The influence of stress on attentional bias to threat: An angry face and a noisy crowd

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Abstract

During stress, attentional capture by threatening stimuli may be particularly adaptive. Individuals are more efficient at identifying threatening faces in a crowd than identifying nonthreatening faces (e.g., Öhman et al., *Journal of Experimental Psychology: General*, 130(3): 466–478, 2001a, Öhman et al., *Journal of Personality and Social Psychology*, 80(3): 381–396, 2001b). However, under conditions of stress, when attention to threat may be most critical, cognitive processes are generally disrupted. The present study explored the attentional advantage of threatening stimuli under stressful conditions. We exposed participants to either high or low stress conditions during a visual search task displaying threatening and nonthreatening facial targets among distractors. Participants' accuracy, reaction times, and self-reported stress were measured. Stress introduced a speed–accuracy trade-off: participants in the high-stress condition were faster, but less accurate, than participants in the low-stress condition. Although both groups of participants showed relative performance advantages in detecting threatening compared with nonthreatening stimuli, this advantage was markedly larger for participants in the high-stress condition. This suggests that the established stress-mediated increase in the activity of the ventral neural network responsible for the reorienting of attention may have enhanced the ability to detect threatening stimuli or buffered the disruptive effects of stress on this process. Our findings highlight the potentially adaptive nature of stress disruption on attentional processes and align research on the anger superiority effect and automated attentional processes under stress.

Keywords Visual search · Stress · Reaction time analysis · Attentional capture

The ability to reliably and quickly identify signs of threat is highly adaptive (Darwin, 1859). It is therefore not surprising that humans have evolved to attend to threatening faces more effectively and efficiently than to nonthreatening faces. A series of studies have shown the “anger superiority” or “face in the crowd” effect (Hansen & Hansen, 1988; Öhman, Lundqvist, & Esteves, 2001b). When observers view an array of emotional faces, they are faster to notice a threatening face among various nonthreatening (happy or neutral) faces than to notice a nonthreatening face among distractors. Although an

ability to quickly notice a source of threat might be particularly advantageous in stressful situations, no studies have examined the effect of acute stress on this attentional bias.

Research has shown that when an individual encounters a threat, the amygdala is signaled independently of conscious awareness. Indeed, neuroimaging studies have revealed that individuals with hemispatial neglect experience amygdala activity without conscious awareness of an image (Vuilleumier, Armony, Clarke, Husain, Driver, and Dolan, 2002). Research by LeDoux (1996, 2000) and colleagues suggests that neural signals originating from fear stimuli activate the amygdala prior to the visual cortex. This pattern of signaling may be adaptive because the amygdala initiates physiological arousal to facilitate a response to the source of threat (i.e., the fight-or-flight response; (Cannon, 1932; Pribram & McGuinness, 1975).

Once the visual signal reaches the occipital lobe, the source of physiological arousal (e.g., the threat) needs to be accurately identified to enable appropriate behavioral responding. Social psychological studies have shown that we can misattribute the cause of physiological arousal leading to different

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emotional and behavioral responses. For instance, physiological arousal caused by an injection of epinephrine can intensify an emotional response (e.g., anger or joy) to environmental stimuli unrelated to the injection (Schachter & Singer, 1962). In the face of threat, such a misattribution could be detrimental.

In order to avoid incorrectly identifying the source of a threat, threatening stimuli in our visual field may have an attentional advantage. That is, the anger superiority effect demonstrated by Öhman, Lundqvist, et al. (2001b) may be evidence of an attentional threat advantage evolved to aid in threat responses, including arousal-attribution processes. In this case, an attentional threat advantage might be especially robust under stressful situations.

