Acute Stress Interference with Attentional Disengagement from Emotional Faces: An Eye-Tracking Study

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Abstract

Acute stress can affect individuals' covert attention bias toward emotional stimuli, but how it influences overt attention bias remains unclear. This study employed eye-tracking methodology to have participants complete an attentional orienting-disengagement task under stress, investigating the mechanisms through which acute stress influences overt attention bias toward positive and negative emotional faces. The results revealed that the stress group exhibited significantly higher cortisol concentrations, anxiety states, and negative emotions compared to the control group, while positive emotions were significantly lower. At the behavioral level, the stress group showed significantly slower attentional orienting toward positive faces than the control group, with no significant difference for negative faces; the stress group demonstrated significantly slower attentional disengagement from both positive and negative faces compared to the control group. In terms of eye movements, no significant differences were observed between the two groups in attentional orienting toward positive and negative faces; the stress group experienced greater difficulty disengaging attention from negative faces compared to the control group, while no significant group difference was found for disengaging from positive faces. These findings indicate that acute stress impairs individuals' attentional disengagement from negative stimuli, which may be attributable to acute stress-induced disruption of attentional functions associated with the brain' s frontoparietal network.

Full Text

The Interference Effect of Acute Stress on Attentional Disengagement from Emotional Faces: An Eye-Tracking Study

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Abstract

Acute stress affects individuals' covert attentional bias toward emotional stimuli, but its impact on overt attentional bias remains unclear. This study employed eye-tracking methodology to investigate the mechanisms through which acute stress influences overt attentional bias toward positive and negative emotional faces by having participants complete an attentional orienting-disengagement task under stress. The results revealed that the stress group exhibited significantly higher cortisol concentrations, anxiety levels, and negative affect compared to the control group, while positive affect was significantly lower. Behaviorally, the stress group showed significantly slower attentional orienting to positive faces, with no significant difference for negative faces; however, attentional disengagement from both positive and negative faces was significantly slower in the stress group than in the control group. Eye-tracking data showed no significant between-group differences in attentional orienting to either positive or negative faces. Critically, the stress group demonstrated greater difficulty disengaging attention from negative faces compared to the control group, whereas no significant group difference emerged for positive faces. These findings indicate that acute stress impairs attentional disengagement from negative stimuli, possibly due to stress-induced disruption of attentional functions associated with the frontoparietal network.

Keywords: acute stress; overt attention; attentional disengagement; eye-tracking

1 Introduction

Acute stress influences attentional bias toward emotional stimuli [?, ?, ?], yet existing research has predominantly focused on negative stimuli (e.g., threat-related cues) [?, ?, ?, ?, ?], with comparatively less investigation of positive emotional stimuli (e.g., happiness) [?, ?]. Furthermore, prior studies have primarily examined covert attentional bias, leaving overt attentional bias relatively unexplored. The present study therefore utilizes eye-tracking technology to investigate the cognitive mechanisms underlying acute stress effects on overt attentional bias toward both positive and negative emotional stimuli.

Attentional bias toward emotional stimuli refers to the tendency to allocate attentional resources preferentially to emotional over neutral stimuli [?, ?], manifesting as facilitated attentional engagement, difficulty in attentional disengagement, and attentional avoidance [?, ?]. Facilitated engagement describes faster attentional shifts toward emotional stimuli, while disengagement difficulty refers to impaired ability to withdraw attention from such stimuli [?, ?]. Attentional avoidance involves directing attention away from emotional stimuli entirely [?, ?]. Although attentional avoidance often serves as a strategy to reduce depressive or anxious symptoms, facilitated engagement and disengagement difficulty are implicated in the onset and maintenance of anxiety and depression, consequently receiving greater research attention [?, ?]. Neurobiologically, facilitated engagement likely involves the amygdala-anterior cingulate cortex network [?, ?], whereas disengagement difficulty may result from failed top-down attentional control by the dorsolateral prefrontal cortex, implicating the broader frontoparietal network [?, ?]. For instance, Mueller et al. [?, ?] observed that threat stimuli elicited larger P1 components using ERP technology, and other research has found greater N2pc amplitudes for threat versus neutral stimuli in dot-probe tasks [?, ?]. These findings suggest that threat stimuli enhance primary visual cortex activation, with the amygdala serving as a key neural mechanism for threat processing that can modulate primary visual cortex activity. Bledowski et al. [?, ?] identified P3 activation associated with attentional disengagement from distractors using ERPs, a result corroborated by fMRI research. Alvaro et al. [?, ?] further demonstrated that the prefrontal cortex constitutes the primary neural mechanism for emotional face disengagement using transcranial direct current stimulation.

