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(A lack of) effects of acute social stress on attentional bias to threat

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ABSTRACT

Attentional biases toward or away from emotionally evocative stimuli have been well documented and are known to be clinically relevant, making it important to understand how various factors contribute to them. Some work has suggested that acute stress modulates attentional biases, but this work has produced inconsistent results. For example, many studies have found that stress enhances attentional bias, others that stress decreases attentional bias, and others still that there is no effect of stress at all. Methodological differences may explain these inconsistencies. For example, discrepancies exist between studies in participant sex (e.g., mixed sample vs. all men) and in the type of attentional bias paradigm. We addressed these gaps by examining the effects of an acute social stressor (vs. control) on attentional bias assessed via facial dot probe, focusing on potential sex differences in these effects ($N = 141$). We found that, overall, participants were significantly biased towards threat, but biases did not differ by stress condition or sex. These findings help to clarify the existing discrepancy in the literature, as we found that stress exerts little if any effect on attentional bias assessed via a facial dot probe.

1. Introduction

Today more than ever, people are exposed to an incredible amount of information and stimuli almost constantly [1]. Consequently, our minds must be selective about the stimuli to which we choose to give our finite attentional resources. These biases in attention and perception can be influenced by motivations, goals, personality traits, and other factors [2]. Specifically, attentional bias to threat (i.e., the tendency for people to focus on threatening stimuli while avoiding others) is something that can vary depending on individual differences and the specific context in which the stimuli are presented [3–6]. This study examined how one context—namely, acute social stress—influences attentional bias.

How exactly acute social stress influences attentional biases is unclear. For example, some studies have found that acute stress reduces attentional bias towards threats [3,7,8]. These studies generally attribute this effect to as a sort of recognition that one does not have the necessary cognitive resources to handle additional emotional regulation and therefore avoid negative stimuli as much as possible. Conversely, other studies have found that acute stress enhances attentional biases toward negative stimuli [9–12]. Specifically, these studies have found that acute stress and elevated levels of cortisol are associated with increased attentional bias towards negative stimuli. This enhancement in biases towards negatively valenced stimuli from acute stress is consistent with the theory of arousal-biased competition [13], which posits that physiological arousal enhances attention towards emotionally arousing stimuli. Although this theory has much support within the literature [14–19], stress-related arousal has faded by the time attentional bias effects have been observed in previous work on stress and attentional bias (e.g., Refs. [7,8,20]. As a result, this theory offers a useful framework for understanding early stress effects, and other perspectives may be helpful for understanding additional discrepancies in the stress and attentional bias literature.

Differences in study designs may explain the above discrepancies. First, three studies which found that stress enhances attentional bias did not include a no-stress control group [9,10,12]; instead, each of them compared performance pre-stressor with performance post-stressor. These studies thus confound stress with practice effects and in doing so prohibit inference about whether stress or practice changed attentional bias from the first to second assessment [21]. Additionally, the fourth study that found an enhancing effect of attentional bias used an unconventional paradigm, having the stressor occur during the attention task rather than prior to, which could potentially impact the results [11]. In contrast, in two studies that found a decrease in attentional bias under stress [7,8] found it when participants were randomly assigned to either a stress or control condition and attentional bias was assessed only after the stressor. Importantly, however, both studies that found a decrease in

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attentional bias when using random assignment exclusively tested male participants [7,8]. The previously mentioned studies that found an enhancing effect of stress on attentional bias all recruited both males and females, and one of those studies found that stress increased attentional bias towards threat specifically in female participants [9]. Stress has been found to differentially affect other cognitive processes, including memory performance, working memory, and emotion regulation, in men and women [22–24]. Given the role of these cognitive processes in informing schema-driven processes [25], attenuating attention to threat [26,27], processing threatening and stressful stimuli [28,29], sex differences should be explored as a potential explanation for the discrepancy in the literature.

1.1. Current research

The current study aims to address the gap in our understanding of the effects of stress on attentional biases by examining whether sex differences exist within the effects of an experimental manipulation of acute stress on attentional bias. To this end, we recruited 141 young adults and randomly assigned them to an acute stress (Trier Social Stress Test; [30] or control condition. Participants subsequently completed a modified facial dot-probe task—with angry, happy, and neutral faces—, which allowed us to quantify their attentional biases. We did not have strong hypotheses about how stress would influence attentional bias, as our primary goal in the study was to determine whether sex differences explained a discrepancy present in the literature in the effects of stress on attentional bias.

