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Research Article

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The Effects of Psychosocial Stress and Sex Differences on Cognitive Effort Avoidance

Abstract

Background: Recent research suggests stress may affect cognitive performance including memory, executive functioning, decision-making, and task-switching. However, it is unknown whether these effects are aversive or advantageous for effort exertion. This experiment aimed to evaluate the effects of acute psychosocial stress on willingness to exert cognitive control processes in a cognitive-effort-based decision-making task.

Methods: To test this, 40 participants (20 female) in a within-subject, fully crossed, randomized design, were exposed to both a psychosocial stress induction condition (the Trier Social Stress Test; TSST) and a control condition. Subsequently, they underwent the Demand Selection Task (DST) that tests for participants' effort aversion by manipulating switch probabilities in a task-switching paradigm.

Results and Conclusion: The induction of stress did not lead to significant error or accuracy rates, or significant differences in cognitive effort avoidance. Previous research indicated sex differences in response to stress. However, there is a lack of data on sex differences in the avoidance of demanding cognitive processes. Therefore, we assessed sex differences in the DST and found that women were more likely to avoid cognitive effort, choosing the less cognitively demanding cue more often than men.

Limitations: A limitation of this study is the small sample size. Future research should increase the sample size and take individual differences in stress responders, type of stressor, and biases on effort exertion into account.

Introduction

Generally, people prefer taking shortcuts, such as taking the escalator instead of the stairs. Hull's "Law of Less Work" explains this tendency for humans to select actions that minimize effort, stating that when organisms are presented with two or more behavioural options, there is a preference towards the less demanding course of action. (1) While the "Law of Less Work" was intended for physical effort, it was suggested that this could be applied to mental tasks. (2) Kool *et al.* posit that individuals typically avoid situations that carry a high cognitive load. (2) They developed an experimental paradigm confirming this preference for less cognitively strenuous tasks, called the Demand Selection Task (DST) to test their hypothesis. (2) The DST requires participants to choose between two cues associated with higher or lower switch frequencies in a task-switching paradigm. Task-switching requires cognitive control, which is thought to be effortful. (3,4) In the DST, it is assumed that higher switch frequencies require more effort expenditure by the participant. Since the publication by Kool *et al.* (2), further studies have shown there is a general tendency for effort avoidance and that people require large incentives to exert effort. (5-8)

While studies have shed light on cognitive effort avoidance, when and why people exert effort is rarely investigated. One potential mechanism that may influence motivation is stress. Evidence suggests that stress affects cognitive performance, which impacts memory, decision-making, and cognitive control. (9-12) Stress elicits a physiological response that activates the autonomic nervous system (ANS) and the hypothalamic-pituitary-adrenal (HPA) axis. (13) The ANS activity results in elevated blood pressure (BP) and heart rate (HR), whereas the HPA axis regulates the release of cortisol, a major stress mediator in the brain. (14) Kirschbaum and Hellhammer (14) demonstrated that stressful situations, such as public speaking, cause increases in salivary cortisol levels. Cortisol is important in the mediation of how stress affects higher cognitive control processes, presumably through its effects on the prefrontal cortex (PFC). The PFC is responsible for mediating complex cognitive processes that are assumed to be effortful, however, it is highly vulnerable to stress. (15,16) While physiological stressors directly affect the paraventricular nucleus (PVN) of the hypothalamus, psychological stressors pass through the limbic system (PFC, hippocampus, amygdala) before activating the HPA axis, and therefore affect higher levels of processing. (17) Because the PFC possesses a high density of cells with receptors sensitive to neurotransmitters released in response to stress, it is reasonable to hypothesize that decision-making and task-switching processes that rely on the PFC can be directly affected by stress. Under stress, executive functions can impair cognitive performance, altering decision-making and task-switching processes. (18,19) Despite the large body of literature demonstrating a link between cognitive functioning and acute stressors, to our knowledge the effects of stress on effort avoidance have not been examined to date. In this study, our main interest was to examine DST performance in response to stress from the TSST.