Attentional bias patterns vary across emotional valences. For example, depressed patients show comparable orienting to positive and negative stimuli but exhibit disengagement difficulty specifically from depression-relevant negative stimuli (e.g., sadness), while demonstrating attentional avoidance of positive stimuli but not negative stimuli [?, ?]. Anxious or depressed individuals display disengagement difficulty from negative stimuli without valence-specific differences in orienting [?, ?]. These differential patterns may reflect distinct brain activation patterns for different valences, with positive emotional images producing greater left hemisphere activation and negative images producing greater right hemisphere activation [?, ?].

Acute stress represents a nonspecific response to sudden changes in internal homeostasis when environmental demands exceed regulatory capacity [?, ?]. During stress, the autonomic nervous system rapidly releases catecholamines (norepinephrine, dopamine) and activates the hypothalamic-pituitary-adrenal (HPA) axis to release glucocorticoids. Receptors for these hormones are widely distributed in the prefrontal cortex, amygdala, and hippocampus, thereby affecting both the amygdala-anterior cingulate and frontoparietal networks [?, ?]. A recent meta-analysis employing activation likelihood estimation across various acute stress induction paradigms revealed that stress primarily activates bilateral claustrum, insula, and inferior frontal gyrus, while parahippocampal gyrus and amygdala activation decreases. The reduced amygdala activation likely reflects brief initial activation followed by emotional evaluation and regulation [?, ?]. Given the overlapping brain regions involved in acute stress and emotional attentional bias, stress can influence attentional bias. For example, Luo et al. [?, ?] used event-related potentials to investigate acute stress effects on threat-related attentional bias, finding impaired disengagement but no orienting effects. However, these studies focused exclusively on covert attentional bias without eye movements, leaving the impact of acute stress on overt attentional bias unclear.

Overt attentional bias involves eye movements accompanying attention to stimuli, such as when sudden environmental events capture attention and trigger saccades [?, ?]. Eye-tracking technology enables more direct and continuous measurement of overt attention allocation to emotional stimuli, providing indices for attentional orienting and disengagement components. Common eye-tracking measures include first fixation direction bias, first fixation latency bias, first fixation duration bias, and total fixation duration bias [?, ?]. These indices are calculated as follows: (1) First fixation direction bias = number of first fixations on emotional stimuli / valid trials in that condition, measuring initial orienting bias (scores >50% indicate orienting bias, <50% indicate avoidance). (2) First fixation latency bias = latency to emotional face - latency to neutral face, measuring accelerated detection (scores <0 indicate accelerated detection, >0 indicate delayed detection). (3) First fixation duration bias = duration on emotional face - duration on neutral face, measuring initial attentional maintenance (scores <0 indicate avoidance, >0 indicate initial maintenance). (4) Total fixation duration bias = total time on emotional stimuli - total time on neutral stimuli, measuring overall attentional maintenance (scores >0 indicate overall maintenance, <0 indicate overall avoidance). Orienting measures include first fixation direction and latency biases, while disengagement measures include first fixation duration and total fixation duration biases.

Sanchez et al. [?, ?] used eye-tracking with an orienting-disengagement task to examine attentional bias patterns in depressed individuals under acute stress, finding no group differences in first fixation direction or latency biases for positive or negative stimuli. However, for negative stimuli, depressed individuals showed significantly longer first fixation and total fixation durations than controls, and lacked positive bias, fixating on positive stimuli for less time. This indicates that acute stress affects attentional bias toward both positive and negative stimuli in depression. Macatee et al. [?, ?] similarly investigated attentional bias toward negative information in healthy individuals under acute stress and its relationship with daily anxiety, finding that attentional bias toward threat correlated with daily anxiety, with increased daily stressors leading to greater attention to threat stimuli. Research has shown that depression-related information bias is specific to dysphoric stimuli, whereas anxiety-related bias extends to general negative stimuli [?, ?]. Macatee et al.' s study focused solely on negative stimuli, neglecting positive stimuli, while Sanchez et al.' s research involved depressed patients and examined how attentional bias predicts stress recovery, using angry faces as threat stimuli. Building on prior work, we investigated acute stress effects on attentional bias toward emotional faces in healthy individuals, comparing positive and negative faces using happy, disgusted, and sad faces—the three emotions with strongest arousal levels. Research indicates that disgusted faces are more threatening than angry or fearful faces [?, ?]. According to cognitive schema consistency theory, attention biases toward information congruent with one' s emotional state (e.g., anxious individuals attend more rapidly and frequently to threat stimuli). While anxiety is associated with specific threat bias, evidence shows that anxious individuals actually exhibit bias toward general negative stimuli [?, ?]. Some researchers propose that threat bias in anxiety is automatic and unconscious, whereas bias toward other negative stimuli is conscious and selective. Anxiety may also involve insensitivity to or avoidance of positive stimuli [?, ?], with attention to positive stimuli reflecting emotional regulation strategies and recovery status. To examine attentional bias across different emotion types, we selected happy, disgusted, and sad face images as stimuli.

