobile eye tracker, participants were thanked and debriefed about the aims of the study.

2.4. Manipulation instructions

Participants were randomly assigned to one of the four experimental conditions: (1) low required effort—support available (LRE-SA); (2) low required effort—no support available (LRE-NSA); (3) high required effort—support available (HRE-SA); or (4) high required effort—no support available (HRE-NSA). Instructions adapted from previous research were used to engage participants with the task and to manipulate participants' perceptions of required effort and support availability (e.g., Moore et al., 2012; Uchino and Garvey, 1997). To ensure task engagement, all participants received instructions emphasizing the importance of the task; that their score would be compared against other participants (published leaderboard); that the task would be objectively evaluated (digital video camera); that low performing participants would be interviewed; and that financial rewards would be given to high performing participants' (top 5 performers awarded cash prizes of £50, £25, £20, £15, and £10, respectively) (see Appendix A).

The low required effort instructions outlined that the task was straightforward, required little physical and mental effort, and would only take approximately 60 s to complete. In contrast, the high required effort instructions indicated that the task was difficult, required a great deal of physical and mental effort, and would take about 60 s to finish. The support available instructions indicated that the experimenters would be in the room while the participant performed the task and that if the participant required assistance for any reason or had any questions regarding the task, the participant could ask the experimenters. Conversely, the no support available instructions emphasized that the experimenters would be in the room while the participant performed the task but that if the participant needed any assistance or had any questions regarding the task, the participant could not ask the experimenters (see Appendix A). It is important to note that despite the latter instructions, no participants in any of the experimental conditions asked for assistance or help during completion of the task.

2.5. Statistical analysis

Prior to the main statistical analyses, outlier analyses were conducted. Ten univariate outliers (values more than 3.3 standard deviation units from the grand mean; Tabachnick and Fidell, 1996) were identified and winsorized by changing the deviant raw score to a value 1% larger or smaller than the next most extreme score (as Moore et al., 2012). Following this analysis, all variables were normally distributed except the perceived support availability data (z-scores for skewness and kurtosis exceeded 1.96).

The heart rate reactivity data were subject to a dependent t-test to assess task engagement and establish that in the sample as a whole,

[1] Gaze and tool movement data were recorded using the ASL system but are not reported in the present study.

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heart rate increased significantly from baseline (as Seery et al., 2009). An effect size was calculated using Cohen's *d*. In order to examine relative differences in challenge and threat states, an index was created by converting each participant's cardiac output and total peripheral resistance residualized change scores into *z*-scores and summing them. Residualized change scores were calculated in order to control for baseline values. Cardiac output was assigned a weight of $+1$ and total peripheral resistance a weight of -1, such that a larger value corresponded with greater challenge (as Moore et al., 2012).

To examine the effects of perceived required effort and support availability a series of 2 (perceived required effort; high required effort, low required effort) × 2 (perceived support availability; support available, no support available) univariate analysis of variance (ANOVA) were conducted with perceived required effort, demand resource evaluation score, challenge and threat index, and completion time data as dependent variables. Effect sizes were calculated using partial eta squared (η_p^2). As the perceived support availability data was non-normally distributed, this data was subject to a Kruskal–Wallis test with follow-up Mann–Whitney *U* tests to examine differences between the four experimental conditions.

3. Results

3.1. Manipulation checks (perceived required effort and support availability)

The ANOVA on the perceived required effort data revealed a significant main effect for perceived required effort, $F_{(1,119)} = 68.89$, $p < .001$, $\eta_p^2 = .37$. Participants in the low required effort condition (i.e., LRE-SA and LRE-NSA) reported that the task would require less effort than those in the high required effort condition (i.e., HRE-SA and HRE-NSA). However, there was no significant main effect for perceived support availability, $F_{(1,119)} = 0.39$, $p = .533$, $\eta_p^2 = .00$, and no significant interaction effect, $F_{(1,119)} = 0.07$, $p = .789$, $\eta_p^2 = .00$. The perceived required effort data are presented in Table 1.

The Kruskal–Wallis test on the perceived support availability data revealed a significant difference between the experimental conditions, $H(3) = 75.35$, $p < .001$. Participants in the support available condition (i.e., LRE-SA and HRE-SA) reported that they perceived there would be more support available during the task than those in the no support available condition (i.e., LRE-NSA and HRE-NSA) (all *p*s < .001). The perceived support availability data are presented in Table 1.

3.2. Demand/resource evaluations

The ANOVA on the demand evaluation data indicated a significant main effect for perceived required effort, $F_{(1,119)} = 55.20$, $p < .001$, $\eta_p^2 = .32$. Participants in the low required effort condition evaluated the task as less demanding than those in the high required effort condition. However, there was no significant main effect for perceived support availability, $F_{(1,119)} = 0.68$, $p = .411$, $\eta_p^2 = .01$, and no significant interaction effect, $F_{(1,119)} = 0.08$, $p = .784$, $\eta_p^2 = .00$. The demand evaluation data are presented in Table 1.