Beyond the overarching motivations of this study, we further examined sex differences in the DST in response to stress. Research has shown sex differences in cognitive processes such as spatial skills, verbal skills, and memory. (20-22) However, little is known about individual differences in motivational effort. Recent studies have examined individual differences in response to stress due to the high prevalence of somatic and pathological disorders related to stress, such as anxiety, depression, and pain. (23-26) Since the HPA axis is implicated in many of these disorders that have sex differences, scholars have posited that stress responses may be different in men and women. (27,28) Studies have found sex differences in cortisol levels, BP, and HR in response to stress, showing that men have greater overall physiological responses under acute stressors. (17,29,30-33) These studies state that a potential factor causing these results may be due to hormonal fluctuations related to the menstrual cycle and/or the use of hormonal contraceptives. (31,34,35) Finally, evidence regarding sexually divergent reactions to psychological stressors reveals that women report higher levels of negative affect than men. (31,36-38)

This experiment sought to answer the following questions: First, how does acute psychosocial stress affect cognitive effort-based decision-making, and how do these changes relate to the participants' cognitive performance on the DST? Second, do men and women differ in their response to stress and does this divergence mediate behaviour in the DST? In order to test DST performance in response to stress, we conducted a within-subject, fully crossed, randomized study. We hypothesized that stress would de-

crease participants' willingness to exert effort and impair task-switching performance in the DST by disrupting executive functioning and working memory, causing more effort avoidance. With respect to sex, we speculated that women would have lower accuracy rates and would be more effort averse than men, as psychological stressors are more often activated in women. To induce stress, we employed the TSST. (39) Over a two-day testing period, 40 healthy participants (20 female) underwent both a stress-inducing condition (TSST) and a control condition before completing the DST. To ensure effective physiological and psychological stress induction, we collected subjective mood reports, salivary cortisol samples, BP, and HR.

Methods

Participants

A total of 40 healthy participants, between the ages of 18 and 30, were recruited from a participant pool of students and the community (20 female; age, mean±SEM: 23.43±0.45 years; body mass index, 22.4±0.45 kg/m2). Participants were free of neurological or psychiatric conditions and did not have any current or acute illnesses (GAD, mean±SEM: 1.7±0.36; PHQ, 2.1±0.37). Exclusion criteria included medication intake, smoking, substance abuse, pregnancy, and use of hormonal contraceptives in women. Women were not tested during their menses. In addition, participants were instructed to abstain from exercise, food, and caffeine during the 2 h period before the testing session. Test protocols were approved by the Research Ethics Board of the Psychology Department at McGill University. Participants provided informed consent and received a financial reward of $50 and a $3 bonus in return for their participation.

Demand selection task

In the DST, we presented participants with two abstract patterned choice cues, with a small cue centered between them marking the midpoint. (2) In each run, participants selected one of the two patterns by rolling a mouse cursor over the desired pattern, which revealed a coloured number within a magnitude/parity task-switching protocol (Fig. 1). In this task, if participants saw a purple number, they were asked to judge the magnitude of the numbers by clicking the left mouse button in response to numbers less than 5 and the right button for numbers above 5. If a yellow number was presented, the task switched to a parity protocol, where participants had to click the left or right mouse button for even and odd numbers, respectively. After each run, participants were required to roll the mouse over the midpoint to reset the choice cues. Participants were unaware that the choice cues were associated with either "high demand" or "low demand" trials. For low demand trials, the colour of the number matched that of the preceding trial on 90% of trials. On high demand trials, the colour from the preceding trial was only repeated 10% of the time. The high-demand choice cue required more frequent task-switching and thus carried a greater cognitive load. The DST had a total of 300 trials and was divided into four blocks, with 75 in each block. The individual's accuracy and low demand choice percentages were recorded.

