10-2011

Acute Stress Eliminates Female Advantage in Detection of Ambiguous Negative Affect

Daniel J. Dedora

Joshua M. Carlson
joshcarl@nmu.edu

Lilianne R. Mujica-Parodi

Recommended Citation

Acute Stress Eliminates Female Advantage in Detection of Ambiguous Negative Affect

3 authors:

Daniel J Dedora
Stony Brook University
9 PUBLICATIONS 43 CITATIONS

SEE PROFILE

Joshua M Carlson
Northern Michigan University
49 PUBLICATIONS 706 CITATIONS

SEE PROFILE

Lilianne R Mujica-Parodi
Stony Brook University
84 PUBLICATIONS 1,119 CITATIONS

SEE PROFILE

Acute Stress Eliminates Female Advantage in Detection of Ambiguous Negative Affect

Daniel J. DeDora, Laboratory for Computational Neurodiagnostics, Department of Biomedical Engineering, Stony Brook University, Stony Brook, NY, USA.

Joshua M. Carlson, Laboratory for Computational Neurodiagnostics, Department of Biomedical Engineering, Stony Brook University, Stony Brook, NY, USA.

Lilianne R. Mujica-Parodi, Director, Laboratory for Computational Neurodiagnostics, Department of Biomedical Engineering, Stony Brook University, Stony Brook, NY, USA. Email: lmujicaparodi@gmail.com (Corresponding author).

Abstract: The human stress response evolved to maximize an individual's probability of survival when threatened. The present study addressed whether physical danger modulates perception of an unrelated ambiguous threat and, if so, to what extent this response is sex-specific. The authors utilized a first-time tandem skydive as a stressor, which had been previously validated as producing a highly-controlled, genuinely stressful environment. In a counter-balanced within-subjects design, participants wore a virtual reality helmet to complete an emotion-identification task during the plane's ascent (stress condition) and in the laboratory (control condition). Participants were presented static male faces morphed between 20-80% aggression, which gradually emerged from degraded images. Using a binary forced-choice design, participants identified each ambiguous face as aggressive or neutral. Results showed that participants characterized emotion more rapidly under stress versus control conditions. Unexpectedly, the results also show that while women were more sensitive to affect ambiguity than men under control conditions, they exhibited a marked decrease in sensitivity equivalent to men while under stress.

Introduction

An individual's ability to respond appropriately to threat is vital for survival, and the standard stress-response paradigm, labeled *fight or flight*, (Cannon, 1929) has been extensively studied, though research has typically focused on males (Taylor et al., 2000). From an evolutionary perspective, the larger size and strength of males (compared to

females, on average) is ideally suited for physically hazardous tasks, such as warfare, hunting, and competition for mates (Geary and Flinn, 2002). Thus, fight or flight appears to be an appropriate evolutionary strategy. Conversely, this response in females could directly jeopardize their survival, and more importantly, the survival of offspring. This suggests the need for the development of sex-specific responses to potential threat.

Sex differences in threat perception have been well described in the literature (Biele and Grabowska, 2006; Goos and Silverman, 2002; McAndrew, 1986; Rotter and Rotter, 1988; Taylor et al., 2000). Men and women have been shown to interpret and characterize emotionally salient faces in distinct ways (Biele and Grabowska, 2006; Boyatzis, Chazan, and Ting, 1993; Goos and Silverman, 2002; Hall, 1978; Kirouac and Dore, 1983; McAndrew, 1986; Nowicki and Hartigan, 1988; Rotter and Rotter, 1988). In particular, women are generally more sensitive to facial displays of emotion (Boyatzis et al., 1993; Hall, 1978; Kirouac and Dore, 1983; Nowicki and Hartigan, 1988), and perform better than men in the detection of negative emotions such as anger (often directly threatening), fear (which suggests the existence of a threat) and sadness (which suggests the consequences of a dangerous encounter; Boyatzis et al., 1993; Montagne, Kessels, Frigerio, de Haan, and Perrett, 2005). Additionally, the literature has suggested that the emotional state of a participant, i.e., "happy" or "sad," elicits a state-congruent shift towards increased sensitivity to facial affect (Lim and Pessoa, 2008), characterized by fitting a curve (commonly a psychometric function) to participant responses to a full range of emotional intensities (0 - 100% fearful) (Lim and Pessoa, 2008). Despite the obvious evolutionary implications of affect detection under stress, the effect of acute stress on affect sensitivity has not yet been elucidated.

