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Impact of Acute Stress on Attentional Orienting to Social Cues

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Research Article

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Abstract

Background: Gaze direction and emotional expression are used in social contexts to direct visuospatial attention to salient features of the environment. The attentional focus and motivational state of another individual can be discerned in part by interpreting his or her communicative facial cues. The goal of the present study was to characterize the effects of realistic acute stress on attentional orienting to social cues.

Methods: Participants were tested before and during military survival school training. During the task, participants were shown faces at fixation that concurrently displayed dynamic gaze shifts and expression changes from neutral to fearful or happy emotions. Military-relevant targets subsequently appeared in the periphery and were spatially congruent or incongruent with the gaze direction. Reaction time data was analyzed using a 2 (Testing Session: baseline, stress) x 2 (Expression: fearful, happy) x 2 (Target Emotion: positive, negative) x 2 (Gaze Direction: left, right) x 2 (Target Location: left, right) repeated measures ANOVA.

Findings: Participants showed faster responses during fearful face trials during the high stress condition compared to baseline, while the response on happy face trials did not change. Additionally, enhanced performance was related to self-report reappraisal usage during emotion regulation at baseline. Reaction times to threatening targets were faster on validly cued trials during both tests. Trials with safe targets showed no differences at baseline.

Discussion/Impact/Recommendations: These results suggest that acute stress plays a role in how individuals evaluate potentially threatening targets. The present findings provide insight into why and how individuals differ in their response to fearful cues.

Keywords: Facial Affect; Shared Attention; Stress; Emotion Regulation

Introduction

Gaze direction and emotional expression are used in social contexts to direct visuospatial attention to salient features of the environment. The attentional focus and motivational state of another individual can be discerned in part by interpreting his or her communicative facial cues. Attentional focus is most readily inferred by noticing the direction of a partner's gaze, although other cues such as body and vocal gestures are also used in social communication. Emotional facial expressions provide information about the motivational state of the actor [1] as well as changes in one's level of safety and threat. People rely on their understanding of changes in facial behaviors and gaze direction in social situations to respond appropriately to both a partner as well as to the stimulus that elicited his or her change in affect and attentional deployment.

Effects of gaze and emotion on attention have been experimentally investigated in studies that vary the standard Posner attentional cuing paradigm by using faces as attention-directing cues [2]. In this task, the peripherally or centrally presented symbolic cues are replaced with a socially relevant cue, a face. At the start of each trial a face with direct gaze is presented at fixation, after a short interval the pupils shift to represent leftward gaze or rightward gaze, or hold position for a direct gaze. Targets are randomly presented at a location in the periphery of the left or right visual field. Participants are faster at responding to targets (detection, localization, or identification) when presented at the gazed-at location (valid) compared to the opposite visual field (invalid) or when there was a direct gaze.

Using this approach, behavioral studies have directly investigated the relationship between emotional expression and gaze during attentional target detection or identification tasks. Previous studies by Fichtenholtz HM, et al. [3,4] have shown that targets are responded to more quickly when observing faces that express a change in emotional expression (fearful, happy, or disgust) regardless of the match between gaze direction and target location. However, some studies have shown that facial expression can interact with gaze validity, with larger validity effects in the presence of a fearful face [5,6] or a happy face [5,7] relative to a neutral face. Another group of studies have found no effect of facial expression (fearful, angry, disgust or happy) and no interactions between gaze direction and facial expression on attention [8,9]. A few studies have interrogated the influence of anxiety on orienting to social cues [5,10,11]. Those that have demonstrated a greater influence of facial expression on the orienting to gaze shifts compared to non-anxious controls. The limitation of these studies is the focus on trait anxiety, not state anxiety or current stress.

In the current study, a modified gaze-cuing paradigm was used in which dynamic gaze shifts and dynamic expression changes were incorporated in face cues (neutral to fearful, or neutral to happy) and attentional targets were objects that varied in emotional meaning (adapted from Fichtenholtz and colleagues) [12]. Changes in gaze shifts, cue emotion and target emotion were fully crossed. Thus, participants were presented with a complex attention-directing face cue that had the appearance of emotionally reacting (happy or fearful expressions) just prior to the appearance of either a threatening or safe target.

Methods

Participants

Thirty-one male, active duty personnel (mean age, 25.42 years; SD 3.42) enrolled in U.S. military Survival School training at the Marine Corps Special Operations Command in Camp Lejeune, North Carolina, participated in this study. Before enrollment in Survival School, MARSOC medical and psychiatric teams cleared all students medically and psychiatrically. No students with clinically significant medical or psychiatric conditions are permitted to participate in Survival School training. Results of psychiatric screenings are not available to the public and, as in our prior studies of Special Operations personnel, are not part of our research assessments. The MARSOC medical and psychiatric teams were able to provide assurances that no students with known medical or psychiatric conditions were enrolled in this study.