Experimental stress induction

The TSST is a standardized psychosocial laboratory stressor used to induce stress in humans. (39) The test involves an anticipation period, an oral presentation and a complicated mental arithmetic task in front of a panel of two "experts". In this study, participants were told to think of their dream job and convince the panelists why he/she is the perfect candidate. The panel was comprised of two unresponsive experimenters (one male, one female), who were introduced to participants as experts trained in analyzing behaviour and took notes during the speech. Participants were given time to prepare before delivering their 5-minute uninterrupted speech to the experts and were told when to stop. If the speech was less than 5 minutes, the panel responded with standardized comments reminding the subject there was time left, and that they should continue. Following the speech, the judges asked the participant to perform a difficult mental arithmetic task in which they serially subtracted the number 17 from 2043 as fast and as accurately as possible. If an incorrect number was stated, they were asked to restart from 2043, and when participants were too slow, they were asked to increase their speed. In the control condition, participants completed a neutral public speaking task in which the panel of judges was removed. With the room to themselves, participants were asked to speak for 5 minutes on a topic of their choice followed by a simpler arithmetic task of counting upwards in increments of five. To assure participants complied with the instructions, the experimenter listened through the door.

Procedures

Shortly after the participants' arrival, they were exposed to either a stress-inducing condition (TSST) or a control condition before completing the DST. Participants were tested on two days, separated by a one-week interval, lasting for 2.5 h each session. All testing occurred between 1:00 P.M. and 6:00 P.M to control for circadian fluctuations in salivary cortisol levels. We obtained informed consent on the first day of experimentation. Afterwards, baseline measurements of subjective feelings were collected as measured by the Positive and Negative Affect Schedule (PANAS; 40) Questionnaire as well as BP and HR measurements. Saliva samples were taken to control for cortisol level variation. The BP and HR measurements were collected seven times throughout day one (baseline, during TSST, +15, +25, +45, + 60, and +75 after stressor onset). The salivary cortisol and PANAS were collected six times (baseline, +15, +25, +45, + 60, and +75 after stressor onset). The Demand Questionnaire was given to the participants following the TSST. Finally, participants completed the DST approximately 45 minutes after the stress onset, in addition to three other effort and decision-making tasks which will not be further discussed. On the second day, participants underwent the same procedures as day one,

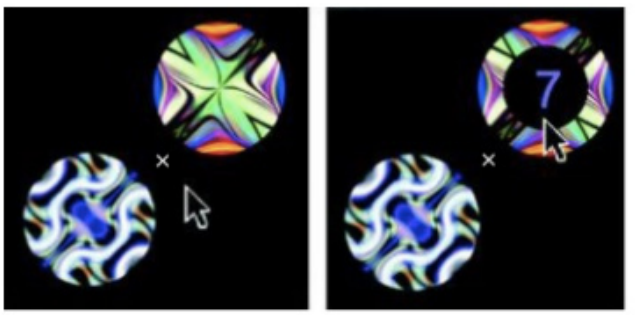

Figure 1. Example of cues in the DST. Participants used the mouse to reveal a coloured number then clicked the left or right mouse button to indicate magnitude (purple) or parity (yellow). One stimulus (high-demand) changed colours more often, demanding frequent task-switching. The other stimulus (low-demand) repeated colours more often, demanding less effort. Cues reset by returning the mouse to midpoint. (2)

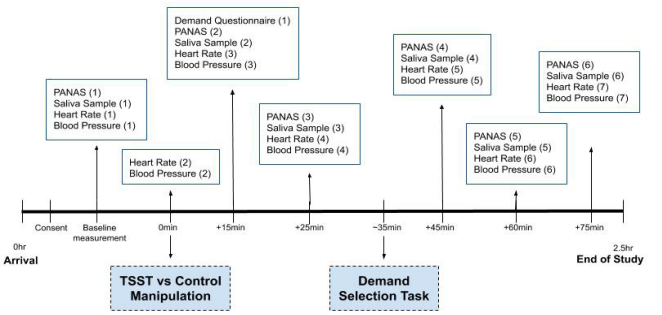

Figure 2. Timeline of the procedure for both days. Participants were exposed to the TSST on one day and the control manipulation on the other day before completing the DST. Time points reflect the number of minutes after stressor onset. PANAS is the Positive and Negative Affect Schedule. Numbers in brackets reflect the number of measurements for the respective stress variables.

but with the opposite TSST condition than they experienced on the day prior (Fig. 2).