Studies indicate that the aforementioned threat response can be initiated by crude (i.e., backward-masked) representations of threatening stimuli, and threat stimuli enhance visual perception of subsequent stimuli (Anderson and Phelps, 2001; Carlson and Reinke, 2008; Phelps, Ling, and Carrasco, 2006). This enhancement in perception appears to be mediated by amygdala-elicited (Anderson and Phelps, 2001; Carlson, Reinke, and Habib, 2009) modulation of attention in location-specific areas of the visual cortex (Carlson, Reinke, Lamontagne, and Habib, 2011). Thus, an important aspect of the human stress response is the facilitatory modulation of perceptual processing afforded by rapid detection of potential and ambiguous threat (Mujica-Parodi, Korgaonkar, et al., 2009). An evolutionarily advantageous compromise between rapid decision-making and information acquisition when a stimulus is presented may cause a decrease in accuracy but increases the probability of survival by reducing reaction time.

The present study was designed to address a number of important gaps in the literature. As mentioned, evaluation of potential threat in the presence of an unrelated acute stressor (such as a hazardous environment), and the extent to which is it sex-specific, has been largely unaddressed. Previous work has indicated that skydiving is successful in the evocation of a reliable acute stress response as measured by endocrine (Rubin, Botanov, Hajcak, and Mujica-Parodi, 2011), cardiovascular (Dikecligil and Mujica-Parodi, 2010), and self-report measures (Mujica-Parodi, Strey, et al., 2009); thus, the ten minutes leading up to a first-time tandem skydive was chosen as an acute stressor for this study. Participants were instructed to categorize images of facial expressions as either *aggressive* or *neutral* in separate stress and control sessions, matched for time of day. Since real-world threat perception often occurs without the availability of all relevant information, we introduced two dimensions of ambiguity as important variables in our study. Faces emerged gradually

from completely degraded images (0% signal/noise) to clear images (100% signal/noise, i.e., "perceptual ambiguity"), and were morphed between poles of neutral and angry expressions to convey varying ambiguous degrees of aggression (20 – 80%, i.e., "affect ambiguity"), as shown in Figure 1.

Based on the literature reviewed above, we tested two hypotheses. It is known that women are more sensitive than men to facial affect (Boyatzis et al., 1993; Montagne et al., 2005); it is also known that psychological states influence affect identification and sensitivity to emotional stimuli (Lim and Pessoa, 2008). However, little is known about the effects of stress on affect identification between sexes. Thus, we predicted that the presence of an acute stressor would elicit a modulatory shift in affect identification, increasing participants' sensitivity to aggression; sensitivity was measured by a statistically significant change in the slope of the line fitted to participants' responses, as in previous work (Lim and Pessoa, 2008). While we expected sex-specific effects based on previous literature, it was unclear how sex might influence our results. Secondly, we predicted that a sex-independent, stress-induced modulation of perceptual processing would lead participants to identify faces as either *neutral* or *aggressive* more rapidly in the presence of an acute stressor. Our findings indicate a sex-dependent shift in sensitivity to aggression and perceptual processing when under acute stress, and the evolutionary implications of these findings are described.

Materials and Methods

Participants

The use of humans in this study was approved by the Institutional Review Board, and all participants provided informed consent. All participants were recruited from individuals who independently contacted a local skydiving school (Skydive Long Island, Calverton, NY) to schedule their first-time skydives. Twenty-nine individuals, (17 male) ranging in age from 18 to 48 years ($M = 24.41$, $SD = 7.03$), participated in the study. To control for order effects, the two conditions were counter-balanced. Eighteen participants (7 female) completed the control day before the stress day, while eleven participants (5 female) completed the stress day before the control day. Due to uncontrollable weather-related circumstances, we were unable to obtain equal numbers of session order; however, order effects were not significant ($p > 0.10$) for any of the variables measured.