2. Method

2.1. Participants

One hundred fifty-two participants were recruited from the university psychology subject pool and were compensated for their participation with course credit.[1] Individuals were ineligible to participate in the study if they were using hormonal contraceptives, had a major physical health disorder, had current insulin-dependent diabetes, had a history of strokes or seizures, were currently pregnant or nursing, had been diagnosed with Post-Traumatic Stress Disorder, were taking inhaled beta-agonists, had taken oral or parenteral corticosteroids within the past 3 months, had had any major sleep disturbances in the past six weeks, had been sick or ill within the past week, or drink more than 8 caffeinated beverages in a day. Eleven participants were excluded for low effort responses: Four were excluded because of the number of trials to which they responded faster than 200 ms or slower than 2000 ms ($M = 16.5$ trials), and seven were excluded because their responses indicated they were randomly pushing buttons rather than following task directions (i.e., accuracy below 70% prompted manual inspection of data files, and change in response style to single-key responding or similar random pressing was the exclusion criterion). As a result, 141 participants' data were analyzed ($M_{age} = 19.07$, $SD = 1.77$, 59.6% female). A post hoc power analysis determined that this sample size achieved 85% power to detect an effect size obtained in a similar study [7]; $\eta_p^2 = 0.177$) in a one-tailed test. Including all participants did not influence any of the following conclusions. Participants were randomly assigned to either the stress condition ($N = 69$, 57.9% female) or the control condition ($N = 72$, 61.1% female). Of this sample, 81.56% identified as White, 6.38% as Hispanic, 6.38% as Asian, 4.96% as Black, and 0.71% as Native Hawaiian or Pacific Islander.

2.2. Materials

2.2.1. Stress

Acute social stress was manipulated using a modified Trier Social Stress Test, adapted for Zoom (see also [31,32], which includes both a stress induction experimental condition and a non-stressful control condition. Participants in the stress condition were given 4 min to prepare a speech in which they described their qualifications for a hypothetical job. This speech was then presented in front of a panel of two neutral evaluators via Zoom. Participants were required to speak for a full 10 min. If they stopped before the full 10 min had elapsed, the evaluator instructed them to continue speaking. Evaluators were instructed to stare into their webcams rather than look at the computer screens so that participants felt as if the evaluators were looking directly at them. Evaluators also wore either lab coats or formal attire that looked psychologically cold and distant and were sat in front of a solid black background. Afterwards, participants were then asked to count backward from 2934 in steps of 13. Participants were periodically instructed to count faster, and if they made a mistake or stopped counting for too long, they were instructed to start over from 2934. During the mathematics task participants were told to count faster after 90 s, 180 s, and 240 s had elapsed. The task ended after 4 min had elapsed. In contrast, participants in the control condition were instructed to sit in silence for 4 min, before being instructed to speak quietly to themselves, unobserved, for 10 min. They were then instructed to count to 30 to themselves as often as they would like for 4 min.

2.2.2. Negative affect

Immediately prior to and after the stress or control task, participants self-reported their current affect using the Positive and Negative Affect Schedule [33]. Items pertaining to negative affect (i.e., distressed, upset, guilty, scared, hostile, irritable, ashamed, nervous, jittery, and afraid) were summed to create a negative affect composite. Baseline affect was assessed ($\alpha = 0.73$) along with affect immediately following the stressor ($\alpha = 0.87$).

2.2.3. Cortisol

Participants provided two saliva samples (baseline and post-manipulation) using the passive drool method. Following collection, saliva samples were stored in a −20 °C or −80 °C freezer (depending upon space available) until assayed using high-sensitivity Salivary Cortisol ELISA Kits from Salimetrics according to manufacturer instructions. Assay sensitivity is < 0.007μg/dL. Values were converted to nmol/L for consistency with most stress and cognition literature.

2.2.4. Attentional bias

Attentional bias was assessed via a modified facial dot-probe task. Sixty images were taken from the NimStim Set of Facial Expression [34]. These images consisted of 20 individuals, each posing with happy, angry, and neutral expressions. Both happy and angry faces were chosen in order to separate biases in attention towards negative faces specifically from biases in attention towards emotionally valenced faces. Images were selected based upon whether 80% of a sample correctly identified the emotion shown in the image, based upon ratings obtained by Tottenham et al. Each happy and angry face was paired with a neutral face from the same model to create Happy-Neutral and Angry-Neutral pairs. Additionally, five models were chosen to have neutral faces paired with a neutral face. The location of faces (i.e., left or right) in a pair was randomly determined. The faces were presented on a white

[1] This was part of a larger study recruiting a total of 187 participants. Of the 187 participants, 35 were unable to run the task due to miscommunications via Zoom (e.g., clicking on the wrong icon on the desktop and skipping the task entirely). Only 152 participants opened and completed the dot probe in the correct order.