The ANOVA on the resource evaluation data indicated a significant main effect for perceived required effort, $F_{(1,119)} = 10.86$, $p = .001$, $\eta_p^2 = .09$. Participants in the low required effort condition reported having greater resources than those in the high required effort condition. However, there was no significant main effect for perceived support availability, $F_{(1,119)} = 0.94$, $p = .335$, $\eta_p^2 = .01$, and no significant interaction effect, $F_{(1,119)} = 0.34$, $p = .562$, $\eta_p^2 = .00$. The resource evaluation data are presented in Table 1.

The ANOVA on the demand resource evaluation score data revealed a significant main effect for perceived required effort, $F_{(1,119)} = 64.62$, $p < .001$, $\eta_p^2 = .36$. Participants in the low required effort condition reported higher scores, reflecting greater challenge, than those in the high required effort condition. However, there was no significant main effect for perceived support availability, $F_{(1,119)} = 1.76$, $p = .187$, $\eta_p^2 = .02$, and no significant interaction effect, $F_{(1,119)} = 0.04$, $p = .834$, $\eta_p^2 = .00$. The demand resource evaluation score data are presented in Table 1.

3.3. Cardiovascular responses

The dependent *t*-test on the heart rate reactivity data revealed that in the entire sample, heart rate increased significantly from baseline ($M = 6.25$ bpm; SD $= 5.09$), $t(114) = 13.16$, $p < .001$, $d = 2.47$, confirming task engagement and enabling the subsequent examination of challenge and threat states. The ANOVA on the challenge and threat index data revealed a significant main effect for perceived required effort, $F_{(1,114)} = 11.93$, $p = .001$, $\eta_p^2 = .10$. Participants in the low required effort condition exhibited larger challenge and threat index values, indicating greater challenge, than those in the high required effort condition. However, there was no significant main effect for perceived support availability, $F_{(1,114)} = 0.22$, $p = .638$, $\eta_p^2 = .00$, and no significant interaction effect, $F_{(1,114)} = 0.28$, $p = .601$, $\eta_p^2 = .00$. The challenge and threat index data are presented in Table 1.

3.4. Task performance

The ANOVA on the completion time data indicated a significant main effect for perceived required effort, $F_{(1,119)} = 15.42$, $p < .001$, $\eta_p^2 = .12$. Participants in the low required effort condition completed the task quicker than those in the high required effort condition. However, there was no significant main effect for perceived support availability, $F_{(1,119)} = 0.04$, $p = .850$, $\eta_p^2 = .00$, and no significant interaction effect, $F_{(1,119)} = 0.14$, $p = .714$, $\eta_p^2 = .00$. The completion time data are presented in Table 1.

4. Discussion

Despite the BPSM (Blascovich, 2008a) receiving increasing research interest in terms of the outcomes associated with challenge and threat states (e.g., Moore et al., 2012), to date, limited research has explicitly

Table 1
Mean (SD) self-report, cardiovascular, and performance data for the four experimental conditions.

	LRE-SA		LRE-NSA		HRE-SA		HRE-NSA	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Required effort (1–7)	3.87	1.07	4.03	1.38	5.47	0.82	5.53	0.68
Support availability (1–7)	4.83	1.29	1.60	1.33	4.90	1.49	1.63	1.07
Evaluated demands (1–6)	3.50	1.01	3.30	1.21	4.80	0.92	4.70	0.79
Evaluated resources (1–6)	4.20	0.76	4.27	0.98	3.53	1.04	3.80	0.96
DRES (−5 to +5)	0.70	1.29	0.97	1.47	−1.27	1.28	−0.90	1.16
Challenge and threat index	0.42	1.34	0.40	1.59	−0.77	1.72	−0.47	1.72
Completion time (s)	54.41	26.22	51.88	18.04	70.56	19.79	71.36	32.65

Note: LRE = low required effort; HRE = high required effort; SA = support available; NSA = no support available; DRES = demand resource evaluation score.

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examined the antecedents of challenge and threat states proposed by this model. Thus, the aim of the present study was to examine the influence of two proposed antecedents, perceived required effort and support availability on demand/resource evaluations, challenge and threat states, and subsequent motor performance.