Consistent with this, unpleasant emotional stimuli tend to receive privileged attentional processing. Fear-related stimuli, such as snakes, have been shown to capture attention more effectively when displayed among images that are considered neutral, such as flowers (Öhman, Flykt, & Estevez, 2001a). Fear stimuli appear to “pop-out” and be pre-attentively recognized among other items. For example, in an attentional blink paradigm, in which a target image is presented among a stream of distractors over a short period of time (e.g., the attentional blink period), the image typically goes unnoticed (Raymond, Shapiro, & Arnell, 1992). However, when the target image is emotionally significant, participants often detect the target, consistent with the idea that emotional stimuli are preferentially processed (Anderson, 2005; Anderson & Phelps, 2001).

However, once stressed, attentional control theory asserts that stress places significant demands on an individual’s cognitive resources and impairs attentional processes (Eysenck, Derakshan, Santos, & Calvo, 2007). The effects of stress on attention can be observed during acute laboratory tasks. In one study participants exhibited impairments in attention, verbal recall, and working memory up to 30 minutes after a stressful speech task (Olver, Pinney, Maruff, & Norman, 2015). Moreover, Paczynski, Burton, and Jha (2015) found that pairing a target face with a stressful image (e.g., a dangerous animal) significantly decreased accuracy in identifying characteristics of the face relative to when pairing it with a benign image (e.g., a building). Thus, an attentional threat advantage may be similarly impaired under stressful conditions.

Although acute laboratory stress appears to disrupt attentional processes, it is clear that threatening visual stimuli draw attention, presumably to help observers recognize threats. What is not known is whether feeling stressed disrupts attentional processes involving threatening stimuli. Because fight-or-flight physiological responses are meant to facilitate behavioral reactions to threat, we hypothesize that attentional processes will be similarly adaptive under stress. That is, attention

to threat will be relatively immune to the disruptive effects of stress on cognition. In fact, stress has been shown to narrow attentional processes towards prominent or salient stimuli in one’s environment (Arnsten, 2000; Hockey, 1970). Therefore, it may be that stress enhances vigilance and attention towards threatening stimuli. We examined this possibility by observing the effect of an acute stressful state on participants’ ability to notice angry faces among a randomly distributed array of happy or neutral faces.

Method

Participants

We recruited 278 North Dakota State University (NDSU) undergraduate (135 male, 143 female) participants online and offered course credit for participation. Upon arrival, participants were screened for hearing and vision impairments that would affect their performance, and then seated at a computer. Individuals were randomly assigned to a high-stress or low-stress condition and wore headphones for the duration of the experiment.

Stimuli and apparatus

Participants sat approximately 50 cm from a computer display with a resolution of $1,024 \times 768$ pixels and a refresh rate of 60 Hz. Stimuli for the visual search task were based on those in the study by Öhman, Lundqvist, et al. (2001b) and consisted of simple, black stick-figure faces with neutral, threatening, or happy/friendly facial expressions (see Fig. 1a) subtending approximately 2.4×2.8 degrees of visual angle against a white background. Previous work indicates emotional faces require more processing than neutral faces, but that threatening faces are processed more quickly than nonthreatening emotional faces (Öhman et al., 2001a, b).

Procedure and design

The NDSU institutional review board approved all procedures. Each trial began with the presentation of a central black fixation point for 2 seconds. Nine faces then appeared at randomly selected locations within a centered 4×4 grid subtending approximately 30×20 degrees of visual angle. Random jitter (~ 1 degree) was added to the position of each face to obscure this grid arrangement. Participants viewed a threatening target among neutral distractors (TAN), a friendly target among neutral distractors (FAN), a friendly target among threatening distractors (FAT), a neutral target among threatening distractors (NAT), a neutral target among friendly distractors (NAF), or a threatening target among friendly distractors (TAF). Participants were instructed to press the S

Fig. 1 **a** Stimuli representing physical differences in a neutral, friendly, or threatening expression. **b** Example of the distribution of faces presented in the task (friendly distribution featuring a threatening target)

key if they thought all the faces had the same facial expression, and the *D* key if one of the faces was different. Search arrays remained on the display until a participant provided a response. Following each response, there was a 3-second intertrial interval in which a blank white screen was presented (see Fig. 1b).