[2] Additional analyses were conducted to specifically examine differences between angry and happy interference, as neutral faces may play a negative stimulus role on happy trials. Difference scores were generated by subtracting happy interference from angry interference. A type III ANOVA was conducted to assess difference scores by condition and sex. There was no significant main effect of condition, $F(1, 135) = 1.14$, $p = .287$, and no significant main effect of sex, $F(1, 135) = 0.88$, $p = .348$. Additionally, there was no significant interaction between condition and sex, $F(1, 135) = 0.68$, $p = .411$.

background. The task consisted of 20 Angry-Neutral pairs, 20 Happy-Neutral pairs, and 5 Neutral-Neutral pairs randomly presented on a white background and repeated 3 times, for a total of 135 trials. Each trial began with a fixation cross presented for a random interval between 500 and 1000 ms in the center of the screen. The face pair then appeared and was displayed for a random interval between 1400 and 1700 ms. These presentation timings were determined from piloting the task; during piloting, these timings best produced indices of attentional bias given other task parameters. The faces then disappeared and were replaced with a small X or K centered on the face image location, with the X or K being randomly placed behind either the left or right face. Participants were told to press the "A" key if the X was on the left side of the screen and the "L" key if the X was on the right side of the screen. Trials where the X was behind the neutral face are referred to as "emotion-incongruent" and trials where the X was behind the emotional face are referred to as "emotion-congruent". Additionally, interference variables were created for emotional trials by subtracting the mean reaction time for correct congruent trials for a given emotion from the mean reaction time for correct incongruent trials, in order to assess how much interference was generated by the presence of a given face (Fig. 1).

2.3. Procedure

Participants were brought into an isolated room in the lab and presented with an informed consent form after joining a Zoom call. They were then instructed to rinse their mouth out, as they would provide saliva samples during the study. They then completed various questionnaires for approximately 5–10 min in order to acclimate them to the laboratory environment. After the questionnaires were completed, a baseline saliva sample was collected via instructions from a remote research assistant, followed by the baseline affect assessment. Participants then completed either the Trier Social Stress Test or the control condition task. Both the experimental condition and control condition of the TSST took 18 min to complete. Post-stressor/control condition, participants first completed the post-manipulation affect assessment, followed by various questionnaires for 10 min, before another saliva sample was collected. Finally, participants completed various cognitive tasks, including a modified facial dot-probe task in which either a Happy-Neutral, Angry-Neutral, or Neutral-Neutral pair of faces was shown. The dot-probe task took place approximately 28 min post-stressor (Fig. 2).

2.4. Data analysis

Behavioral analyses examined whether there was a significant difference in interference (i.e., the difference between mean reaction time for congruent and incongruent trials for a given stimulus type) between stimulus types and whether the level of interference for each of the three stimulus types was significant different from zero. Additionally, ANOVAs were conducted to assess whether participant reaction time differed as a function of sex, stress condition, trial congruence, and stimulus type. ANOVAs were conducted both including and excluding trials with Neutral facial pairs, in order to determine whether their inclusion had a significant impact on the overall results. All data analyses were conducted using R, version 4.1.2, with Type III SS ANOVAs (with orthogonal contrasts) conducted using the car package, version 3.0–12.

3. Results

3.1. Preliminary analyses

We first examined whether negative affect and salivary cortisol changed from baseline to post stressor, and whether that change differed between conditions. In a 2x2 repeated-measures ANOVA predicting negative affect from Condition (stress, control) and Time (baseline, post-manipulation), significant main effects of Condition, $F(1, 137) = 20.83$, $p < .001$, and Time, $F(1, 137) = 27.98$, $p < .001$, emerged, along with a significant Condition × Time interaction, $F(1, 137) = 55.58$, $p < .001$. Examining the Condition × Time interaction we found that participants in the stress condition had significantly greater negative affect post-manipulation ($M = 20.2$, $SE = 0.707$) than baseline ($M = 13.8$, $SE = 0.488$), $t(137) = -8.92$, $p < .001$. In contrast, participants in the control