In summary, acute stress may influence overt attentional bias toward both positive and negative faces. This study employed the Maastricht Acute Stress Test (MAST) to induce acute stress responses, followed by an attentional orienting-disengagement task with simultaneous eye-tracking recording. Based on our previous covert attention bias findings [?, ?] and evidence that acute stress primarily affects frontoparietal network mechanisms, we hypothesized that acute stress would impair attentional disengagement from both positive and negative faces.

2 Methods

2.1 Participants

Power analysis using G*Power indicated a required sample size of 42 ($f = 0.2$, $\alpha = 0.05$, power = 0.8). Given that female menstrual cycles affect cortisol rhythms [?, ?] and recruiting women across different cycle phases was impractical, we recruited 48 healthy male adults (age 17.40–30.98 years, $M = 20.84 \pm 2.44$; BMI $= 20.72 \pm 2.97$) via convenience sampling. All participants were right-handed, had no physical or psychological disorders, had normal or corrected-to-normal vision, and had not used steroid medications within one month prior to the experiment. Participants were randomly assigned to stress and control groups. The study was approved by the university ethics committee, and participants provided informed consent before receiving compensation. Two participants were excluded due to incomplete eye-tracking data, yielding a final sample of 46 participants (stress group $n = 24$, control group $n = 22$).

2.2 Experimental Design

A 2 (Group: stress vs. control) × 4 (Emotion Pair: neutral-happy, neutral-disgusted, neutral-sad, non-attention allocation condition) mixed design was employed, with Group as a between-subjects factor and Emotion Pair as a within-subjects factor.

2.3 Materials

2.3.1 Questionnaires The State-Trait Anxiety Inventory (STAI) [?, ?], adapted by Zheng et al. [?, ?], comprises state anxiety (S-AI) and trait anxiety (T-AI) subscales, each containing 20 items rated on a 4-point scale from "not at all" to "very much so." Half the items are reverse-scored, with higher total scores indicating greater anxiety severity [?, ?]. In this study, Cronbach' s α was 0.94 for the full scale, 0.96 for state anxiety, and 0.80 for trait anxiety.

The Positive and Negative Affect Scale (PANAS) Chinese version consists of 20 emotion descriptors forming positive and negative affect subscales with 10 items each, rated on a 5-point scale from "very slightly or not at all (1)" to "extremely (5)." Subscale scores reflect current emotional states. Cronbach' s α was 0.94 for positive affect and 0.74 for negative affect.

2.3.2 Experimental Stimuli Emotional face stimuli were selected from the Chinese Affective Face Picture System (CAFPS) [?, ?]. Emotional and neutral faces of the same identity formed picture pairs (e.g., happy-neutral), totaling 240 images (half male, half female) with 120 emotional and 120 neutral faces. Based on previous research [?, ?], we selected happy, disgusted, and sad faces (40 each), with each image used only once. Images measured 10° × 7.3° visual angle and were standardized for brightness and size using Photoshop.

2.4 Procedure

The experimental procedure is illustrated in Figure 1 [Figure 1: see original paper]. Participants were contacted by phone three days prior to testing and instructed to avoid smoking, alcohol, strenuous exercise, and food consumption before the experiment. Testing occurred between 13:00–18:00. Upon arrival, participants rested for 30 minutes while baseline saliva cortisol and state anxiety data were collected twice (Time1, Time2). They then completed the 15-minute MAST stress induction task, rested for 3 minutes, and provided a third cortisol and anxiety sample (Time3). Subsequently, participants performed the attentional bias eye-tracking task, which included a 5-minute break during which the fourth sample was collected (Time4). A final sample was obtained after task completion (Time5), after which participants were compensated.