Recruitment of participants was conducted by the principal investigator (C.A.M.). It was explicitly stated to the prospective participants by the Command that the investigator was a civilian and that participation in the study was voluntary; furthermore, prospective participants were informed that their decision to participate in the research project would not influence their status in the Survival School course. After explaining the study, the PI conducted a question and answer period with prospective participants. Individuals who chose to participate in the study (100%) then provided written informed consent. The study was approved by Institutional Review Boards of VA Connecticut Healthcare System and the University of Maryland.

Venue

Numerous studies from have established that military Survival School training represents a valid, reliable venue for assessing the impact of acute stress in humans [13,14]. The stress is intense and produces alterations of both psychological and biological processes similar to those elicited by life threatening events. This venue offers a unique opportunity to evaluate how stress affects affective-cognitive functioning.

Survival school training is comprised of two phases. The first (didactic) phase consists of classroom instruction, and ''hands on'' practice to learn specific survival skills. The second (experiential) phase consists of the students demonstrating the skills they learned in a semi-controlled environment. During the first day of the non-stressful, didactic phase of the course, participants completed valid, reliable, self report measures of individual's emotional expressivity (BEQ) [15], and emotion regulation strategies (ERQ) [16].

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On the third classroom day, participants completed a baseline administration of social orienting task. The social orienting task was also administered during the Captivity/Isolation phase of Survival School training. This test took place approximately 17 days after the baseline test (see Figure 1B). Each participant was tested separately in a private area without external distractions. Evaluators who administered the social orienting task during this phase were the same individuals who performed data collection during the didactic phase.

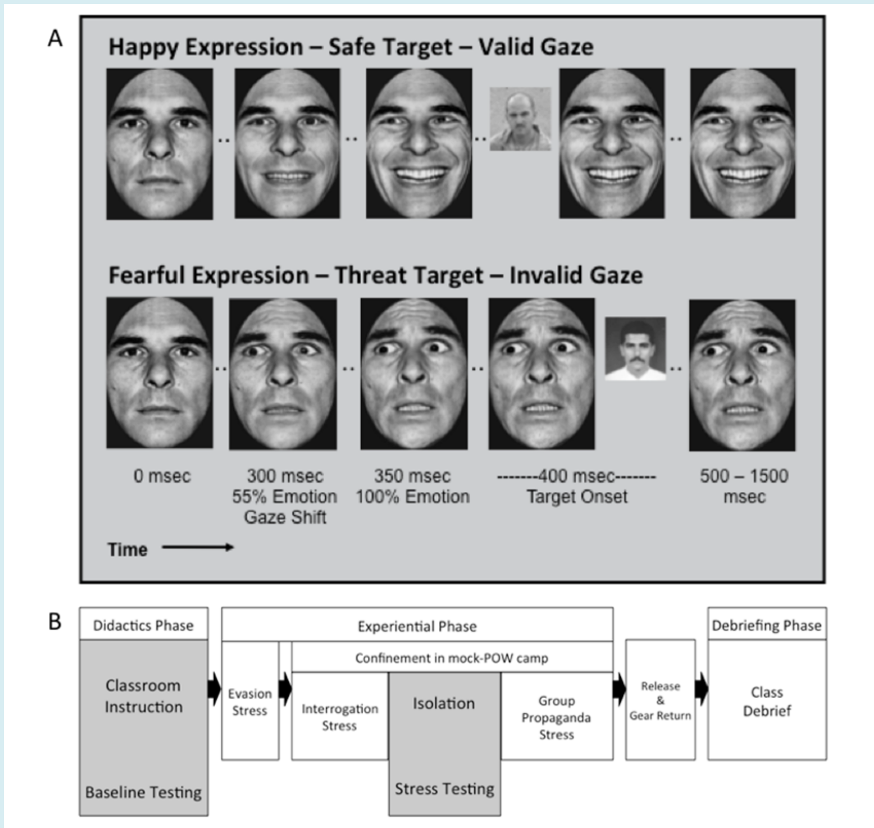

Figure 1: A: This Novel Variation on the Gaze Direction Cueing Task Uses Both Dynamic Expression and Gaze Shifts, as Well as an Emotionally Salient Target. The Expression Change is a Two-Stage Process that Lasts for 150 Msec and the Gaze Shift is a Single Step that Begins at the Same Time as the Expression Change. Total Trial Duration was 1500 Msec with a Random Inter-Trial Interval Between 1500-2000 msec. **B:** Order of Events at MARSOC Survival School. Testing Times are Highlighted in Grey.