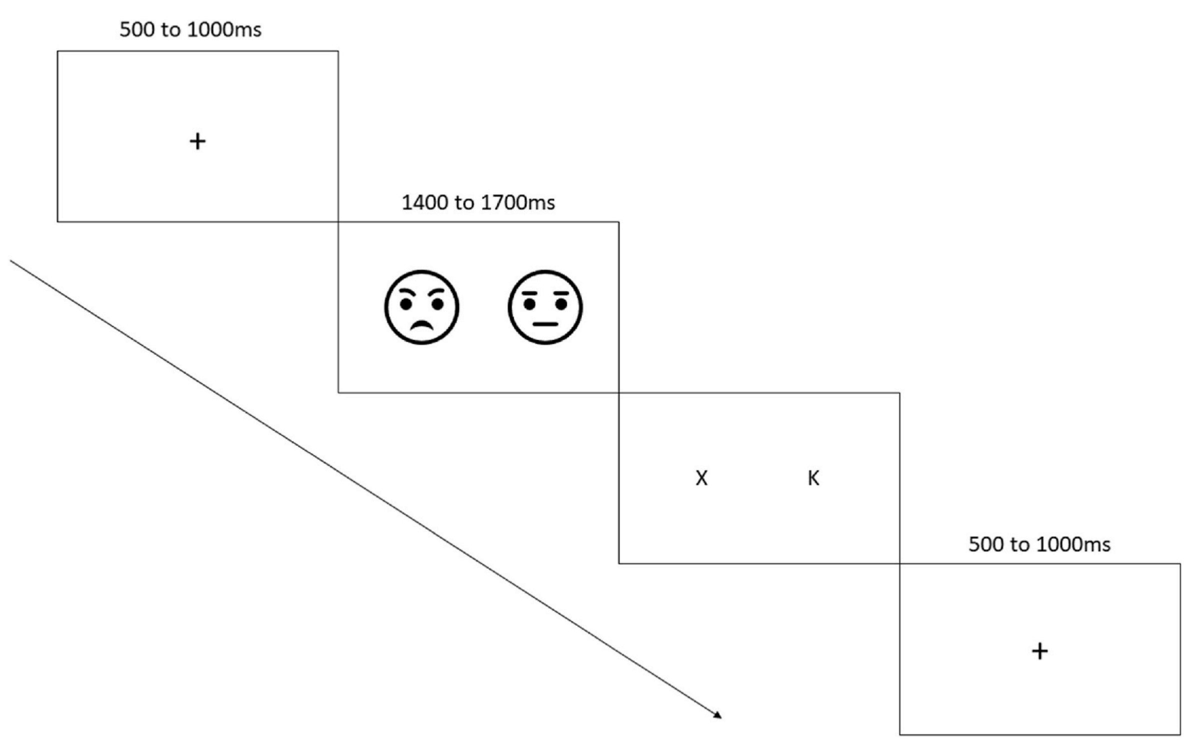

Fig. 1. An example angry congruent trial from the modified facial dot-probe task. Faces shown are a graphical representation of faces used. Photographs taken from the NimStim Set of Facial Expressions were used in the actual trials.

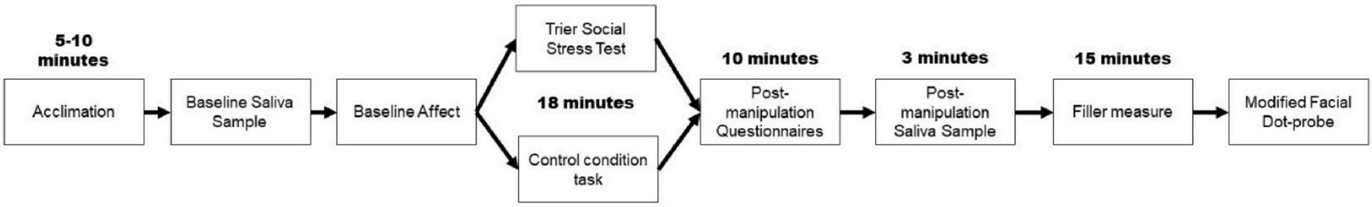

Fig. 2. General procedures and timing for the study.

condition had no significant change in affect from baseline to post-manipulation, $t(138) = 1.55$, $p = .124$. Raw change in salivary cortisol was then examined. In a 2x2 repeated-measures ANOVA predicting salivary cortisol from Condition and Time, a significant main effect of Condition emerged, $F(1, 122) = 4.27$, $p = .041$, and a significant Condition × Time interaction emerged, $F(1, 122) = 14.91$, $p < .001$. Examining the Condition × Time interaction, we found that participants in the stress condition ($M = 10.71$, $SE = 0.727$) had significantly higher cortisol post-manipulation than participants in the control condition ($M = 7.01$, $SE = 0.727$), $t(122) = 3.60$, $p < .001$. In contrast, baseline cortisol did not significantly differ between the two conditions, $t(122) = 0.346$, $p = .730$ (Fig. 3).

3.2. Behavioral analyses

Interference values for angry and happy faces were analyzed to determine whether they significantly differed from zero and significantly differed from one another. Angry interference ($M_{angry} = 10.90$, $SE_{angry} = 4.63$) was significantly different from zero, $t(138) = 2.36$, $p = .019$, such that participants responded 10.90 ms faster when the angry face was target-congruent than when the neutral face was target-congruent. Happy interference ($M_{happy} = -4.66$, $SE_{happy} = 4.16$) however was not significantly different from zero, $t(138) = -1.03$, $p = .306$. Furthermore, interference from angry faces was significantly greater than interference from happy faces, $t(138) = 2.34$, $p = .021$. When comparing stimulus interference by stress condition, there was no significant difference between stress groups for angry interference and happy interference, $ps > .215$. Finally, when comparing stimulus interference by both stress condition and sex, there was no significant effect of stress on angry interference, $F(1, 135) = 0.17$, $p = .683$, or happy interference, $F(1, 135) = 1.41$, $p = .238$, and there was no significant effect of sex on angry interference, $F(1, 135) = 0.01$, $p = .952$, or happy interference, $F(1, 135) = 0.67$, $p = .415$. Furthermore, there was no significant interaction effect between stress and sex on angry interference, $F(1, 135) = 1.59$, $p = .210$, or happy interference, $F(1, 135) = 0.006$, $p = .937$ (Fig. 4).

Finally, change in cortisol was examined as a predictor of angry interference and happy interference. Cortisol was not associated with angry or happy interference no matter the approach to quantifying change in cortisol, $ps > .135$ (see Supplemental Material).