Each participant completed a single block of 24 practice trials in which feedback was provided in the form of a centrally presented plus sign for correct responses and a minus sign for incorrect responses. Following practice, participants completed three blocks of 72 trials each—36 target absent, 36 target present, equally distributed across target/distractor combinations—with no error feedback in a random order.

After completing all trials, participants were asked to complete questionnaires assessing emotional and psychological stress responses to the tasks. These measures were the Positive and Negative Affect Scale–Expanded form (PANAS-X; Watson & Clark, 1994), which asks participants to rate the extent to which they felt 20 emotions “during the task,” on a scale from 1 (*not at all*) to 5 (*extremely*). Also, participants completed the stress and arousal checklist (King, Burrows, & Stanley, 1983), which asks participants to rate the extent to which they felt 20 adjectives related to stress (e.g., *distressed*) and arousal (e.g., *alert*) on a scale from 0 (*definitely not*) to 4 (*definitely yes*). These are validated, reliable measures often used in stress manipulation research. Positive affect

(PA), negative affect (NA), stress, and arousal subscales were computed by summing appropriate items.

Stress manipulation Participants in the high-stress condition were told prior to the task to perform as accurately and quickly as possible. Further, they were informed their performance on the task would be observed and evaluated by assistants monitoring from the next room. To elicit stress, 70% of the trials in this condition included a 100 dB burst of white noise played through the participant’s headphones at a random interval between 500 to 1,500 milliseconds after a response. The noises were played for 1 second, 2 seconds, or .5 seconds twice, separated by 1 second of silence. Between blocks in the experiment, we induced social evaluative threat through a recorded message that was designed to sound like an experimenter, observing in the next room, who criticized the participant’s performance as not fast or accurate enough, and strongly urged the participant to respond more quickly and accurately. The recording included phrases such as “in order to use your data, you need you to respond more accurately” and “you are not responding fast enough.”

Participants in the low-stress condition were told prior to the task to perform as accurately and quickly as possible but were not informed of any evaluative threat. Between blocks, a friendly recorded voice introduced itself as a recording and

reminded the participant to respond as quickly and accurately as possible.

Results

Data from 13 participants who showed mean RT or accuracy values that were beyond four standard deviations of the grand mean for a condition—likely indicating disengagement with the task—were not included in our analyses. This left us with data from 132 participants in the low-stress group and 133 participants in the high-stress group.

Manipulation checks

To examine if the stress manipulation was effective, independent-samples *t* tests were used to compare the effects of stress condition on self-reported NA, PA, stress, and

arousal. These analyses revealed a significant effect of condition on NA, $t(260) = -7.46, p < .01$. Participants in the high-stress condition reported significantly higher levels of NA ($M = 19.63, SD = 7.13$) than those in the low-stress condition ($M = 13.95, SD = 4.99$). There was no significant effect of condition on PA, $t(260) = -1.42, p > .05$. Similarly, self-reported stress was higher in the high-stress ($M = 15.58, SD = 6.78$) than in the low-stress condition ($M = 7.54, SD = 6.27$), $t(274) = -10.22, p < .01$. Additionally, self-reported arousal was higher in the high-stress ($M = 10.49, SD = 4.11$), than in the low-stress condition ($M = 7.36, SD = 4.05$), $t(266) = -6.26, p < .01$. Therefore, the stress manipulation appears to have been successful.