Participants were screened to ensure good general health; exclusion criteria included pregnancy, history of heart problems, and drug use. All participants completed the Spielberger Trait Anxiety (Spielberger, Gorsuch, and Lushene, 1970; $M_{males} = 33.56$, $SD = 7.66$; $M_{females} = 32.08$, $SD = 7.61$) and Zuckerman Sensation Seeking (Zuckerman and Link, 1968; $M_{males} = 25.17$, $SD = 4.30$; $M_{females} = 24.33$, $SD = 4.77$) questionnaires. Men did not deviate from an average male sensation seeking score ($M_{males} = 25.17$, $SD = 4.30$; $M_{average, males} = 23.26$, $SD = 5.43$ (Schroth, 1995); $p > .05$); women scored significantly higher than average female scores ($M_{females} = 24.33$, $SD = 4.77$; $M_{average,females} = 17.64$, $SD = 6.17$ (Schroth, 1995); $p = .001$). However, differences between sexes were not significant for any of the questionnaires (p's $> .05$).

General protocol

Testing took place over two separate days, time-locked to prevent confounds due to diurnal variability. On both days, participants arrived at the hospital (General Clinical

Research Center in the Stony Brook University Medical Center) at 7:30 a.m. Prior to completing the task, saliva samples were taken from participants, and questionnaires assessing personality were completed. The facial identification task was administered under two conditions. The stress condition took place immediately prior to the participants' first tandem skydive, while the control condition took place in a hospital room. Both sessions used isolating virtual reality helmets (nVisor SX60, NVIS Inc, Reston, VA) to control for ambient differences between environments, and participants completed the task on both days from an identical, seated posture. On both days the facial identification task was completed at 10:15 a.m. Salivary cortisol samples, as well as the abbreviated state anxiety inventory (Spielberger et al., 1970), were taken prior to (10:00 a.m.) and immediately following (10:45 a.m.) completion of the facial identification task.

Acute stressor

A first-time tandem skydive was chosen as our acute stressor. A skydive exposes participants to a hazardous environment with potentially fatal consequences; the result is the evocation of a genuine stress response in reaction to real threat. Solo jumpers require significant training prior to a skydive, allowing the skydiver to acclimate to the environment; thus, tandem first-time jumps were chosen to maximize the inherent anticipatory stress. The skydive protocol allowed for identical time courses between participants, minimizing potential time-related effects.

Stimuli and equipment

For this study, we used neutral and aggressive facial expressions of two male faces obtained from the Pictures of Facial Affect (Paul Ekman Inc., Oakland CA) standardized database. Stimuli were grey-scaled and cropped to eliminate hair and other extraneous features. Using commercially available software (MorphMan 3.0, STOIK Imaging, Moscow, Russia), we manipulated the images to provide emotionally ambiguous expressions. Seven levels were produced between the *neutral* (0%) and *aggressive* (100%) poles (20-80%, in 10% increments; see Figure 1a). Noise was added to images using a 15% Gaussian white noise filter (Photoshop CS 2 Version 9.02, Adobe Inc, San Jose, CA). To provide environmental isolation, all subjects were fitted with a head-mounted display (nVisor SX60, NVIS Inc, Reston, VA) connected to a laptop computer. The task was programmed and run using E-Prime software version 1.2 (Psychology Software Tools, Inc, Sharpsburg, PA).

Facial identification task

As depicted in Figure 1b, each trial started with a 1500 ms period of dynamic visual white noise. Images of the faces appeared in series; each grainy, pixilated image gradually revealed a face over the course of 5250 ms (35 iterative images each, with 150 ms duration, displayed at 6.67 Hz). Participants were instructed to rate each face as either *neutral* or *aggressive* with a left or right mouse click, respectively, and were instructed to decide as quickly and accurately as possible. Responses for a concluding trial were recorded both during the 5250 ms face segment and in the period of 1500 ms inter-trial interval (dynamic white noise) preceding the next trial. Participants could not influence the timing of the task by responding more rapidly (i.e., responses did not terminate trials). The task consisted of 70 trials and lasted for 7 minutes and 52 seconds.