3.3. Exploratory analyses

We examined a number of potential moderators of the potential effect of stress on attentional bias. These analyses were largely nonsignificant and are presented in the Supplemental Material.

4. Discussion

The purpose of this study was to investigate how exposure to an acute social stressor affects attentional bias to threat. Although we found evidence for attentional bias towards angry faces, we did not find that acute social stress affected attentional bias in either men or women.

Attentional bias to threat is a finding that is well documented throughout the literature [35–37]. This study thus replicated prior work finding that people respond faster to targets when they occur where an angry face was located than when they occur where a neutral face was located. Additionally, the present study only found evidence of attentional bias towards angry faces, with no evidence of bias for or against happy faces (vs. neutral faces)[2]. This finding suggests that individuals are specifically biased towards threat rather than just emotionally salient stimuli.

Prior work had obtained discrepant findings regarding the effects of acute stress on attentional bias to threat, which we attempted to resolve with this study. We hypothesized that this discrepancy may be due to methodological differences in utilizing randomly assigned stress/control groups, using both male and female participants, or other methodological decisions related to attentional bias. When using randomly assigned stress/control groups, recruiting both male and female participants—and exploring sex differences in our analyses[3]—, and assessing attentional bias via a facial dot-probe task, we found no evidence that acute social stress significantly affects attentional bias to threat, no evidence of significant sex differences in attentional bias, and no significant interaction between stress and sex. Hypothesized changes in methodology explain differences in results between the present study and prior studies that found an enhancing effect of stress on attentional bias. However, many of the studies that found a reduction in attentional bias following acute stress utilized random assignment to a stress or control group and assessed attentional bias post-stress using a dot-probe task [7,8]. The present study provides evidence that discrepant findings within the literature may be in part due to methodological differences between studies examining attentional bias, though discrepancies still exist between the findings in the present study and studies utilizing similar experimental design—described below.

There are a number of factors that may explain the discrepancy between the results obtained in our study and the results of prior studies. First, prior studies obtained more nuanced results rather than direct effects of a stress condition on attentional bias, as did the current study. For instance, Ref. [8] specifically found evidence of attentional bias when using a modified facial dot-probe that contained go/no-go trials, with a difference in response accuracy being observed between congruent and incongruent trials in the control group but not in the stress group specifically on no-go trials. Given that the dot-probe used in the present study did not contain go/no-go trials, and that attentional bias was assessed via changes in reaction time, the difference in findings is more understandable. Additionally, [7] found attentional bias

[3] Additional analyses examining menstrual phase as a predictor of attentional bias were conducted. Participants were asked to report the first day of their last period, and the difference in time between their dates of participation and their responses were then used to approximate their phase as follicular phase (1–14 days), luteal phase (15–40days), or non-menstruating (>40 days or self-reported male) based on responses. A type III ANOVA was conducted to assess attentional bias to angry faces by condition and menstrual phase. No significant main effect of phase was observed, $p = .095$. Additionally, no significant interaction between condition and phase was observed, $p = .078$. Similar analyses were conducted to assess attentional bias to happy faces by condition and menstrual phase. No significant main effect of phase was observed, $p = .992$. Additionally, no significant interaction between condition and phase was observed, $p = .963$.