Task Parameters

The task consisted of one run. Each run contained 120 trials, 5 each of 24 stimulus categories, and lasted approximately 7 min. Trials were pseudorandomized in an event-related design across participants. Each trial consisted of a dynamic facial cue stimulus that changed gaze direction (left, right) and facial expression (happy, neutral, fearful), followed by presentation of a target individual (fellow Marine – SAFE, known terrorist – THREAT). All of these variables were fully crossed in the experimental design. The nomenclature for the direction of gaze is based upon the participants' frame of reference so on a leftward gaze shift trial the pupils move to the left of center. Trial with affective cues consisted of three phases. The first phase was the presentation of a neutral face for 300 msec. The second phase consisted of the presentation of a 50% fearful or 50% happy expression and a left or right eye gaze presented for 75 msec. The third phase consisted of the presentation of a 100% fearful or 100% happy expression and a left or right eye gaze presented for 75 msec. Following this third phase, the cue stimulus maintained its facial configuration and remained on the screen for the remainder of the trial (1000 msec). Spatial location of the target was validly cued by gaze shifts 50% of the time, and congruency of emotion in cues and targets (e.g., Marine following happy faces) occurred 50% of the time. This task is a modified version of the task used by Fichtenholtz and colleagues (2007, see Figure 1A).

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The dynamic expression change created a situation where the participant saw the cue stimulus become either afraid or pleased in response to the upcoming stimulus. Additionally, previous research has shown that emotional expressions are more accurately identified when presented dynamically [17] which should enhance the perceived emotional experience of the participant. One hundred and fifty msec after the onset of the gaze shift, the attentional target was presented for 100 msec. The attentional target consisted of a rectangular image of either a fellow Marine or a known terrorist presented in the periphery (2.1° above fixation, 7.4° left or right of fixation) of the upper left or right visual field (see Figure 1 for a visual depiction of the task). There was a random inter-trial interval between 1500-2000 msec.

Throughout the entire run, participants were asked to fixate on a centrally-presented cross. The participants' task was to identify the content (Marine or terrorist) of the target image using two buttons on the keyboard. Responses were made with the index finger of each hand. Response mapping was balanced across subjects.

Stimuli

One male actor (P.E.) was selected from the Ekman and Friesen18 pictures of facial affect to act as the centrally-presented cuing stimulus. One actor was used and compared across emotion categories because previous studies have established that facial identity modulates the perception of facial expression [18,19].

The original photos posed fearful, happy, and neutral facial expressions with direct gaze. Adobe Photoshop (Adobe Systems Incorporated, San Jose, CA) was used to manipulate gaze direction so that irises were averted between 0.37° and 0.4° from the centrally-positioned irises in the faces with direct gaze. Thus, five digitized greyscale photographs were used – a neutral face with direct gaze as the initial anchor for the morph and the factorial combination of two facial expressions (fear, happy) and two gaze directions (left, right) from the same actor. In order to create realistic dynamic emotional expressions, fearful and happy facial expressions of intermediate intensity were created using the morphing methods outlined in LaBar KS, et al. [20] using MorphMan 2000 software (STOIK, Moscow, Russia). Three morphs depicting 55% fearful or happy/45% neutral expression were created with left- and right-looking gaze and were used to create a more natural-looking appearance of apparent motion. The greyscale facial cuing stimuli were presented at fixation and subtended approximately 6.3° of horizontal and 8.9° of vertical visual angle.

Target stimuli consisted of two photos that were found online to represent the appropriate categories. One stimulus was positively-valent and depicted the face of a fellow Marine; the other was negatively-valent and depicted the face of a known terrorist and was taken from the FBI terrorist watch list (http://www.fbi.gov/wanted/wanted_terrorists). The stimuli were chosen, for their opposing valence, military relevance, and shared similar features (i.e., both were pictures of faces with some facial hair and closed mouths). The original photos were cropped to include only the face area and were converted into grey scale photos. The contrast and luminance of the target photos was equated to that of the facial cues. Targets measured approximately 2.5° of visual angle.

Data Analysis

Accuracy approached the ceiling (M 95.98, SD 2.19) therefore the data analysis focused on reaction time in participants. Mean reaction time (RT) was computed for correct trials from each condition and participant. Any trials with RTs shorter than 100 msec or longer than 1000 msec (duration of the face on the screen after target presentation) were excluded from this and all subsequent analyses. Two (Testing Session: baseline, stress) x 2 (Expression: fearful, happy) x 2 (Target Emotion: positive, negative) x 2 (Gaze Direction: left, right) x 2 (Target Location: left, right) ANOVAs were conducted for RT.