Figure 1a. Levels of facial morphing corresponding to levels of ambiguous aggression

20%   30%   40%   50%   60%   70%   80%

Increasing Anger Level
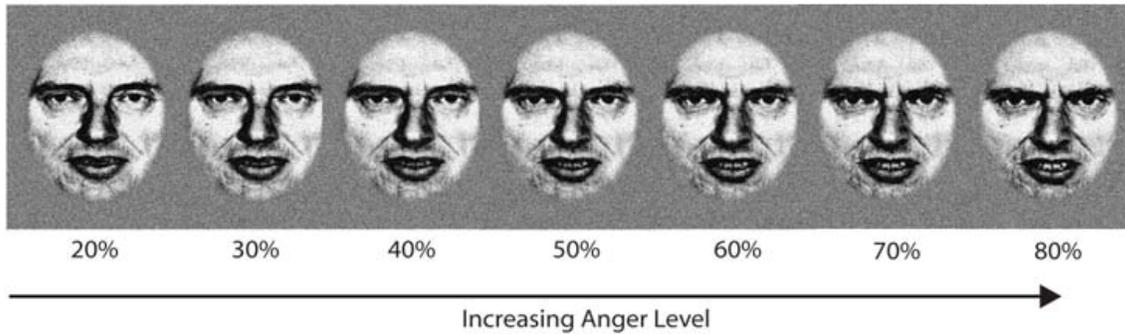
Figure 1b. Signal/noise ratio over the course of 5250 ms

1500 ms
Dynamic
White Noise

5250 ms
Faces gradually
emerge from noise
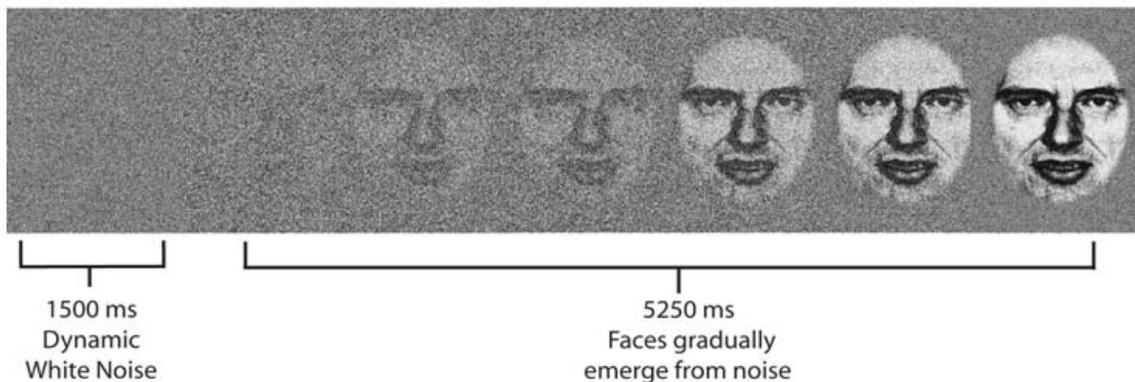
Statistical analysis of data

Salivary cortisol levels and state anxiety scores were compared between stress and control environments using a two-tailed student's *t*-test to validate experimental manipulation of physiological state. Two independent 2×2×7 mixed-model analyses of variance (ANOVAs) were conducted to assess the effects of gender (male vs. female), stress level (stress vs. control), and aggression level (20 - 80%) on affect identification (aggressive vs. neutral) and perceptual processing (reaction time). In our 2×2×7 ANOVA of the ratings data, we assessed sensitivity to aggression level using a linear trend analysis. Our follow-up comparisons of significant effects were made by fitting a line to participants' responses and testing for differences in the slopes across conditions with Bonferroni-corrected *t*-tests; the data fitting procedure used by Lim and Pessoa (2008) utilized a sigmoid for fitting responses to fearful faces across a full range of emotion (0 - 100% fearful), however a line fit our limited range of emotion (20 - 80%) more appropriately. The slope of the best-fit line indicated sensitivity towards aggression, e.g., an increase in slope indicated an increase in sensitivity. Where appropriate, Bonferroni-corrected post-hoc follow-up tests were used to further evaluate significant interactions.