Visual search task

Table 1 displays descriptive statistics for target-present trials across the six combinations of target and distractor types,

Table 1 Means (*M*) and standard deviations (*SD*) across conditions—target-present trials

Reaction time	Overall (<i>N</i> = 265)			Low stress (<i>N</i> = 132)			High stress (<i>N</i> = 133)		
	<i>M</i>	<i>SD</i>	Threat advantage	<i>M</i>	<i>SD</i>	Threat Advantage	<i>M</i>	<i>SD</i>	Threat advantage
Neutral/friendly distractors	1,593.99 ^a	381.77		1,698.92 ^a	378.18		1,489.84 ^a	357.23	
Threat /friendly distractors	1,391.11 ^b	370.27	202.88	1,499.56 ^b	374.73	199.36	1,283.48 ^b	333.78	206.36
Friendly/threat distractors	1,585.09 ^a	420.56		1,719.54 ^a	382.41		1,451.66 ^a	415.45	
Neutral/threat distractors	1,595.14 ^a	374.57		1,705.99 ^a	364.09		1,485.11 ^a	352.93	
Friendly/neutral distractors	1,322.11 ^c	340.14		1,380.26 ^c	367.37		1,264.39 ^c	301.18	
Threat /neutral distractors	1,128.57 ^d	279.63	193.54	1,203.24 ^d	309.23	177.02	1,054.45 ^b	224.44	209.94
Accuracy									
Neutral/friendly distractors	70.47% ^a	19.35%		78.54% ^a	16.61%		62.47% ^a	18.59%	
Threat /friendly distractors	89.73% ^b	10.62%	19.26	92.21% ^b	9.48%	13.67	87.26% ^b	11.13%	24.79
Friendly/threat distractors	77.49% ^c	16.20%		81.82% ^a	15.20%		73.20% ^c	16.08%	
Neutral/threat distractors	76.00% ^c	18.51%		80.43% ^a	18.06%		71.61% ^c	17.95%	
Friendly/neutral distractors	88.04% ^b	12.89%		93.22% ^c	9.21%		82.90% ^d	13.95%	
Threat /neutral distractors	95.20% ^d	7.37%	7.16	96.21% ^b	6.27%	2.99	94.19% ^e	8.23%	11.29
Inverse efficiency									
Neutral/friendly distractors	2,436.09 ^a	1047.05		2,246.67 ^a	613.62		2,624.09 ^a	1,321.92	
Threat /friendly distractors	1,566.70 ^b	429.72	869.39	1,648.65 ^b	461.34	598.02	1,485.37 ^b	381.63	1138.72
Friendly/threat distractors	2,095.96 ^c	549.63		2,151.10 ^a	504.80		2,042.24 ^c	587.75	
Neutral/threat distractors	2,207.32 ^c	695.24		2,242.97 ^a	778.65		2,171.94 ^c	602.08	
Friendly/neutral distractors	1,526.79 ^b	420.08		1,493.62 ^c	412.30		1,559.70 ^d	426.65	
Threat /neutral distractors	1,192.04 ^d	304.07	334.75	1,259.12 ^d	345.69	228.5	1,125.47 ^b	239.49	434.23

Note. Reaction time is in milliseconds; accuracy is in percentage correct; inverse efficiency = (RT/proportion correct). For each set of target/distractor conditions, means with different superscript letters indicate statistically significant differences ($p < .05$) found with post hoc pairwise comparisons employing a Bonferroni correction

Table 2 Means (*M*) and standard deviations (*SD*) across conditions—target-absent trials

	Low stress (<i>N</i> = 132)		High stress (<i>N</i> = 133)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Reaction time				
Friendly distractors	2,192.58	611.23	1,711.81	531.24
Threatening distractors	2,075.33	569.04	1,644.56	507.37
Neutral distractors	1,813.83	466.88	1,461.60	388.94
Accuracy				
Friendly distractors	93.56	7.49	89.11	10.59
Threatening distractors	93.94	8.11	90.47	9.87
Neutral distractors	96.40	6.14	94.31	8.81

Note. Reaction time is in milliseconds; accuracy is in percentage correct

while Table 2 displays descriptive statistics for target-absent trials across the three distractor types. Consistent with previous research, we found an anger superiority effect (Öhman et al., 2001a, b)—participants were faster and more accurate at detecting a threatening target among distractors than among friendly or neutral targets. Also replicating previous work (Öhman et al., 2001a, b) we found performance was generally slower and less accurate with emotional (i.e., threat and friendly) distractors than with neutral distractors (see Table 1).