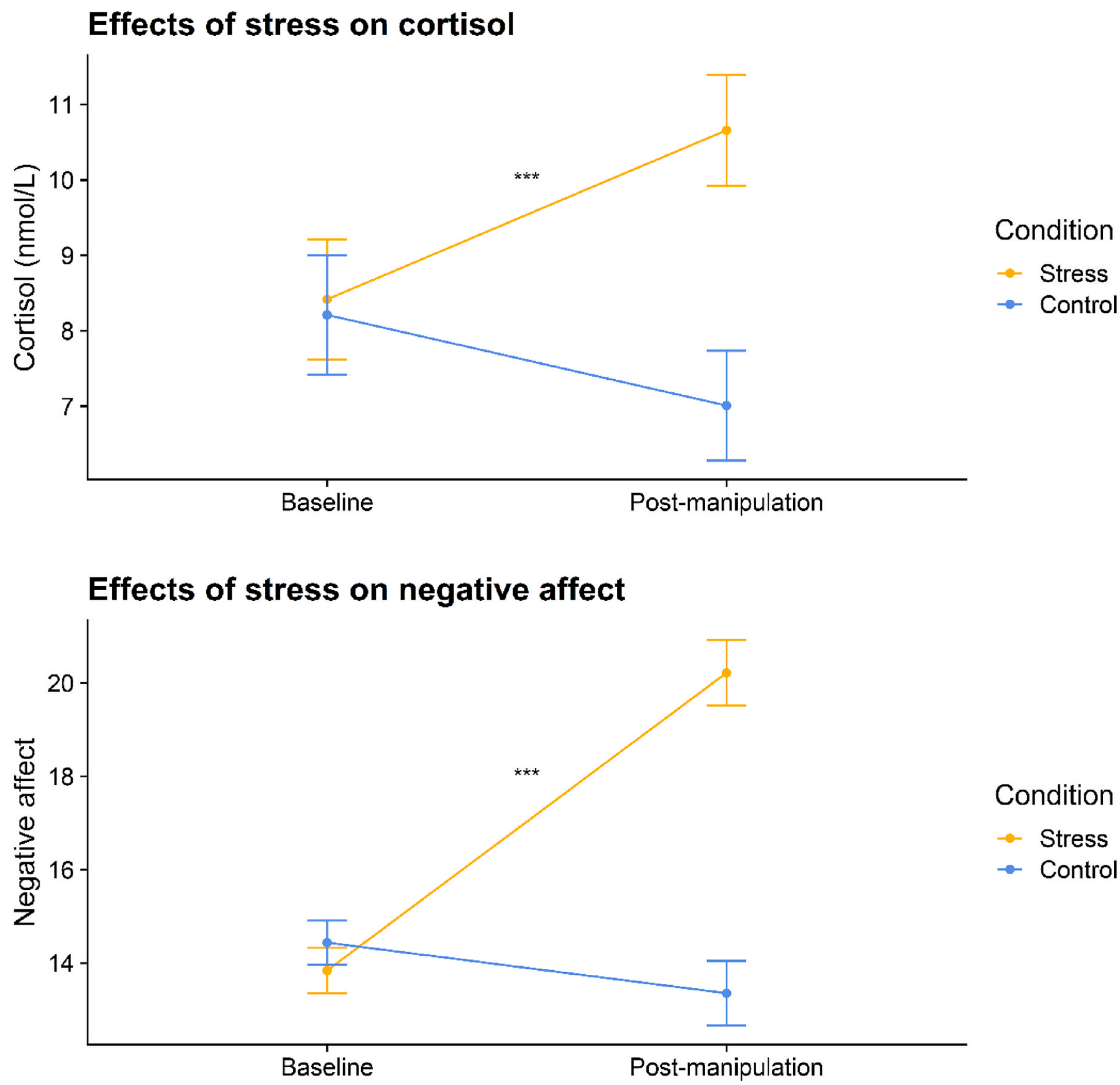

Fig. 3. Change in cortisol and negative affect from baseline to post-manipulation by stress condition. Participants in the stress condition had significantly higher cortisol and significantly more negative affect post-manipulation than at baseline, while participants in the control condition had no significant change. ***$p < .001$, **$p < .01$, *$p < .05$.

specifically regarding differences in visual fields, rather than an overall difference in reaction time. However, even when accounting for the position of the probe and the emotional face when presented, we failed to replicate the results obtained by Brüne et al.[4] Finally, one study in the literature [20] found no effect of acute stress on attentional bias to threatening faces. The study conducted by Ref. [20] utilized a facial dot-probe task, random assignment, but notably included only male participants. Additionally, their facial dot-probe task took place at a similar time as the one in the current study (approximately 25 min post-stressor). However, the study conducted by von Dawans et al. differed with ours in several key ways. While we used an individual TSST adapted for use over Zoom, von Dawans et al. used an in-person Trier Social Stress Test for Groups. Additionally, facial stimuli in the study conducted by von Dawans et al. were presented for approximately 500 ms whereas our stimuli were presented for approximately 1550 ms.The study conducted by von Dawans et al. also had a sample size of 54 men, whereas the current study had a sample of 141 men and women. These results suggest that the subtle differences between our paradigm and von Dawans' are not sufficient for producing an attentional bias effect.

Finally, the present study observed no significant association between change in salivary cortisol and attentional bias to angry or happy faces. The present study assessed attentional bias approximately 28 min post-stressor. Prior work has shown that the difference between cortisol in stress and control groups is often still increasing at 28 min post-stressor [17,38]. This suggests that different results may have been obtained with a different delay. However, the delay used in the present study was done to be consistent with prior working regarding the effects of acute stress on attentional bias [10]. Nevertheless, future research

[4] A type III repeated measures ANOVA was conducted to assess mean reaction time for each combination of probe location and emotional face location There was no significant interaction between stress group, probe location, and emotional face location, $F(1, 135) = 0.996$, $p = .320$. Additionally, there was no significant four way interaction between sex, stress condition, probe location, and emotional face location, $F(1, 135) = 0.402$, $p = .527$, and no significant five way interaction between sex, stress condition, probe location, emotional face location, and face expression, $F(1, 135) = 0.093$, $p = .761$. Additionally, we analyzed interference scores themselves as function of stress, sex, and face location (data not shown), with no significant interaction between stress and face location observed.