Results

Validation of skydive as an acute stressor

Results showed that salivary cortisol levels (time-locked between conditions) were significantly elevated during the acute stressor as compared to the control, $t = 7.03$, $p <$

.001. Likewise, state anxiety scores were significantly higher during the acute stressor as compared to the control, $t = 4.22$, $p = .001$. These effects were significant for both men and women when analyzed separately; however, women only showed a trend, $t = 2.10$, $p = .061$, toward increased anxiety between stress and control conditions, as compared to men, $t = 3.19$, $p = .007$.

Analysis of rating data

For each of the 70 binary forced-choice trials, participants chose between *neutral* ("1") and *aggressive* ("2"). A 2×2×7 repeated measures ANOVA was conducted to assess the effects of sex (male vs. female), stress level (stress vs. control), and aggression level (20 -80%) on participants' ratings. There was a significant effect of aggression level on ratings, $F(6,162) = 169.12$, $p < .001$, $\eta^2 = .86$; participants rated each incremental increase in aggression level with a linear increase in rating. We found a significant three-way interaction between stress level, aggression level, and sex using a linear trend analysis, $F(6,162) = 9.78$, $p = .004$, $\eta^2 = .27$; this indicated a sex-specific difference in affect sensitivity between stress and control conditions. Follow-up comparisons (utilizing the slopes of the aforementioned best-fit lines; see Figure 2) showed that men showed no difference in sensitivity to aggression during stressful vs. control conditions, $p = .41$; however, women showed a marked decrease in sensitivity under stressful conditions, $t = 4.49$, $p < .001$. Under control conditions, women were significantly more sensitive to changes in aggression level than men, $t = 2.15$, $p = .04$ (see Figure 2); however, women were identical to men in affect characterization under stressful conditions, $p = .54$. Women rated the ambiguous faces on the aggressive end of the spectrum (50%, 60%, 70%, and 80% aggression) as significantly more neutral under stress versus control conditions, p's < .03. All other effects were not significant, p's > .10.

Figure 2. Best-fit linear trend lines for aggression ratings, by condition and sex
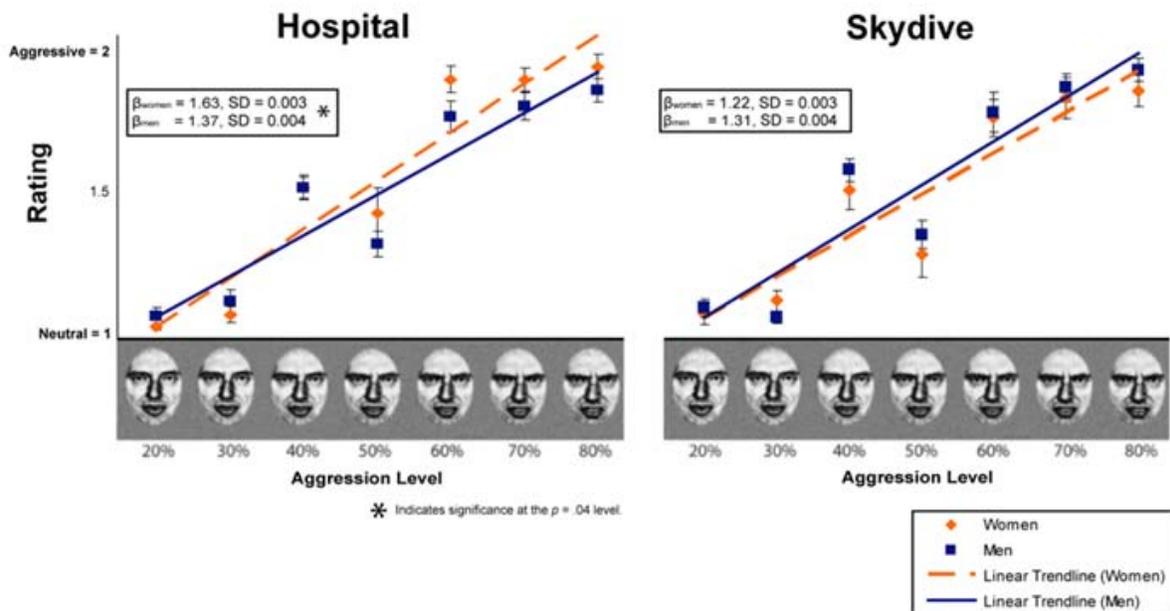
Analysis of reaction time data

A 2×2×7 repeated measures analysis of variance (ANOVA) was conducted to assess the effects of sex (male vs. female), stress level (stress vs. control), and aggression

level (20 - 80%) on reaction time. There was a main effect of stress level, $F(1,27) = 10.79$, $p = .003$, $\eta^2 = .29$; reaction times were significantly faster under stressful conditions ($M = 4065.25$ ms, $SE = 100.05$) compared to control conditions ($M = 4349.16$ ms, $SE = 124.74$), $p = .003$. All other effects were not significant, p's $> .10$.