To test our hypothesis that stress differentially influences the detection of threatening versus nonthreatening stimuli among distractors, we conducted 6×2 mixed ANOVAs with a within-subjects factor of trial type and a between-subjects factor of stress condition on RT and accuracy data, as well as on a combined measure of performance, the inverse efficiency score (IES; i.e., RT/proportion correct). Table 3 displays the results of these analyses. As can be seen from these tables, we found significant main effects of trial type and stress condition for both RT and accuracy measures—participants in the high-stress condition generally responded faster, but less accurately, than participants in the low-stress condition. Importantly, we also found a significant interaction between trial type and

stress condition for these dependent variables. While participants in both the low-stress and high-stress groups showed an anger superiority effect, this advantage for threatening targets tended to be larger for participants in the high-stress group. Table 3 shows that the IES analysis likewise yielded a significant main effect of trial type as well as a significant interaction.

To more thoroughly examine this interaction, we ran independent-samples *t* tests comparing IES for the high-stress and low-stress groups for each of the six trial types (see Fig. 2a). Interestingly, participants in the high-stress group had significantly lower IES than participants in the low-stress group for both distractor types with threatening targets, $t(1, 263) = 3.14, p = .002$ for TAF; $t(1, 263) = 3.66, p < .001$ for TAN, but significantly higher IES in NAF trials, $t(1, 263) = -2.98, p = .003$. The difference between IES for high-stress and low-stress groups did not differ for FAN, FAT, or NAT trial types (all *p* values $> .10$). Taken together, these analyses indicate that participants in the high-stress group outperformed their counterparts in the low-stress group, but only for trials where a threatening target was present among distractors.

In addition to these analyses, we collapsed each participant's reaction time, accuracy, and IES data for trials in which the target was a threatening face and compared them with trials in which the target was a nonthreatening face. This provides a more conservative test of our stress hypothesis because we are combining friendly and neutral target conditions with reaction times that differ (Öhman et al., 2001a, b), but are not believed to benefit from the threat advantage. Figure 2b displays the mean IES for these collapsed data. Table 4 displays the results of 2×2 mixed ANOVAs with a within-subjects factor of target type (threatening vs. nonthreatening) and a between-subjects factor of stress condition (low vs. high) on RT, accuracy, and IES data. As can be seen from Table 4, reaction time, $F(1, 264) = 757.23, p < .001, \eta_p^2 = 0.74$; accuracy, $F(1, 264) = 556.57, p < .001, \eta_p^2 = 0.68$; and IES, $F(1, 264) = 1,306.31, p < .001, \eta_p^2 = 0.83$, yielded a significant

Table 3 6×2 Trial Type (NAF/TAF/FAT/NAT/FAN/TAN) $\times$ Group (stress/no stress) ANOVA

	Factor	<i>F</i>	<i>p</i>	η_p^2
Reaction time	Trial type	$F(5, 259) = 366.22$	$<.001$	0.58
	Stress condition	$F(1, 263) = 25.43$	$<.001$	0.09
	Trial Type $\times$ Stress Condition	$F(5, 259) = 7.54$	$<.001$	0.03
Accuracy	Trial type	$F(5, 259) = 255.08$	$<.001$	0.49
	Stress condition	$F(1, 263) = 40.26$	$<.001$	0.13
	Trial Type $\times$ Stress Condition	$F(5, 259) = 15.87$	$<.001$	0.06
Inverse efficiency	Trial type	$F(5, 259) = 228.99$	$<.001$	0.47
	Stress condition	$F(1, 263) = 0.1$	.91	<0.001
	Trial Type $\times$ Stress Condition	$F(5, 259) = 10.37$	$<.001$	0.04