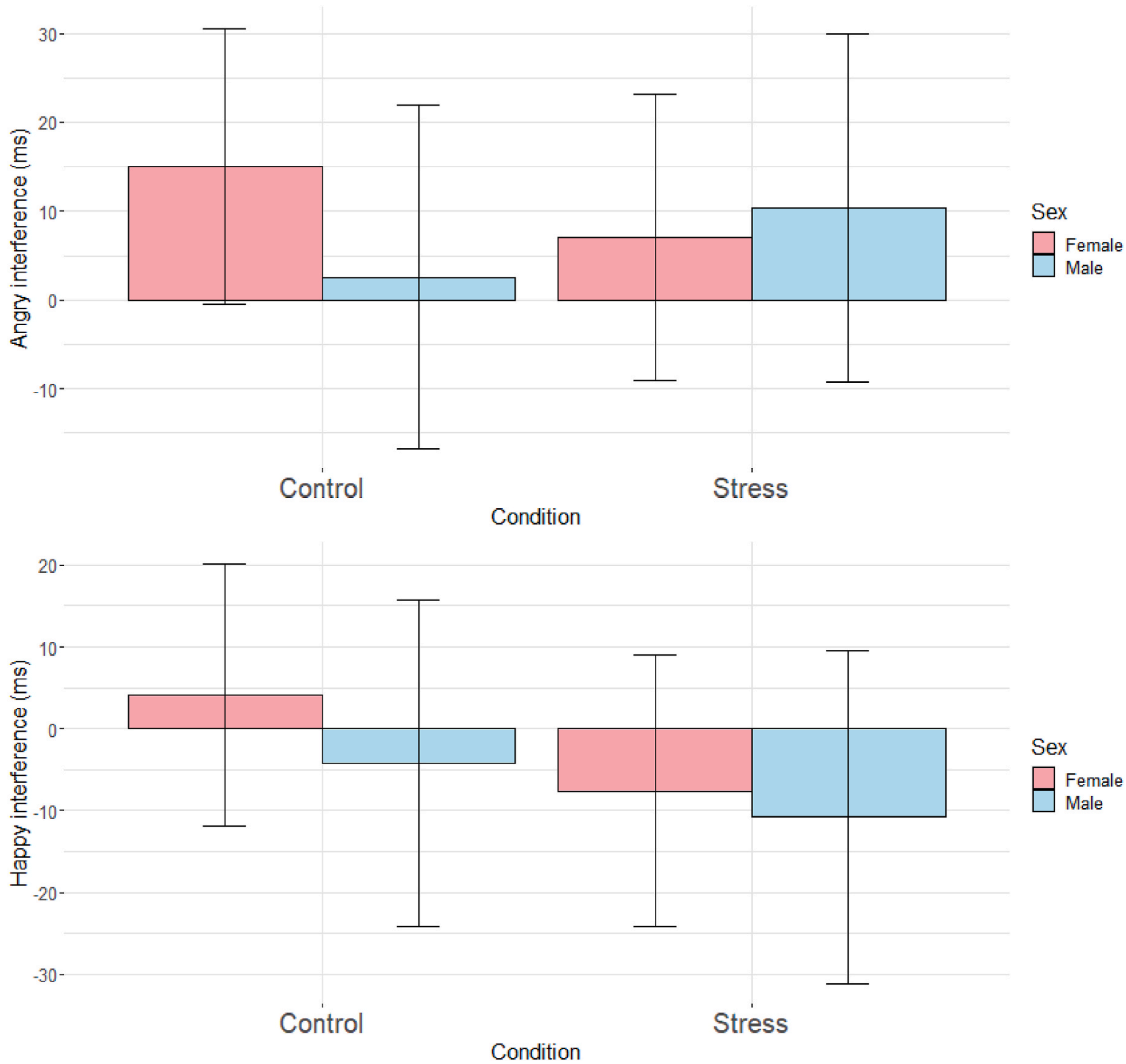

Fig. 4. Interference from angry faces and happy faces by stress condition and sex. No significant main effect of condition or sex, or a significant interaction between the two, was observed for angry interference or happy interference.

should consider examining variable delays between the stressor and the attentional bias task as a potential predictor of changes in attentional bias.

Might there be conditions in which acute social stress would affect attentional bias? Yes, and we do not claim otherwise. For example, stress may differentially affect automatic vs. top-down attentional processes, which may differentially influence attentional bias as a function of stimulus presentation time. We presented facial stimuli for 1400 ms–1700 ms. It is possible that we might have found an effect of stress on attentional bias if we had assessed it following shorter stimulus presentation times, making other attentional processes more important in attentional bias effects than they were in our paradigm [39,40]. However, this explanation requires further study to address with certainty. Furthermore, the theory of arousal-biased competition would suggest that arousal following a stressor should further bias attention towards emotionally valenced stimuli. However, although we observed a bias towards angry faces, we found no significant effect of stress. This may suggest that the negative affective components of the stress response could be related to decreases in attention towards emotional stimuli, thus nullifying the enhancements from physiological arousal.