Psychological questionnaires

Throughout both days of the experiment, participants reported their subjective affective states. The Positive and Negative Affect Schedule (PANAS; 40) is a self-report questionnaire that consists of two 10-item scales that measure positive and negative affect. The positive affect (PA) scale includes attentive, active, alert, excited, enthusiastic, determined, inspired, proud, interested, and strong. The negative affect (NA) scale includes distressed, upset, guilty, scared, hostile, irritable, ashamed, nervous, jittery, and afraid. Participants rated the degree to which they felt these items on a 5-point scale of 1 (not at all) to 5 (very much). PANAS data were collected six times simultaneously with the physiological measurements (Fig. 2). Using the Demand Questionnaire, ratings of difficulty, unpleasantness, and stressfulness were collected following the TSST. These ratings range from 0 (not at all) to 100 (extremely) in intervals of 10, which resembles the widely validated Visual Analogue Scales (VAS). (41)

Physiological measures

To evaluate the effectiveness of the stress induction, in addition to subjective reports, endocrine and autonomic responses were measured. Six saliva samples were collected per day using Salivette® collection devices (Sarstedt Inc., Rommelsdorf, Germany). (42) The first sample was taken before the TSST, another following the stress or control exposure, and the rest were collected throughout the remainder of the study, after the cognitive tasks. Saliva samples were stored at -18 °C and analyzed for cortisol concentrations using a chemiluminescence immunoassay (IBL Hamburg, Germany). BP and HR data were collected along with the self-report questionnaires and saliva samples, with one additional measurement taken during the TSST/control manipulation, for a total of seven measurements. A LotFancy BP-103H arm BP monitor assessed the participants' diastolic and systolic BP as well as their HR. We recorded the mean of the two consecutive measurements.

Experimental design and statistical analyses

For both the stress condition and the DST condition, the study utilized a within-subject randomized design, in which the two factors, stress induction (stress vs control condition), and demand task (high vs low demand), were fully crossed. Subjective, physiological, and sex parameters were analyzed using a mixed model ANOVA, with the within-subjects factors "condition" (stress and control), "time" of sample collection (systolic and diastolic BP, and HR: seven samples; PANAS and salivary cortisol: six samples), and the between-subject factor "sex" (male and female). Significant main and interaction effects were followed up by post hoc tests to analyze the differences in single time point evaluations. Paired samples t-test were applied to analyze responses in the Demand Questionnaire as well as accuracy and low demand effort choices in the DST of the TSST and control conditions. Data were analyzed using SPSS, Version 24. All analyses were two-tailed, with the significance level set at $p<0.05$, and adjusted by Bonferroni correction for multiple comparisons. Greenhouse-Geisser degrees of freedom adjustment was applied to correct for violations of sphericity.

Results

Cortisol responses to stress

Consistent with previous research, salivary cortisol levels increased significantly following the TSST (main effect of time, $F(1.688,65.844)=12.161$, $p<0.001$, $\eta p2=0.238$; main effect of condition, $F(1,39)=18.99$, $p<0.001$, $\eta p2=0.328$; time x condition interaction, $F(2.32,90.489)=9.022$, $p<0.001$, $\eta p2=0.199$). Cortisol concentration from the samples taken at +15 minutes and +45 minutes of the study were significantly higher than at +60 and +75 time points (both $p<0.001$). Cortisol levels peaked +25 minutes after the stressor onset (third time point) and were significantly higher than all time points after the TSST (all $p<0.021$) (Fig. 3a). Post hoc analyses confirmed that, overall, participants had significantly higher concentrations of cortisol in the stress condition following stress onset (all $p<0.001$). These results indicate stress was successfully induced and was increased at the time participants performed the DST.