MAST Stress Induction Task: The Maastricht Acute Stress Test [?, ?] induced acute stress responses through a 5-minute preparation phase and 10-minute stress/control task involving five alternating cycles of cold-pressor and mental arithmetic tasks (60–90 seconds each). In the stress condition, water temperature was maintained at approximately 2°C, and the arithmetic task required serial subtraction of 17 from 2043 (minimum 45 seconds), with participants reporting answers aloud. Errors prompted negative feedback and task restart.

The entire procedure was video-recorded for data analysis purposes only. In the control condition, water temperature was 36–38°C, arithmetic involved subtracting 10 from 1000, and no recording occurred; all other parameters matched the stress condition.

Attentional Engagement-Disengagement Task: Adapted from Sanchez et al.'s eye-tracking paradigm [**?**, **?**], the task comprised free viewing, attentional engagement, attentional disengagement, and non-attention allocation conditions. As shown in Figure 3 [Figure 3: see original paper], free viewing trials began with a 500 ms blank screen followed by a 500 ms central fixation cross, after which face pairs (happy-neutral, disgusted-neutral, sad-neutral) appeared for 3000 ms with instructions to view freely. In engagement trials, a white dot appeared on the neutral face after free viewing, requiring participants to maintain attention there for at least 100 ms before a square or circle frame appeared on the opposite face, prompting a shape discrimination response (F or J key, counterbalanced across participants). Disengagement trials were identical except the dot appeared on the emotional face. Following the response, a blank screen preceded the next trial. Non-attention allocation trials used neutral-neutral or emotional-emotional pairs. The task comprised 120 trials: 24 each for free viewing, engagement, and disengagement, plus 48 non-attention allocation neutral trials to equate emotional and neutral face presentations across conditions. E-Prime 2.0 controlled task presentation and behavioral data collection.

Figure 2 [Figure 2: see original paper] illustrates the eye-tracking task flow. The engagement condition required attentional shift from the white dot on the neutral face to the emotional face for shape judgment, whereas the disengagement condition required shifting from the emotional face to the neutral face.

2.5 Data Analysis

2.5.1 Saliva Storage and Assay Saliva samples were stored at -20°C. Before assay, samples were thawed and centrifuged at 3000 rpm for 10 minutes. Salivary cortisol concentrations were determined via electrocheminescence immunoassay (Cobas e601, Roche Diagnostics, Numbrecht, Germany) with a sensitivity of 1.5 nmol/L (lower limit).

2.5.2 Behavioral Data Analysis Given our research aims, non-attention allocation trials served as filler conditions and were excluded from analysis. Error rates were below 0.15 for both groups with no significant between-group difference, F(1, 44) = 0.014, p = 0.907, permitting reaction time analysis. Correct reaction times were retained after excluding data <200 ms or >2000 ms and outliers beyond $±$3 standard deviations. Behavioral data from engagement and disengagement conditions were analyzed using 2 (Group: stress vs. control) × 3 (Emotion Pair: happy-neutral, disgusted-neutral, sad-neutral) repeated-measures ANOVAs.

2.5.3 Eye-Tracking Recording and Analysis Eye movements were recorded using an Eyelink 1000 Plus eye-tracker (1000 Hz sampling rate, 0.1° spatial resolution) with participants positioned 73 cm from the screen. Nine-point calibration preceded each recording. Fixations were defined as eye movements stabilized within 1° visual angle for at least 100 ms [**?**, **?**].

Due to incomplete eye-tracking data during the wait-for-fixation and response screens, analysis was restricted to the free viewing phase across free viewing, engagement, and disengagement conditions. Offline analysis examined first fixation direction, first fixation latency, first fixation duration, and total fixation duration biases to assess attentional bias components [**?**, **?**]. Valid fixation criteria required the initial fixation at screen center followed by fixation within the region of interest (ROI) defined separately for emotional and neutral face locations. Invalid fixations were excluded, as were two stress group participants with missing data. Non-attention allocation neutral trials were omitted, focusing analysis on attention allocation conditions. Trials were excluded if first fixation duration or total fixation duration was <100 ms or >3000 ms, first fixation latency was <80 ms or >800 ms, or the first fixation fell outside the ROI. Final valid fixations within ROIs comprised 68.40% of all trials.