Although this study has a number of strengths, there are also some limitations that should be mentioned. First, data collection was conducted during the COVID-19 pandemic, which has been found to impact stress resilience, mental health, and immune responses in a variety of ways [41–43]. As a result, stress-related results should be considered in the context of social distancing during a global pandemic. Related, another potential limitation is the stressor used in this study. Because we conducted this study under lingering safety-focused COVID-19 protocols, we adapted the Trier Social Stress Test for use over Zoom, as has been done with adolescents [31,32]. It may be possible that the in-person version of the TSST is perceived as more stressful, and results in a more severe stress response. This difference in severity could potentially account for the observed difference in findings between the present study and previous studies in the literature. Third, as described above, there may be specific task conditions necessary to eliciting stress-induced differences in attentional bias, and although these conditions, if they exist, are not entirely clear, we only assessed attentional bias using a single task that may have lacked these conditions. The current study only examined the effects of an acute social stressor, the TSST. While this measure is common in prior attentional bias work, different findings may have been observed had we used other stress paradigms. Similarly, there is a great deal of variability in attentional bias tasks throughout the literature [8,10,12,20]. Although the one used in the current study's attentional bias task parameters were determined based on piloting task variants, with the chosen task best producing attentional bias effects in those pilot data, there are multiple attentional processes that could be modified by stress and influence attentional bias (e.g., Refs. [44–46]. For example, if stress increases early attentional facilitation towards threat but also decreases difficulty of disengagement, stress would dynamically influence attentional bias to threat but in a way that is difficult to detect within our paradigm. As such, there may be task-related differences in acute stress effects on attentional bias, depending upon the attentional processes most strongly contribute to biases within a given task. Future research should examine the effects of multiple types of stress as well as varying stress durations on attentional bias to threat using a variety of attentional tasks, such as those that can disentangle attentional facilitation from difficulty of disengagement and inhibition of return (e.g., Ref. [44]. Sixth, the present study observed no significant association between change in salivary cortisol and attentional bias to angry or happy faces. Although significant cortisol differences were observed between conditions, the timing used may not have fully characterized cortisol recovery. Cortisol was primarily assessed to confirm a stress response, rather than to characterize a biological mechanism, as the stress effect itself on attentional bias is what was of most interest in the current study[5]. Future research should analyze cortisol at multiple time points post-stressor in order to examine how cortisol recovery is related to attentional bias. The present study assessed attentional bias approximately 28 min post-stressor. Prior work has shown that the difference between cortisol in stress and control groups is often still increasing at 28 min post-stressor [17,38]. This suggests that different results may have been obtained with a different delay. However, the delay used in the present study was done to be consistent with prior working regarding the effects of acute stress on attentional bias [10]. Nevertheless, future research should consider examining variable delays between the stressor and the attentional bias task as a potential predictor of changes in attentional bias. Work examining these dynamics should particularly focus on placing the attentional bias task immediately after the manipulation in order to best capture the effects of catecholamines. Furthermore, although face images were selected based on emotional ratings from the NimStim Set of Facial Expression [34], participant emotional ratings for each face were not obtained. Individual interpretations of emotions can vary. Therefore, future research should ask participants to rate the valence of each face after trial completion. Furthermore, positive and negative affect are not monolithic. There are a number of different positive or negative emotions that may evoke attentional biases differently and may be differentially affected by acute social stress. Future research should examine a multitude of face types (sadness, disgust, amusement, etc.) in addition to happy and angry faces[6]. Finally, participants were recruited from university courses. As a result, the sample as a whole were relatively young and came from a Western, Educated, Industrialized, Rich, and Democratic (WEIRD) society [47], which impacts the generalizability of our findings to larger samples.

[5] Time of day analyses were conducted to determine whether the time participants completed the study interacted with stress to affect attentional bias. A type III ANOVA was conducted to assess attentional bias to angry faces by condition, sex, and time of day. A marginal interaction between sex and time of day was observed, $p = .065$, such that there was a marginal sex difference among participants that completed the study in the morning but no such difference for afternoon participants. No significant interaction between condition and time of day and no significant three-way interaction between condition, time of day, and sex were observed, ps > .113. The same analyses were conducted with attentional bias to happy faces as the outcome of interest. No significant interaction between sex and time of day, condition and time of day, or the three-way interaction was observed, ps > .759.

[6] Interference scores were re-generated and primary analyses conducted only using trials containing emotional faces with a rating of at least 90% from the NimStim set. Using these interference scores, we found similar results as our primary analyses: Angry interference significantly differed from zero, $p = .020$, but happy interference did not, $p = .306$. Additionally, there was no significant effect of condition or sex on angry interference, ps > .210, or on happy interference, ps > .777.

5. Conclusion

A discrepancy in the literature exists regarding the effects of acute stress on attentional bias to threat. We found that participants randomized to an acute social stressor did not show significantly different attentional bias than participants that completed a control task, though we did find overall participants across groups were attentionally biased toward threat. Our findings help to clarify the discrepancy in the prior literature, as methodological differences (i.e., differences in stress paradigm, attentional bias measure, procedures, etc.) may preferentially affect varying aspects of attentional bias to threat in different ways. While the present study did not find an effect on biases to threat from an acute social stressor, it opens future avenues of research examining the processes that are responsible for attentional biases and the methodological differences that affect them.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cpnec.2023.100195.

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