Results

The Stress (testing session) x Expression x Target Emotion x Gaze Direction x Target Location ANOVA for RT revealed significant Stress x Expression ($F(1,30) = 5.58$, $p < 0.025$), Stress x Target Emotion x Target Location ($F(1,30) = 5.79$, $p < 0.022$), and Stress x Target Emotion x Gaze Direction x Target Location ($F(1.30) = 5.28$, $p < 0.029$) interactions.

Reaction time decreased from baseline (M 516.65, SD 60.78) to stress (M 500.79, SD 51.45); $t(30) = 2.24$, $p < 0.032$. On trials with happy faces RT remains constant (Baseline: M 498.58, SD 54.95; Stress: M 492.91, SD 51.51), $t(30) = 0.86$, $p > 0.05$ (see Figure 2A). Additionally, the change in RT from the baseline to the stress test sessions was significantly correlated with self-reported use of cognitive reappraisal as an emotion regulation strategy ($r(30) = 0.42$, $p < 0.02$) but not use of suppression to regulate emotions ($r(30) = -0.12$, $p > 0.05$) (see Figure 2B).

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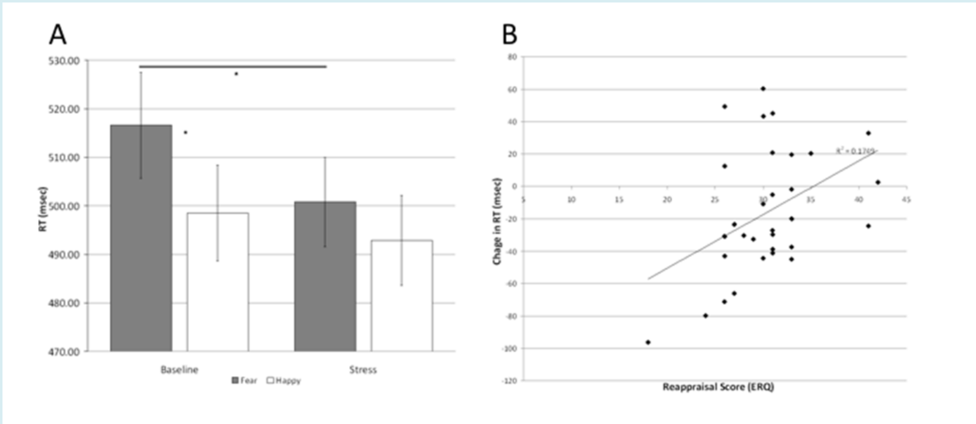

Figure 2: A: Stress Improves Reaction Time During Fearful Face Trials but not Happy Face Trials. **B:** The Performance Benefit on Fearful Face Trials is Predicted by Lower Self-Report of Cognitive Reappraisal.

Follow-up analyses on the Stress x Target Emotion x Gaze Direction x Target Location interaction by Target Emotion revealed a significant Gaze Direction x Target Location interaction ($F(1,30) = 12.66$, $p < 0.001$) for Threat target trials. RT was faster for trials where the gaze direction and target location matched (M 495.93,SEM 9.99) compared to trials where the gaze direction and target location did not match (M 508.29,SEM 9.19). On trials with the Safe target there was a significant main effect of Stress ($F(1,30) = 6.13$, $p < 0.019$) and a significant Stress x Gaze Direction x Target Location interaction ($F(1.30) = 5.14$, $p < 0.031$). Post-Hoc comparisons showed that during the baseline test there was no difference in RT was on trials where the gaze direction and target location matched (M 508.85,SEM 10.24) compared to trials where the gaze direction and target location did not match (M 513.15,SEM 11.40), $t(30) = -0.82$, $p > 0.05$. During the stress testing session RT was faster for trials where the gaze direction and target location did not match (M 489.29,SEM 8.16) compared to trials where the gaze direction and target location matched (M 489.96,SEM 8.89) (see Figure 3). The complete ANOVA table can be found in Table 1.