Heart rate and blood pressure responses to stress

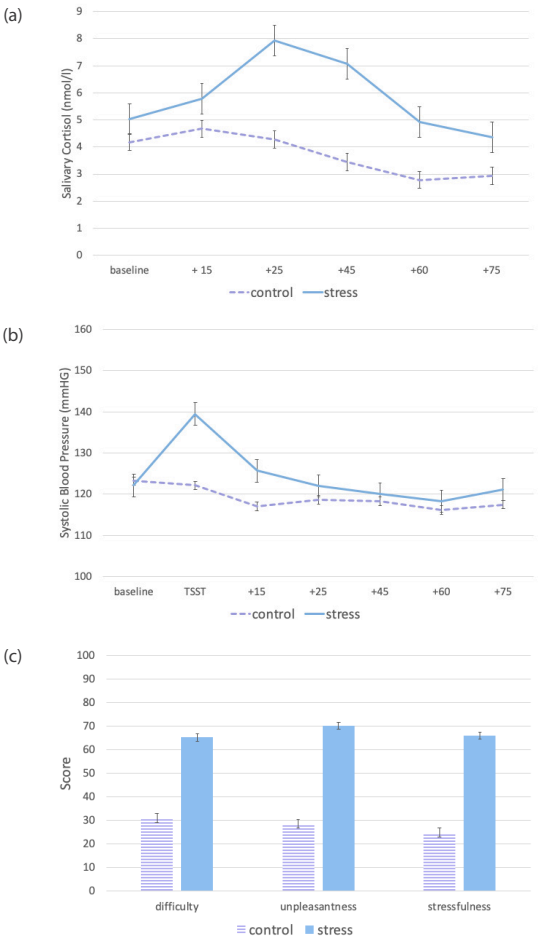

Figure 3. Successful stress induction in response to the TSST. (a) Mean salivary cortisol levels during stress induction and control manipulation. (b) Mean systolic blood pressure for control vs stress condition. (c) Mean scores on ratings of difficulty, unpleasantness, and stressfulness immediately after the TSST vs control manipulation. Error bars represent the standard error of the mean (SEM).

There was a significant increase in blood pressure (BP) and heart rate (HR) in response to the exposure of the experimental stress induction (main effect of time, systolic: $F(3.799,132.965)=14.829$, $p<0.001$, $\eta p2=0.298$; diastolic: $F(3.236,113.262)=9.426$, $p<0.001$, $\eta p2=0.212$; HR: $F(3.236,113.262)=9.426$, $p<0.001$, $\eta p2=0.212$; main effect of condition, systolic: $F(1,35)=22.409$, $p<0.001$, $\eta p2=0.390$; diastolic: $F(1,35)=17.753$, $p<0.001$, $\eta p2=0.337$; time x condition interaction, systolic: $F(6,210)=10.954$, $p<0.001$, $\eta p2=0.238$; diastolic: $F(3.83,134.050)=5.978$, $p<0.001$, $\eta p2=0.146$; HR: $F(3.83,134.050)=5.978$, $p<0.001$, $\eta p2=0.146$). Differences in HR across the two conditions were not significantly different (main effect of condition, $F(1,35)=3.476$, $p=0.071$, $\eta p2=0.090$). Post hoc tests revealed that individuals in the stress condition had significantly higher systolic and diastolic BP and HR during the TSST (all $p<0.001$) and at the +15 min time point for systolic BP only ($p<0.001$) (Fig. 3b). There was no significant change in BP at other time points (systolic: all $p>0.168$, diastolic: all $p>0.189$, HR: all $p>0.125$). Overall, BP and HR peaked during the TSST manipulation, then returned to baseline for the remainder of the experiment.

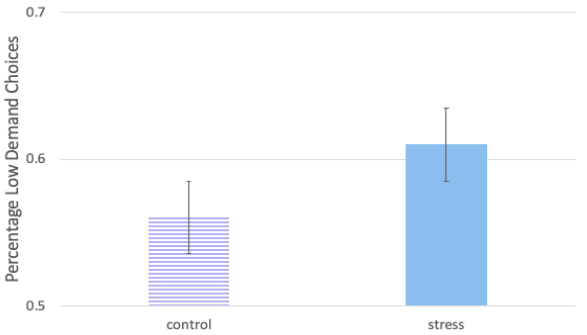

Figure 4. Percentage of participants' choice of the low demand option on the DST in both conditions. Results did not significantly differ by the TSST. Error bars represent the standard error of the mean (SEM).