3 Results

3.1 Cortisol Concentration

A 2 (Group: control vs. stress) × 5 (Time: Time1–Time5) repeated-measures ANOVA revealed significant main effects of Group, F(1, 44) = 10.08, p = 0.003, ^{2}p = 0.19, and Time, F(4, 41) = 6.41, p < 0.001, ^{2}p = 0.67, and a significant Group × Time interaction, F(4, 41) = 4.94, p = 0.002, ^{2}p = 0.33. Simple effects analysis showed that at Time3, cortisol concentration was significantly higher in the stress group (10.59 ± 1.18) than the control group (6.79 ± 1.24), F(1, 44) = 4.92, p = 0.032, ^{2}p = 0.10. At Time4, the stress group (14.63 ± 1.45) was significantly higher than controls (6.63 ± 1.51), F(1, 44) = 14.62, p < 0.001, ^{2}p = 0.25. At Time5, the stress group (10.32 ± 1.17) remained significantly elevated relative to controls (5.19 ± 1.22), F(1, 44) = 9.17, p = 0.004, ^{2}p = 0.17. These results demonstrate that the MAST task successfully induced acute stress responses.

Figure 3 [Figure 3: see original paper] presents cortisol concentrations and state anxiety scores across time points for both groups. Following the MAST acute stress task, the stress group exhibited significantly higher cortisol concentrations at Time3, Time4, and Time5, and higher state anxiety scores at Time3 compared to the control group. Additionally, the stress group' s cortisol at Time4 was significantly greater than at Time1, Time2, Time3, and Time5, while state anxiety at Time3 was significantly higher than at all other time points. * indicates p < 0.05.

3.2 Anxiety State Changes

Independent samples t-tests revealed no significant difference in trait anxiety between the stress (41.38 ± 6.34) and control (44.00 ± 7.37) groups, t(2, 44) = 1.30, $p = 0.201$. For state anxiety, a 2 (Group) × 5 (Time) repeated-measures ANOVA showed a significant main effect of Time, F(4, 41) = 12.23, $p < 0.001$, ^{2}p = 0.54, no Group main effect, F(1, 44) = 0.63, $p = 0.430$, and a significant Group × Time interaction, F(4, 41) = 6.45, $p < 0.001$, ^{2}p = 0.39. Simple effects analysis indicated that compared to baseline (Time1, Time2), state anxiety was significantly higher in the stress group (45.17 ± 1.53) than the control group (37.86 ± 1.60) at Time3, F(1, 44) = 10.91, $p = 0.002$, ^{2}p = 0.20. These results confirm that the stress task enhanced participants' anxiety states.

3.3 Positive and Negative Affect

Figure 4 [Figure 4: see original paper] displays positive and negative affect scores across time points for both groups. Following the MAST task, the stress group showed significantly lower positive affect at Time3 and significantly higher negative affect at Time3 and Time4 compared to the control group.

Separate 2 (Group) × 5 (Time) repeated-measures ANOVAs for positive and negative affect revealed: For positive affect, significant main effects of Time, F(4, 41) = 21.23, $p < 0.001$, ^{2}p = 0.67, and a significant Group × Time interaction, F(4, 41) = 2.67, $p = 0.046$, ^{2}p = 0.21, but no Group main effect, F(1, 44) = 2.26, $p = 0.140$. Simple effects analysis showed that compared to baseline (Time1, Time2), positive affect scores were significantly lower in the stress group (24.25 ± 1.20) than the control group (29.46 ± 1.26) at Time3, F(1, 44) = 8.94, $p = 0.005$, ^{2}p = 0.17. For negative affect, significant main effects of Time, F(4, 41) = 8.81, $p < 0.001$, ^{2}p = 0.46, and a significant Group × Time interaction, F(4, 41) = 4.10, $p = 0.007$, ^{2}p = 0.29, emerged, with no Group main effect, F(1, 44) = 2.18, $p = 0.147$. Follow-up tests revealed that negative affect scores were significantly higher in the stress group (21.29 ± 0.93) than the control group (15.91 ± 0.97) at Time3, F(1, 44) = 15.96, $p < 0.001$, ^{2}p = 0.27, and at Time4 (stress: 21.25 ± 0.87; control: 17.14 ± 0.90), F(1, 44) = 10.80, $p = 0.002$, ^{2}p = 0.20. These results demonstrate that the stress task increased negative affect and decreased positive affect.