Fig. 2 **a** Mean inverse efficiency scores by trial type and condition. Error bars represent ± 1 SEM, $**p < .01$. **b** Mean inverse efficiency scores for participants in each stress condition for detecting threatening and nonthreatening targets. Error bars represent ± 1 SEM, $**p < .01$

main effect of target type, displaying the expected anger superiority effect. Also, we found a significant interaction between target type and stress condition for both the accuracy, $F(1, 264) = 37.34$, $p < .001$, $\eta_p^2 = 0.12$, and inverse efficiency, $F(1, 264) = 22.61$, $p < .001$, $\eta_p^2 = 0.08$, measures. There was no significant interaction between target type and stress condition for reaction time.

We followed up with independent-samples t tests comparing accuracies across the lowstress and high-stress groups for threatening targets, $t(264) = 3.454$, $p = .001$, and nonthreatening targets, $t(264) = 6.599$, $p < .0001$. Also, independent-samples t tests comparing IES across the low-stress and high-stress groups for threatening targets and nonthreatening

targets indicated that this significant interaction was driven by the fact that there was a significant difference between groups for threatening target trials, $t(264) = 3.78$, $p < .001$, but not for nonthreatening target trials, $t(264) = -0.17$, $p = .86$. These results are consistent with the interpretation that participants in the high-stress group experienced relatively stronger performance benefits in detecting threatening targets than did participants in the low-stress group.

Discussion

Consistent with our hypothesis, participants under stress experienced an enhanced attentional threat advantage. Specifically, while participants in both the low-stress and high-stress conditions were generally faster and more accurate at detecting threatening compared with nonthreatening targets among distractors, this performance boost for threatening targets was significantly larger for participants who were experiencing acute stress. These results are the first to show how two disparate lines of research are related. Studies have shown that stress and anxiety disrupt performance on a variety of attentional tasks (Eysenck et al., 2007) in which participants experience a decline in accuracy while simultaneously increasing their reaction time. Separately, studies have shown that there is an “anger superiority” effect in a visual search paradigm (Hansen & Hansen, 1988; Öhman, Lundqvist, & Esteves, 2001b). Participants are faster and more accurate at identifying angry faces relative to nonangry faces. Our study shows that while stress does disrupt accuracy performance on a facial attention task, an attentional threat advantage persists.

In the context of visual attention, behavioral neuroscience research concerning voluntary and automatic processes is consistent with our findings. Research supports the distinction between voluntary attentional processes that require conscious effort (e.g., a difficult visual search task) and more automated processes (e.g., an attentional threat advantage; Müller & Rabbitt, 1989). For instance, when attention is voluntarily

Table 4 2×2 Target Type (threat/nonthreat) $\times$ Group (stress/no-stress) ANOVA

	Factor	<i>F</i>	<i>p</i>	η_p^2
Reaction time	Target type	$F(1, 264) = 757.23$	<.001	0.74
	Stress condition	$F(1, 264) = 25.50$	<.001	0.09
	Target Type $\times$ Stress Condition	$F(1, 264) = 1.12$	.29	<0.01
Accuracy	Target type	$F(1, 264) = 556.57$	<.001	0.68
	Stress condition	$F(1, 264) = 35.09$	<.001	0.12
	Target Type $\times$ Stress Condition	$F(1, 264) = 37.34$	<.001	0.12
Inverse efficiency	Target type	$F(1, 264) = 1306.31$	<.001	0.83
	Stress condition	$F(1, 264) = 3.06$	.08	0.01
	Target Type $\times$ Stress Condition	$F(1, 264) = 22.61$	<.001	0.08

focused on a motivated task, research has shown a distinct pattern of ventral network suppression that prevents distraction. However, attention can be automatically redirected to behaviorally significant stimuli outside the focus of attention by a ventral frontoparietal network (Corbetta, Patel, & Shulman, 2008; Feldmann-Wüstefeld, Schmidt-Daffy, & Schubö, 2011). The coordinated interplay between these systems allows for a reorienting of attention from being engrossed in reading a novel to hearing your name mentioned across the room. It is possible a similar ventral frontoparietal autodetection facilitates the attentional threat advantage in the context of a visual search task. Our research suggests this attentional advantage continues to exist under stress and in fact may be enhanced by stress.