Subjective feeling responses to stress

Participants in the stress induction showed the expected increase in scores of psychological stress. A paired samples t-test evaluating responses from the Demand Questionnaire demonstrated that participants reported the stress induction as significantly more difficult, unpleasant, and stressful following the TSST compared to the control task (difficulty: t(38)=-7.857, p<0.001, d=1.258; unpleasantness: t(38)=-8.257, p<0.001, d=1.322; stressfulness: t(38)=-9.170, p<0.001, d=1.468) (Fig. 3c). PANAS results revealed greater NA directly after the TSST (main effect of time, F(3.274,121.145)=9.054, p<0.001, ηp2=0.196; time x condition interaction, F(2.963,109.615)=11.256, p<0.001, ηp2=0.233). However, reported feelings of NA did not differ across conditions (main effect of condition, F(1,37)=9.844, p=0.576, ηp2=0.009). Feelings of PA decreased from baseline consistently throughout the study (main effect of time, F(3.568,132.027)=15.687, p<0.001, ηp2=0.298). Participants' PA was not affected by the TSST (main effect of condition, F(1,37)=0.704, p=0.407, ηp2=0.19; time x condition interaction, F(3.235,120.362)=0.364, p=0.795, ηp2=0.1). Post hoc tests for PA and NA were performed to assess differences between the conditions at each time point. While no significance was found for PA throughout the experiment (p>0.235), individuals reported feelings of greater NA at baseline when experiencing the stress condition (p<0.004) and at the time point following the TSST (p<0.001).

DST results

Mean accuracy rates on the DST in both stress and control conditions were 88%, yielding insignificant results, F(1,39)=0.054, p=0.817, ηp2=0.001. Additionally, the rate in which participants chose the low versus the high demand choice did not significantly differ across the two conditions, F(1,39)=3.714, p=0.061, ηp2=0.087, in which the mean of choosing the low demand cue was 56% in the control condition and 61% in the stress condition (Fig. 4).

Sex differences in stress responses

To compare the sex differences in stress responses, we subtracted the baseline from the peak level in each modality. In physiological measurements of salivary cortisol concentration (Fig. 5a) and BP (Fig. 5b), we found that men had significantly greater increases than women, following the TSST (salivary cortisol: t(38)=2.791, p<0.008; systolic: t(38)=2.071, p<0.046; diastolic: t(38)=2.358, p<0.024). For self-reported measures, women reported significantly higher feelings of unpleasantness after the TSST compared to men (t(37)=-2.023, p<0.05) (Fig. 5c). There were no significant sex differences in HR, or reports of NA, difficulty or stressfulness following the TSST (HR: t(38)=0.791, p=0.434; NA: t(38)=-0.057, p=0.955; difficult: (37)=-0.604, p=0.550; stress: t(37)=-0.402, p=0.69).