3.4 Behavioral Results

To examine acute stress effects on attentional orienting and disengagement for positive and negative emotional faces, reaction times in both conditions were analyzed using separate 2 (Group: control vs. stress) × 3 (Emotion Pair: happy-neutral, disgusted-neutral, sad-neutral) repeated-measures ANOVAs.

For attentional orienting, neither the Group main effect, F(1, 46) = 3.48, $p = 0.069$, nor Emotion Type main effect, F(2, 45) = 0.54, $p = 0.585$, was significant, but the Group × Emotion Type interaction was significant, F(2, 45) = 3.36, $p = 0.044$, ^{2}p = 0.130. Simple effects analysis revealed that the control group

(727.59 ± 40.01 ms) responded significantly faster than the stress group (873.62 ± 36.81 ms) to happy faces, F(1, 46) = 7.22, p = 0.010, ^{2}p = 0.136, with no significant differences for disgusted or sad faces, F(1, 46) = 0.76, p = 0.388 and F(1, 46) = 0.91, p = 0.346, respectively.

For attentional disengagement, the Group main effect was significant, with the stress group (877.61 ± 37.34 ms) showing longer reaction times than the control group (755.78 ± 40.60 ms), F(1, 46) = 4.88, p = 0.032, ^{2}p = 0.096. The Emotion Type main effect was also significant, with sad faces (849.50 ± 31.11 ms) producing longer reaction times than happy (798.88 ± 28.67 ms) and disgusted faces (801.70 ± 29.09 ms), F(2, 45) = 4.56, p = 0.015, ^{2}p = 0.090. The Group × Emotion Type interaction was not significant, F(2, 45) = 2.27, p = 0.114. These behavioral data indicate that acute stress slows orienting to positive stimuli and impairs disengagement from both positive and negative stimuli.

Figure 5 [Figure 5: see original paper] presents reaction times and eye-tracking measures for both groups across orienting and disengagement conditions. In attentional orienting, the stress group showed significantly longer reaction times than the control group for happy-neutral faces, but no group differences emerged for first fixation direction or latency bias eye-tracking measures. In attentional disengagement, the stress group exhibited significantly longer reaction times than the control group across all emotion types. For eye-tracking measures, no significant differences appeared for first fixation duration bias, but total fixation duration bias scores were significantly greater in the stress group than the control group for disgusted-neutral and sad-neutral faces, with no difference for happy-neutral faces.

3.5 Eye-Tracking Results

Separate 2 (Group: control vs. stress) × 3 (Emotion Pair: happy-neutral, disgusted-neutral, sad-neutral) repeated-measures ANOVAs were conducted on first fixation direction bias, first fixation latency bias, first fixation duration bias, and total fixation duration bias scores, with one-sample t-tests comparing scores against no-bias standards (0 or 50%).

For first fixation direction bias, no significant effects emerged: Group, F(1, 44) = 0.064, p = 0.802; Emotion Type, F(2, 88) = 0.60, p = 0.550; Group × Emotion Type interaction, F(2, 88) = 0.82, p = 0.442. One-sample t-tests against chance (50%) also revealed no significant effects.

For first fixation latency bias, no significant effects were found: Group, F(1, 44) = 0.13, p = 0.720; Emotion Type, F(2, 88) = 0.44, p = 0.644; Group × Emotion Type interaction, F(2, 88) = 0.76, p = 0.469. One-sample t-tests against the no-bias standard (0) showed no significant effects for either group.

For first fixation duration bias, no significant effects emerged: Group, F(1, 44) = 0.44, p = 0.512; Emotion Type, F(2, 43) = 0.09, p = 0.918; Group × Emotion Type interaction, F(2, 43) = 0.92, p = 0.405. One-sample t-tests against 0 revealed no significant effects.