Discussion

Our results validated a first-time tandem skydive as an acute stressor through physiological and self-report measures. Our findings support sex-dependent variance in sensitivity to aggression in response to a real-world acute stressor; the presence of a stressor caused a significant decrease in sensitivity towards aggression in female subjects, but had no effect in men. Our findings also include a sex-independent enhancement of visual perceptual processing following introduction of an acute stressor.

Sex and threat perception

Under real-world conditions, the ability to accurately characterize potential threat proves evolutionarily advantageous for survival, and past research has shown that women are typically more effective and accurate at characterizing facial displays of emotion (Biele and Grabowska, 2006; Goos and Silverman, 2002; Hall, 1978; McAndrew, 1986; Taylor et al., 2000). Though our results suggest that women are indeed more sensitive to aggression than their male counterparts under controlled conditions, we found that women were no more sensitive than men in characterizing aggression under stressful conditions (see Figure 2). Contrary to the fight or flight paradigm, which predicts that both sexes should react to stressful environments with heightened awareness and increased sensitivity to threat, including social conflict (Cannon, 1929), we found that women were significantly more likely to characterize emotionally ambiguous faces and aggressive faces as benign when under stress. We believe that this decrease in sensitivity is a result of a compromise between rapid decision making and information acquisition when a threat is presented; e.g., under threatening conditions, a decision must often be made without the availability of all pertinent information, which compromises accuracy but increases the probability of survival by reducing reaction time (see next section). Because rapid decision-making in dangerous situations is typically made without the availability of all relevant information, the introduction of ambiguity as a key variable was designed to enhance the extension of our results to real-world environments.

Another possible explanation for the marked decrease in sensitivity to aggression is the theory set forth by Taylor and colleagues' (2000), called *tend and befriend*. This theory of female stress response asserts that, when threatened, women are more likely than men to seek social support as a defense mechanism to increase chances of survival (Taylor et al., 2000). As previously mentioned, the faces presented in the task were unrelated to the stressor; thus, the characterization of emotion may have represented a friend or foe assessment, i.e., when threatened, a woman may be more willing to forgo potentially aggressive signals from an unrelated source for the sake of social support. Further studies will be necessary to evaluate this potential effect.

A final alternative explanation for our results is due to our exclusive use of male faces for the task. It has been shown that the sex of a static face influences the accuracy of emotion identification (Erwin et al., 1992; Goos and Silverman, 2002). Therefore, it may be possible that the apparent decrease in sensitivity towards facial displays of aggression in

women is specific to male static faces. Though our data cannot directly address this possibility, a simple modification of our task via the inclusion of female faces could shed light on this topic.

Perceptual processing and threat

As hypothesized, participants exhibited a stress-induced modulation of sensitivity to perceptual ambiguity. When in a state of danger, the rapid and accurate evaluation of facial expressions is essentially a friend or foe appraisal, with obvious evolutionary utility in deciding whether to face the danger alone or affiliate with a stranger. Participants evaluated the affect of perceptually degraded faces with lower signal/noise when exposed to acute stress; this effect was equal for both sexes and evident for all aggression levels.

Greater enhancements in perception have previously been shown to correlate with higher levels of anger, aggression, and fear in static faces (Amaral, Behniea, and Kelly, 2003; Carlson and Reinke, 2008; Carlson et al., 2009; Phelps et al., 2006). However, a critical methodological distinction between our research and previous studies is that the research cited above utilized threatening faces as the means of *inducing* the threat condition. In contrast, our study design tested how a pre-existing state of threat (in this case, physical danger) would affect interpretation of an orthogonal stimulus (emotional expression of an unfamiliar face). Since our participants were already in a state of heightened alert when the task began, the previously reported facilitatory effects of aggressive expressions may have been rendered negligible.