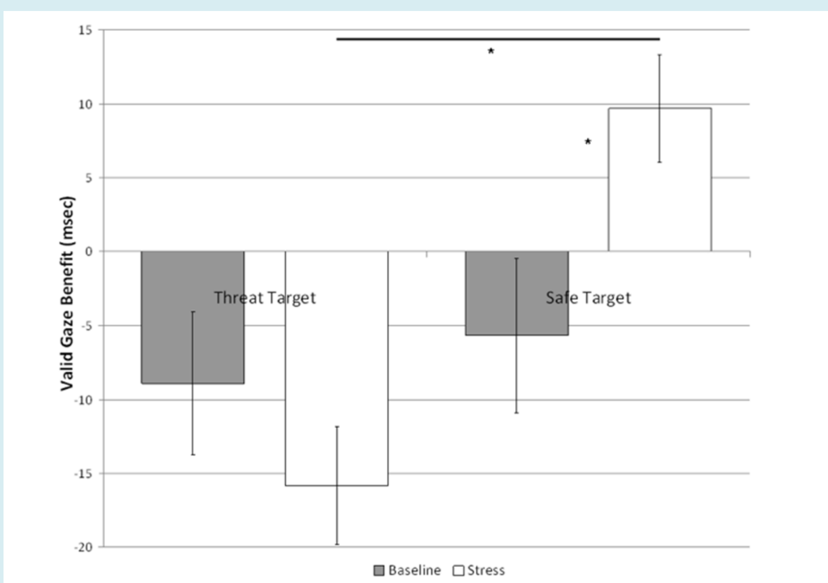

Figure 3: Reaction Times to Threatening Targets were Faster on Validly Cued Trials During Both Tests. Trials with Safe Targets Showed a Benefit for Invalidly Cued Trials During Stress.

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Effect	F	p
Stress	2.76	ns
Stress x Facial Expression	5.58	*
Stress x Facial Expression x Target Emotion	0.39	ns
Stress x Facial Expression x Gaze Direction	1.4	ns
Stress x Facial Expression x Target Location	0	ns
Stress x Facial Expression x Target Emotion x Gaze Direction	0.44	ns
Stress x Facial Expression x Target Emotion x Target Location	0.01	ns
Stress x Facial Expression x Target Emotion x Target Location	0.61	ns
Stress x Facial Expression x Target Emotion x Gaze Direction x Target Location	0.18	ns
Stress x Target Emotion	3.85	ns
Stress x Target Emotion x Gaze Direction	0.01	ns
Stress x Target Emotion x Target Location	5.79	*
Stress x Target Emotion x Gaze Direction x Target Location	5.28	*
Stress x Gaze Direction	3.26	ns
Stress x Gaze Direction x Target Location	1.22	ns
Stress x Target Location	0.49	ns
Facial Expression	24.46	***
Facial Expression x Target Emotion	0.55	ns
Facial Expression x Gaze Direction	33.05	***
Facial Expression x Target Location	0.4	ns
Facial Expression x Target Emotion x Gaze Direction	8.36	**
Facial Expression x Target Emotion x Target Location	21.22	***
Facial Expression x Gaze Direction x Target Location	11.02	**
Facial Expression x Target Emotion x Gaze Direction x Target Location	10.77	**
Target Emotion	0	ns
Target Emotion x Gaze Direction	11.35	**
Target Emotion x Target Location	10.83	**
Target Emotion x Gaze Direction x Target Location	8.49	**
Gaze Direction	0.62	ns
Gaze Direction x Target Location	6.16	*
Target Location	4.32	*
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$; all df = (1,30)		

Table 1: Results of Omnibus ANOVA.

Discussion

The current study used the acute high stress elicited by MARSOC Survival School to investigate the impact of stress on orienting in response to changes in social cues. The current study builds upon prior research by examining the impact of acute stress in contrast to trait anxiety. Previous studies have demonstrated that the impact of facial expression on gaze directed orienting is larger in anxious individuals than controls [5,10,11], however, this effect was seen across facial expressions. The current study shows a differential pattern of responding between fearful and happy face cues, with responses on trials with fearful faces getting faster and responses on trials with happy faces remaining constant. These data provide support for the theory that cognitive resources (especially attention) are preferentially allocated

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to process stimuli with affective salience [21]. This increase in performance on fearful face trials is inversely related to the use of cognitive reappraisal as an emotion regulation strategy. The relationship between less efficient processing of fearful facial cues and increased cognitive reappraisal may be indicative of the increased resources necessary to regulate emotions in this manner, potentially decreasing the cognitive flexibility necessary to perform the task.

In addition to these findings relating to the facial cue, we also show an interaction between stress, target status and gaze validity. During the baseline assessment, participants were faster responding to looked-at compared to looked-away targets for both threatening and safe conditions. While under stress, responses to threatening targets remained faster when looked-at compared to the responses to safe targets which were faster to looked-away targets. This interaction suggests that when experiencing an acutely stressful situation, the emotional salience of external stimuli is a significant factor in engaging attentional mechanisms [21].

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