For total fixation duration bias, the Group main effect was significant, F(1, 44) = 12.34, p = 0.001, ^{2}p = 0.22, while the Emotion Type main effect was not, F(2, 88) = 1.30, p = 0.279. The Group × Emotion Type interaction was significant, F(2, 88) = 3.37, p = 0.039, ^{2}p = 0.07. Simple effects analysis revealed that for disgusted faces, the stress group (109.57 ± 51.47 ms) showed significantly greater bias than the control group (-122.60 ± 53.76 ms), F(1, 44) = 9.73, p = 0.003, ^{2}p = 0.18. For sad faces, the stress group (32.63 ± 51.18 ms) also showed significantly greater bias than controls (-131.60 ± 53.45 ms), F(1, 44) = 4.93, p = 0.032, ^{2}p = 0.10. No significant difference emerged for happy faces (stress: 17.47 ± 47.89 ms; control: 63.52 ± 50.02 ms), F(1, 44) = 0.44, p = 0.510. One-sample t-tests against 0 revealed that the stress group showed bias toward disgusted faces in disgusted-neutral pairs, t = 2.13, df = 23, p = 0.044, but not for happy-neutral (t = 0.42, df = 23, p = 0.681) or sad-neutral pairs (t = 0.68, df = 23, p = 0.506). Conversely, the control group showed bias toward neutral faces in disgusted-neutral (t = -2.28, df = 21, p = 0.033) and sad-neutral pairs (t = -2.32, df = 21, p = 0.030), with no bias for happy-neutral pairs (t = 1.14, df = 21, p = 0.269).

3.6 Correlation Analysis

To further clarify relationships between stress and attentional orienting/disengagement, Pearson correlations were computed within the stress group between eye-tracking measures and changes in state anxiety scores (Time3–Time2), positive/negative affect scores, and cortisol area under the curve differences (AUC: Time3–Time4 minus Time2–Time3). Results showed that first fixation latency for disgusted faces was significantly negatively correlated with state anxiety change, r = -0.417, p = 0.043, indicating that higher state anxiety was associated with faster attention to disgusted faces, consistent with prior research [**?**, **?**]. Total fixation duration for sad faces was significantly negatively correlated with positive affect change, r = -0.461, p = 0.023, suggesting that lower positive affect was associated with longer viewing of sad faces. First fixation direction bias for sad faces was significantly negatively correlated with negative affect change, r = -0.454, p = 0.026, as was first fixation duration, r = -0.447, p = 0.028, indicating that higher negative affect was associated with fewer initial fixations and shorter initial fixation durations on sad faces, possibly reflecting an emotion regulation strategy [**?**, **?**]. Total fixation duration for happy faces was significantly negatively correlated with negative affect change, r = -0.620, p = 0.001, while total fixation duration for sad faces was positively correlated with negative affect change, r = 0.411, p = 0.046, suggesting that higher negative affect reduced viewing of happy faces but increased viewing of sad faces. No significant correlations emerged between eye-tracking measures and cortisol AUC changes.

4 Discussion

This study investigated acute stress effects on overt attentional bias toward positive and negative emotional faces using eye-tracking technology. The findings revealed that the stress group exhibited significantly slower attentional orienting to positive emotional faces compared to controls, with no significant difference for negative faces. However, both positive and negative face disengagement reaction times were significantly longer in the stress group. No group differences emerged for orienting eye-tracking measures (first fixation direction and latency biases). For disengagement, the stress group showed significantly greater total fixation duration bias toward negative emotional faces than controls, with no difference for positive faces.

These results demonstrate that in overt attentional bias, acute stress disrupts attentional disengagement from emotional faces, consistent with previous findings on covert attentional bias [**?**, **?**, **?**]. Additionally, this study provides novel evidence that acute stress slows attentional orienting to positive stimuli, complementing prior research.

The MAST task effectively induced acute stress, as confirmed by cortisol concentrations and subjective emotional states. Cortisol levels were significantly higher in the stress group than controls, with stress group cortisol at Time3, Time4, and Time5 significantly exceeding baseline (Time1). Subjectively, the stress group showed significantly higher state anxiety and negative affect, and lower positive affect, at Time3 compared to controls, with state anxiety and negative affect significantly elevated above baseline (Time2) and positive affect significantly reduced below baseline. These findings align with previous research [**?**, **?**, **?**], confirming MAST as a stable and effective acute stress induction method.

Regarding attentional orienting, behavioral data revealed significantly slower orienting to happy faces in the stress group. This suggests that acute stress slows orienting to positive stimuli, a finding that diverges from Alvaro et al.’ s study which found no significant acute stress effect on positive orienting bias in depressed individuals [**?**, **?**], possibly due to sample differences. Research has demonstrated positive stimulus bias in non-anxious/non-depressed individuals, while depressed and anxious individuals lack such bias [**?**, **?**]. Our findings further support emotion-congruence effects, wherein slowed orienting to positive stimuli may result from reduced positive affect [**?**, **?**]. This may reflect rapid amygdala activation during acute stress facilitating emotional regulation [**?**, **?**], or greater impact on left hemisphere mechanisms involved in positive emotion and attentional orienting.