We speculate that this decrease in reaction time may be attributed to amygdala-elicited enhanced attentional and perceptual processing, based on related work (Anderson and Phelps, 2001; Carlson et al., 2009; Geary and Flinn, 2002; Phelps et al., 2006). Studies have shown that threatening faces, as compared to neutral faces, solicit attention and increase amygdala activity (Mujica-Parodi, Korgaonkar, et al., 2009; Phelps et al., 2006). It is thought that the amygdala provides feedback to the visual cortex and other brain regions prior to awareness, enhancing perception (Amaral et al., 2003; Carlson et al., 2009; Carlson et al., 2010; Mujica-Parodi, Strey, et al., 2009; Phelps et al., 2006; Rubin et al., 2011) and allowing an individual to respond to potential threat with as little information as possible.

Limitations

A trade-off inherent to the nature of the study is possibility of self-selection. For ethical reasons, every participant volunteered for his or her skydive, which involved very clear risks. This may introduce a self-selection bias, and though male subjects did not strongly deviate from an average sensation seeking score, female subjects scored significantly higher than average. Additionally, men and women did not deviate from each other in sensation seeking score, although the literature suggests that, in general, men score higher on the sensation seeking scale than women (Byrnes, Miller, and Schafer, 1999). It is therefore currently unknown whether these results would extend to a more general population of women.

An important concern regarding the validity of our results is whether reaction times could have been influenced by participants eager to complete the task by answering as quickly as possible, or by the inherent distractions present in the plane. To address these potential confounds, the task was programmed such that participants could not influence its timing; each trial length was fixed. Therefore, attempting to quickly progress through the

task by responding hastily did not have any effect on timing. To minimize distraction by ambient visual or auditory cues, the virtual reality helmet used was completely isolating. To prevent differences in reaction time being caused by postural or ergonomic confounds, we had participants assume an identical seated posture under both conditions. Thus, we believe it is unlikely that our data were significantly influenced by these variables. One variable we were not able to control for was ambient vibration under the stress but not control conditions, and this remains a limitation of the present study.

Conclusions

This study adds to our understanding of the human stress response in an authentically threatening environment, including perceptual processing and sex differences in potential threat perception. Our results indicate a stress-dependent shift in sensitivity to facial displays of aggression in women, but not in men. Future studies with larger participant sample sizes, the inclusion of female facial expressions (the present study used only male faces) and the inclusion of expression poles of different emotional valence (not only aggression, but also happiness, sadness, and fear) will explore more fully this important area of research.

References

Amaral, D. G., Behniea, H., and Kelly, J. L. (2003). Topographic organization of projections from the amygdala to the visual cortex in the macaque monkey. *Neuroscience, 118*, 1099-1120.

Anderson, A. K., and Phelps, E. A. (2001). Lesions of the human amygdala impair enhanced perception of emotionally salient events. *Nature, 411*, 305-309.

Biele, C., and Grabowska, A. (2006). Sex differences in perception of emotion intensity in dynamic and static facial expressions. *Experimental Brain Research, 171*, 1-6.

Boyatzis, C. J., Chazan, E., and Ting, C. Z. (1993). Preschool children's decoding of facial emotions. *Journal of Genetic Psychology, 154*, 375-382.

Byrnes, J., Miller, D., and Schafer, W. (1999). Gender differences in risk taking: A meta-analysis. *Psychological Bulletin, 125*, 367-383.

Cannon, W. B. (1929). *Bodily changes in pain, hunger, fear and rage: An account of recent research into the function of emotional excitement* (2nd ed.). New York: Appleton-Century-Crofts.

Carlson, J. M., and Reinke, K. S. (2008). Masked fearful faces modulate the orienting of covert spatial attention. *Emotion, 8*, 522-529.

Carlson, J. M., Reinke, K. S., and Habib, R. (2009). A left amygdala mediated network for rapid orienting to masked fearful faces. *Neuropsychologia, 47*, 1386-1389.

Carlson, J. M., Reinke, K. S., Lamontagne, P. J., and Habib, R. (2011). Backward masked fearful faces enhance contralateral occipital cortical activity for visual targets within the spotlight of attention. *Social Cognitive Affective Neuroscience, 6*, 639-645.