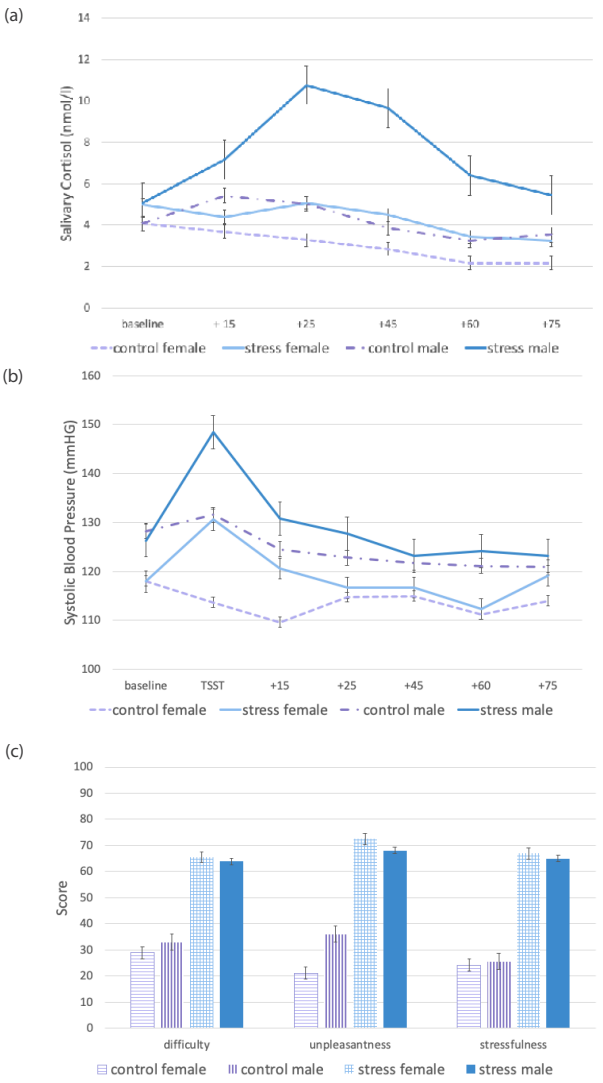

Figure 5. Sex differences in response to the TSST. (a) Mean cortisol concentration for male and female participants across the control and stress conditions. (b) Mean systolic blood pressure between males and females on both conditions. (c) Mean difficulty, unpleasantness, and stressfulness scores in males and females on both conditions. Error bars represent the standard error of the mean (SEM).

Sex Differences in the DST

For the DST, we investigated sex differences in high versus low demand choices under TSST and control conditions. A repeated-measures ANOVA assessing the between-subjects factor of sex revealed that in both conditions, women more often chose the low demand choice (Fig. 6), with a mean rate of 60% in the control condition and 66% in the stress condition, while men chose the low demand choice 52% of the time in the control condition and 56% in the stress condition (main effect of sex, F(1,38)=4.83, p<0.034, ηp2=0.113). There were no significant differences between conditions nor a sex x condition interaction (main effect of condition, F(1,38)=3.626, p=0.064, ηp2=0.087; sex x condition interaction, F(1,38)=0.077, p=0.783, ηp2=0.002). A post hoc test confirmed that across both conditions, women chose the low demand choice more often, 63% of the time, compared to men who chose the low demand choice 54% (p<0.034).

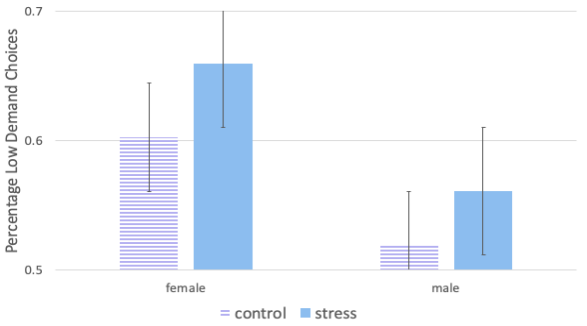

Figure 6. Sex differences in low demand choices in the DST. Error bars represent the standard error of the mean (SEM).

Discussion

Stress is often present during cognitively effortful tasks in our everyday lives. However, stress has been shown to jeopardize executive functions and working memory. (18,19) The purpose of this study was to assess whether the induction of acute psychosocial stress promotes or hinders motivation to exert effort. Participants' efforts were assessed using the DST after experiencing a standardized laboratory psychosocial stressor (TSST) or a control condition. We hypothesized that motivation to exert effort and task-switching performance during the DST would be impaired by stress. Specifically, we predicted that the activation of the HPA axis would affect the PFC, diminishing cognitive performance such that it causes individuals to make errors and avoid using effort. Further, we predicted that stress from the TSST would have greater effects on women, causing more errors and effort avoidance on the DST than in men. The present experiment demonstrated women were more likely to avoid cognitive effort, but stress induced by the TSST did not significantly influence cognitive performance.

Our study confirmed that the TSST elicited significant physiological changes. This was in line with previous research that demonstrated that public speaking tasks enhance stress and NA. (31,36-38) Our results uphold that feelings of NA were significantly greater following the TSST manipulation than at other time points of the experiment and compared to the control condition. Participants regarded the stress induction as more difficult, unpleasant, and stressful. Salivary cortisol levels reached its highest point approximately 25 minutes after participants were exposed to the TSST, which is consistent with previous research stating that cortisol in saliva peaks 20-30 minutes after stressor onset. (43) These physiological and psychological stress responses reflect prolonged HPA-axis activity, indicating successful stress induction.