Interestingly, eye-tracking data during free viewing revealed no acute stress-related slowing of orienting to happy faces. This behavioral-eye-tracking discrepancy may stem from our sequential data collection phases: eye-tracking during initial free viewing and behavioral responses during later wait-for-fixation and response screens. Prior cognitive processing during the eye-tracking phase may have produced attentional avoidance during the subsequent behavioral phase [?, ?], a phenomenon observed in other studies [?, ?, ?, ?, ?]. Attentional avoidance represents an emotion regulation strategy that reduces focus on emotional stimuli [?, ?]. Alternatively, the unequal ratio of positive to negative emotional stimuli may have contributed to these divergent findings.

For attentional disengagement, behavioral data revealed impaired disengagement from both positive and negative stimuli under acute stress, while eye-tracking data specifically indicated disengagement impairment for negative stimuli. This suggests that acute stress reliably disrupts disengagement from negative stimuli, consistent with prior covert attention research [?, ?, ?]. Correlation analyses indicated that disengagement difficulty from negative stimuli in the stress group was primarily driven by stress-induced increases in negative affect. Quigley et al. [?, ?] found that anxiety induction produced attentional bias toward threat but not positive stimuli, with this bias related to state but not trait anxiety, supporting the notion that emotional state changes influence attentional bias. Nelson et al. [?, ?, ?] reported similar results, showing that state anxiety specifically affected threat disengagement but not orienting. This aligns with Isaacowitz et al.' s emotion-congruence hypothesis, wherein negative affect induction produces sustained attentional processing of negative stimuli, and positive affect induction produces sustained processing of positive stimuli [?, ?].

Additionally, eye-tracking data showed that the stress group exhibited shorter first fixation durations on disgusted faces compared to neutral faces in disgusted-neutral pairs, which does not contradict emotion-congruence effects but may reflect an emotion regulation strategy [?, ?]. Ellenbogen et al. [?, ?] found that acute stress prompted faster attentional shifts from negative to positive or neutral stimuli, a finding replicated by Sanchez et al. [?, ?] who demonstrated that avoidance of negative stimuli correlated positively with positive emotional regulation changes. The differential effects of acute stress on disengagement from positive versus negative stimuli may reflect distinct hemispheric mechanisms activated by different valences, with our study further demonstrating that acute stress impacts general negative stimuli rather than threat-specific processing.

The impairment in disengagement from negative stimuli under acute stress may reflect compromised prefrontal cortex function, leading to enhanced bottom-up perceptual processing and weakened top-down prefrontal control. Research has shown that dorsolateral prefrontal cortex activation impairs emotional stimulus disengagement [?, ?], and studies of anxious individuals identify the dorsolateral prefrontal cortex as a critical neural mechanism for disengagement. The cortical network' s functional balance between ventral (anterior cingulate cortex, limbic structures) and dorsal (dorsal ACC, dorsolateral prefrontal cortex) compartments is essential for emotional control, with disengagement difficulty from emotional information potentially reflecting failed top-down attentional control by the dorsolateral prefrontal cortex and associated frontoparietal network dysfunction.

The discrepancy between behavioral and eye-tracking disengagement measures may arise from two primary factors. First, the temporal mismatch in data collection represents a significant limitation, as incomplete eye-tracking data during the wait-for-fixation and response screens prevented simultaneous measurement. This timing difference likely constitutes the main source of inconsistency. Second, the unequal ratio of emotional stimulus valences may have contributed. Future research should balance positive and negative stimulus proportions and integrate overt and covert attention measurement techniques to investigate these differences, which would provide important evidence for the "mind-wandering" phenomenon of attention-eye movement dissociation.

In summary, our findings partially support our hypothesis, demonstrating that acute stress impairs disengagement from negative stimuli during later attentional processing stages, as evidenced by total fixation duration bias scores indicating generalized negative stimulus disengagement difficulty. Moreover, this impairment appears primarily related to negative affect changes induced by stress. These results suggest bidirectional influences between emotional state and attentional bias, with implications for attentional bias modification as an emotion regulation intervention for depression and anxiety disorders.

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