Dikecligil, G. N., and Mujica-Parodi, L. R. (2010). Ambulatory and challenge-associated heart rate variability measures predict cardiac responses to real-world acute emotional stress. *Biological Psychiatry, 67*, 1185-1190.

Erwin, R. J., Gur, R. C., Gur, R. E., Skolnick, B., Mawhinney-Hee, M., and Smailis, J. (1992). Facial emotion discrimination: I. Task construction and behavioral findings in normal subjects. *Psychiatry Research, 42*, 231-240.

Geary, D. C., and Flinn, M. V. (2002). Sex differences in behavioral and hormonal response to social threat: Commentary on Taylor et al. (2000). *Psychological Review, 109*, 745-750; discussion 751-743.

Goos, L., and Silverman, I. (2002). Sex related factors in the perception of threatening facial expressions. *Journal of Nonverbal Behavior, 26*, 27-41.

Hall, J. A. (1978). Gender effects in decoding nonverbal cues. *Psychological Bulletin, 85*, 845-857.

Kirouac, G., and Dore, F. Y. (1983). Accuracy and latency of judgment of facial expressions of emotions. *Perceptual and Motor Skills, 57*, 683-686.

Lim, S. L., and Pessoa, L. (2008). Affective learning increases sensitivity to graded emotional faces. *Emotion, 8*, 96-103.

McAndrew, F. T. (1986). A cross-cultural study of recognition thresholds for facial expressions of emotion. *Journal of Cross-Cultural Psychology, 17*, 211-224.

Montagne, B., Kessels, R. P., Frigerio, E., de Haan, E. H., and Perrett, D. I. (2005). Sex differences in the perception of affective facial expressions: Do men really lack emotional sensitivity? *Cognitive Processing, 6*, 136-141.

Mujica-Parodi, L. R., Korgaonkar, M., Ravindranath, B., Greenberg, T., Tomasi, D., Wagshul, M., ... Malaspina, D. (2009). Limbic dysregulation is associated with lowered heart rate variability and increased trait anxiety in healthy adults. *Human Brain Mapping, 30*, 47-58.

Mujica-Parodi, L. R., Strey, H. H., Frederick, B., Savoy, R., Cox, D., Botanov, Y., ... Weber, J. (2009). Chemosensory cues to conspecific emotional stress activate amygdala in humans. *PLoS One, 4*, e6415.

Nowicki, S., Jr., and Hartigan, M. (1988). Accuracy of facial affect recognition as a function of locus of control orientation and anticipated interpersonal interaction. *Journal of Social Psychology, 128*, 363-372.

Phelps, E. A., Ling, S., and Carrasco, M. (2006). Emotion facilitates perception and potentiates the perceptual benefits of attention. *Psychological Science, 17*, 292-299.

Rotter, N. G., and Rotter, G. S. (1988). Sex differences in the encoding and decoding of negative facial emotions. *Journal of Nonverbal Behavior, 12*, 139-148.

Rubin, D., Botanov, Y., Hajcak, G., and Mujica-Parodi, L. R. (2011). Second-hand stress: Inhalation of stress sweat enhances neural response to neutral faces. *Social Cognitive Affective Neuroscience*. Advance online publication. doi: nsq097 [pii]10.1093/scan/nsq097

Schroth, M. L. (1995). A comparison of sensation seeking among different groups of athletes and nonathletes. *Personality and Individual Differences, 18*, 219-222.

Spielberger, C. D., Gorsuch, R. L., and Lushene, R. E. (1970). *Manual for the state-trait anxiety inventory* (self-evaluation questionnaire). Palo Alto, CA: Consulting Psychology Press.

Taylor, S. E., Klein, L. C., Lewis, B. P., Gruenewald, T. L., Gurung, R. A., and Updegraff, J. A. (2000). Biobehavioral responses to stress in females: Tend-and-befriend, not fight-or-flight. *Psychological Review, 107*, 411-429.

Zuckerman, M. and K. Link (1968). Construct validity for the sensation-seeking scale. *Journal of Consulting and Clinical Psychology, 32*, 420-426.