When under stress, stress-related hormones and neurotransmitters (e.g., cortisol and noradrenaline) act as neuromodulators to prompt an increase in the activity of the ventral neural network responsible for the reorienting of attention (Hermans et al., 2011). Cortical noradrenergic projections also promote an increase in the activity of thalamic and sensory regions. This facilitates direct communication between the thalamus and amygdala, thereby potentiating physiological reactions (e.g., sympathetic nervous system activity) to threatening stimuli without conscious awareness of the threat (LeDoux, 1996; Öhman, 2005; McEwen & Gianaros, 2010). In other words, automated processing of threatening stimuli occurs via a direct route to the amygdala, bypassing cortical processing involved with other sensory and visual information (LeDoux, 1996; Liddell et al., 2004). In the context of our research, this neural pattern of stress responding could have enhanced an attentional threat advantage.

We found that accuracy suffered in all conditions when stress was present, but not to as great an extent in the detection of a threatening face. Therefore, stress-induced shifting of activity toward a ventral frontoparietal network may have a buffering effect on the stress-related disruption of attention. An increase in the activity in the ventral reorienting network (Hermans et al., 2011) may cause or be associated with inhibition of stress-mediated disruption in other areas of the brain related to the detection of threat (e.g., the amygdala; Vuilleumier, 2005). This mechanism may have developed in order to avoid the disruptive effects of emotional responses that could delay adaptive behaviors.

In addition, it may be adaptive for stress to disrupt attention to nonthreatening stimuli, which may facilitate hypervigilance to threat-relevant stimuli in the visual environment. This would be consistent with research on decision-making under stress. That is, under normal conditions, individuals are likely to fully evaluate information, resources, and possible outcomes in order to come to a well-informed decision (Johnston, Driskell, & Salas, 1997). In contrast, individuals who are stressed employ hypervigilant decision-making strategies. Hypervigilant decision-making involves considering

only a limited number of alternatives (Janis & Mann, 1977). This is adaptive particularly when quick and efficient behavioral responding is necessary, for example, when facing a threat (Johnston et al., 1997). Similar to the effect on decision-making, the effect of stress on attention to nonthreatening stimuli we observed may have potentiated hypervigilant threat detection.

This is the first study of its kind to explore the relationship between stress and the anger superiority effect. Future research should investigate the attentional threat advantage and stress using a more diverse set of stimuli. As the recognition of emotion and facial decoding are essential and universal human skills, it would be logical to replicate these findings with photographs (Schmidt & Daffy, 2011) instead of the traditional schematic stimuli sets (Hansen & Hansen, 1988). Furthermore, as has been explored in decision-making (Johnston et al., 1997), the adaptive advantages of hypervigilant *attentional* processes (i.e., the attentional threat advantage) should be investigated. That is, it is not yet entirely clear what adaptive advantages are afforded by the disrupted attentional processes explored in this study. Finally, stress can be conceptualized in many different ways (e.g., chronic vs. acute, psychological vs. physical). In the present study, we implemented a multidimensional manipulation of stress (i.e., varying noise bursts and evaluative cues). Future studies should investigate how the threat advantage is impacted by different forms and dimensions of stress.

The present study extends the existing anger superiority effect literature to provide a broader understanding of how visual attention processes occur when an individual is under stress. Previous research has shown that stress disrupts attentional processes. Automatic detection of threat, when in an innocuous situation, is clearly adaptive. When in a stressful state, perhaps due to current situational demands or in anticipation of threat, detection of threatening stimuli may be crucial. Here, we have shown that an automatic attentional threat advantage is buffered and perhaps facilitated by the disruptive effects of stress.

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