Perceptions of required effort and support availability were successfully manipulated using task instructions adapted from previous research (e.g., Uchino and Garvey, 1997). Specifically, participants in the low required effort condition reported that the task would require less effort to complete than participants in the high required effort condition. Moreover, participants in the support available condition indicated that more support would be available to them during the task than participants in the no support available condition. Importantly, given the nature of the task and experimental environment, the other antecedents proposed by the BPSM (Blascovich, 2008a), including psychological and physical danger, familiarity, uncertainty, and skills, knowledge and abilities, should have been approximately equivalent across the experimental conditions. For instance, none of the participants had prior experience of laparoscopic surgery and so familiarity, uncertainty, and skills, knowledge, and abilities should have been comparable across the conditions. Furthermore, the surgical task and experimental environment were consistent for all participants and contained no elements of psychological or physical danger and so these factors should have been similar across the conditions.

Consistent with our hypotheses, there were significant main effects of perceived required effort on demand/resource evaluations, challenge and threat index, and performance. Participants in the low required effort condition evaluated the task as less demanding and reported having greater personal coping resources than those in the high required effort condition. Subsequently, low required effort was associated with evaluating the task as a more of a challenge (i.e., personal coping resources match or exceed task demands; Blascovich, 2008a), compared to high required effort. Consistent with the predictions of the BPSM, this divergence in demand/resource evaluations was accompanied by different cardiovascular responses. Indeed, while participants in the low required effort condition exhibited larger challenge and threat index values more reflective of a challenge state (i.e., relatively higher cardiac output and lower total peripheral resistance; Seery, 2011), those in the high required effort condition displayed smaller index values more indicative of a threat state (i.e., relatively lower cardiac output and higher total peripheral resistance; Seery, 2011). Finally, congruent with previous research (Blascovich et al., 2004; Gildea et al., 2007; Mendes et al., 2007; Moore et al., 2012, 2013; Seery et al., 2010; Turner et al., 2012, 2013; Vine et al., 2013), the different evaluations and cardiovascular responses were accompanied by varying levels of performance. More specifically, participants in the low required effort condition performed better (i.e., quicker completion time) than those in the high required effort condition.

Contrary to our hypotheses, perceptions of support availability appeared to have little impact on how participants evaluated, responded to, and performed the surgical task. Furthermore, there were no significant interaction effects between perceptions of required effort and support availability on any of the variables. Although the limited impact of perceived available support may be surprising, it should be noted that previous research examining the effect of perceived social support on cardiovascular reactivity to stress has revealed mixed results (see O'Donovan and Hughes, 2008). There are several possible explanations for the null effects. First, the participants may have perceived the available support differently. While some may have viewed the support as an extra coping resource, leading to a challenge state, others may have believed that the support providers were going to evaluate their performance (i.e., social evaluation), increasing the evaluated demands of the task, resulting in a threat state (see Blascovich et al., 1999; O'Donovan and Hughes, 2008). Second, the nature of the task may have affected how the available support was perceived. The surgical task was an individual task that participants were instructed to perform both accurately and quickly. Thus, although participants recognized that support was available (as evidenced by the manipulation check data), this support may not have influenced their demand/resource evaluations and cardiovascular responses as the participants may have felt that they would not have the necessary time to utilize the available support and still perform the task efficiently.

The findings of the present study have some important implications. From a theoretical perspective, the findings support the BPSM (Blascovich, 2008a) as an explanatory model of performance variability under stress. Furthermore, while the findings support the inclusion of perceived required effort as an antecedent of demand/resource evaluations and challenge and threat states in the model, they raise questions about the inclusion of the availability of support. However, we would encourage further research to experimentally examine these and other antecedents proposed by the BPSM (e.g., psychological and physical danger, familiarity, uncertainty, and skills, knowledge and abilities; Blascovich, 2008a). Indeed, such research is important as it will help establish the relative importance and influence of each determinant on demand/resource evaluations, challenge and threat states, and performance, contributing to the further development of the model. Moreover, this research will also help elucidate which factors should be targeted in interventions aimed at encouraging individuals to evaluate and respond to stressful tasks more adaptively, as a challenge rather than a threat. From an applied perspective, the findings of the present study and previous research suggest that a more resilient, challenge state can be fostered via simple pre-task instructions that reduce the evaluated demands of the task and increase the evaluated resources of the individual (e.g., Feinberg and Aiello, 2010). More specifically, the findings imply that such alterations can be accomplished using instructions that help the individual perceive that the task requires little physical and mental effort to perform effectively.