The results of this study reveal sexually divergent responses to stress, as male participants exhibited greater increases in both cortisol levels and BP following the TSST. These findings are in line with previous research that suggests men exhibit higher cortisol outputs under acute stress. (17,31-33) Additionally, women reported higher feelings of unpleasantness after the TSST compared to men, consistent with previous findings that women subjectively report more NA. (31,36-38) However, the results of this study do not confirm previous research demonstrating impaired task switching performance (44) and decision-making (19,45) while under stress. Nonetheless, we showed that women chose the low demand choice more often than men. Because we controlled for potential hormonal confounds such as pregnancy, hormonal contraceptive use and menses, this finding cannot be attributed to these factors. Biases for effort demand were examined, revealing that there are individual differences in cognitive effort. (46) People may be Demand Avoiders, who avoid more frequent task-switching tasks, or Demand Seekers, who routinely choose them. (46) Future research should look more carefully at these effort biases to allow for a better understanding of why these preferences develop and how these biases affect stress responses.

Our experiment revealed that performance on the DST (accuracy rates and low versus high demand choices) did not vary significantly whether participants were exposed to stress or not. A possible explanation could be due to the differences in the way people respond to the TSST. Studies have shown there are habitually high and low responders to stress, as well as sex differences in responders. A study by Preston *et al.* (19) investigated how stress from the anticipation of public speaking affects performance on the Iowa Gambling Task (IGT), a paradigm to assess risky decision-making. (47) Women showed a higher stress response yet performed better under anticipatory stress, while men performed worse. Similarly, Van den Bos *et al.* (45) examined the effects of the TSST on decision-making performance on the IGT. They concluded that there are sex differences in response to the TSST and that cortisol reactivity is a decisive factor in behavioural performance. In women, low responders had slightly elevated cortisol levels after the TSST, which improved their IGT performance, whereas high responders had highly elevated cortisol levels, which hindered performance. In men, overall increases in cortisol levels impaired their IGT performance. It is reasonable to consider these responder differences may have differently affected our participants' cognitive performance. Moreover, our sample size was divided in half in order to observe sex differences, which presented as a limitation. Further studies should increase sample size to aid in better controlling for individual differences when assessing the effects of stress on cognitive performance tasks.

As previously mentioned, differences in cognitive performance as a result of differences in stress response may be due to the nature of a stressor. Preston *et al.* (19), Plessow *et al.* (44) and Van den Bos *et al.* (45) used public speaking stressors, which may produce a phenomenon called social-evaluative threat. (13) This occurs when important aspects of one's identity have the potential to be negatively judged by others. Because participants in our study were required to speak on a topic of their choice, this implies a social-evaluative threat and may be stress eliciting. It has been shown that women are more sensitive to social rejection, as they tend to respond to stress in more socially oriented ways (38,48), so it could be expected that women may be more susceptible to the social-evaluative components of the TSST. However, women seem to be less sensitive to the TSST than men. (17,35) Previous findings suggest that men are more sensitive to the achievement components of the TSST (48) and exert more effort in response to the challenges. (39) Accordingly, men may interpret stressors differently than women and depending on the type of stressor used, men or women may be more sensitive to its effects. Future research should take the type of stressor into account.

Our results showed high effort avoidance in women but not in men. This study did not reveal results consistent with our hypothesis which predicted that stress induction would impair cognitive performance such that participants would make more errors and avoid effort. Potential factors that led to these results include individual biases in effort exertion (Demand Avoiders versus Seekers), differences in stress response, and type of stressor. It may be beneficial for future studies to investigate these confounding factors and control for their effects. Nevertheless, given the increasing evidence of prefrontal cortex involvement in the regulation of the HPA axis, it is important to find reliable methods to reduce or prevent stress-induced cognitive impairments.

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