The limitations of the present study highlight some avenues for future research. First, the present study employed a between-subjects design and did not include baseline performance trials. Although this makes it difficult to control for any inherent group differences, baseline trials are problematic when assessing challenge and threat states. Indeed, previous task exposure has been shown to dampen cardiovascular responses and influence future demand/resource evaluations (Kelsey et al., 1999; Quigley et al., 2002; Vine et al., 2013). Second, based on early conceptions of the BPSM (Blascovich and Mendes, 2000), perceived required effort was manipulated using instructions regarding task difficulty and length as well as instructions directly relating to physical and mental effort. Subsequently, it is difficult to identify which of these instructions had the strongest influence on perceptions of required effort, an interesting issue that should be addressed in future research. Third, how the antecedents proposed by the BPSM impact demand/resource evaluations and challenge and threat states could have been influenced by intrapersonal differences in various dispositional traits (Blascovich, 2014). However, such dispositional traits (e.g., trait social anxiety; Shimizu et al., 2011) were not assessed in the present study but could be examined in future research. Indeed, the present study examined a simplified model of the influence of two possible antecedents on demand/resource evaluations, challenge and threat states, and motor performance. Future research should therefore examine a more complex model in which dispositional traits and the interplay between additional antecedents are taken into consideration. Finally, although the cardiovascular markers of challenge and threat were recorded in the present study, the neuroendocrine responses predicted to underpin changes in these measures were not (e.g., cortisol; see Seery, 2011). Thus, future research is encouraged to record the neuroendocrine responses accompanying challenge and threat states to test the predictions of the BPSM and help our understanding of how these states affect the cardiovascular system.

To conclude, the results demonstrate that perceptions of required effort can have a powerful influence on how individuals' evaluate, respond to, and perform a stressful task. Furthermore, the results suggest that perceptions regarding the availability of support may have a limited impact on individuals' stress responses, although this antecedent warrants further investigation and might benefit from being examined using different support manipulations and experimental tasks (e.g., co-operative task). Finally, the results highlight that the performance of a stressful and novel task can be facilitated by providing pre-task instructions that elicit a challenge state. More specifically, the results imply that reducing perceptions relating to task difficulty and the physical and mental effort required to successfully complete a stressful task may be an important message to include in such instructions.

Appendix AA.1. *Task engagement instructions*

The rest period has now finished. We will shortly ask you to perform a laparoscopic surgery task consisting of one trial on a ball pick-and-drop task. This is the most important part of the experiment and it is very important that you try, ideally, to complete the task as quickly as you can with as few errors as possible. We will instruct you when you may begin the trial, and then you should complete the trial as quickly and accurately as possible. After the trial, we will record the completion time and the number of errors. That is the time it takes you to finish the task and the number of balls you knock off or drop. Do you have any questions?

A measure of task performance will be calculated for each participant and placed on a leaderboard. At the end of the study the leaderboard will be emailed to all participants and displayed on a noticeboard so you can compare how you did against other students. The top five performers will be awarded cash prizes of £50, £25, £20, £15, and £10, respectively. The worst five performers will be interviewed. Further, please note that the trial will be recorded on a digital video camera and maybe used to aid teaching and presentations in the future.

A.2. Low required effort and support available instructions

The simple task you are about to complete is designed to help identify medical students who have good basic laparoscopic surgery skills. The task is straightforward. It requires very little physical and mental effort to perform effectively and will only take approximately 60 s to complete. We will be right next to you while you perform the task. If you require assistance for any reason, or if you have any questions regarding the task, please don't hesitate to ask one of us. We appreciate your participation in the experiment, and we'd like to assist you should you need any help.

With these instructions in mind, please now sit quietly for 1 min and think about the upcoming task.

A.3. Low required effort and no support available instructions

The simple task you are about to complete is designed to help identify medical students who have good basic laparoscopic surgery skills. The task is straightforward. It requires very little physical and mental effort to perform effectively and will only take approximately 60 s to complete. We will be in the room while you perform the task. However, if you require any assistance or have any questions regarding the task, you will not be able to ask one of us. Although we appreciate your participation in the experiment, we cannot assist you should you need any help.

With these instructions in mind, please now sit quietly for 1 min and think about the upcoming task.

A.4. High required effort and support available instructions

The difficult task you are about to complete is designed to help identify medical students who have good basic laparoscopic surgery skills. The task is tough. It requires a great deal of physical and mental effort to perform effectively and will take approximately 60 s to complete. We will be right next to you while you perform the task. If you require assistance for any reason, or if you have any questions regarding the task, please don't hesitate to ask one of us. We appreciate your participation in this experiment, and we'd like to assist you should you need any help.

With these instructions in mind, please now sit quietly for 1 min and think about the upcoming task.

A.5. High required effort and no support available instructions

The difficult task you are about to complete is designed to help identify medical students who have good basic laparoscopic surgery skills. The task is tough. It requires a great deal of physical and mental effort to perform effectively and will take approximately 60 s to complete. We will be in the room while you perform the task. However, if you require any assistance or have any questions regarding the task, you will not be able to ask one of us. Although we appreciate your participation in the experiment, we cannot assist you should you need any help.

With these instructions in mind, please now sit quietly for 1 min and think about the upcoming task.

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