

How Social Threat Influences Attentional Orienting and the Role of Anxiety

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DEDICATION

To my mother and father, Gloria and Seyed Hossein Azarian, for providing intellectual encouragement from an early age and throughout my academic career.

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ABSTRACT

HOW SOCIAL THREAT INFLUENCES ATTENTIONAL ORIENTING AND THE ROLE OF ANXIETY

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Past research indicates that threatening social information can exert strong influence over attention, particularly in individuals reporting high levels of anxiety. However, until now these findings have been largely restricted to threatening facial expressions with direct or averted eye gaze. Through a series of experiments we investigated whether these effects on attentional orienting are unique to threatening faces, or extend to other forms of threat-related social stimuli, and in particular, fearful and angry human body postures. Research surrounding attentional orienting and threatening body postures is relatively scarce, despite its ability to provide a more comprehensive description of how our cognitive systems process threatening social information and how such information can bias attention. In each of three experiments eye tracking was

employed to measure saccade reaction time instead of the more traditional manual response, since it provides greater sensitivity and allows one to trace overt orienting directly. In all studies, postures or head cues were presented centrally, followed by targets that appeared in the periphery and whose fixation required an eye movement. Where direct-facing angry and fearful postures held attention, evidenced by slower eye movements towards targets, the same postures in averted position caused orienting to congruent targets to be facilitated. This occurred even though posture emotion and direction were always task irrelevant, suggesting that the threat-related attentional modulations were automatic and involuntary. These results suggest that for anxious individuals, the ability to orient attention away from a posture and toward a target is affected in exactly opposite ways depending on the directionality of the threatening posture stimulus. In conclusion, our findings indicate that both fearful and angry postures can powerfully guide attention in a manner that is determined by their orientation, but only when anxiety is present. Such modulations bias attention toward threat, keeping the eyes focused on negative features of the environment, which over time may promote further worry and distress.

1. INTRODUCTION

Attention is the cognitive process of selectively focusing on one aspect of the environment while ignoring others. With its limited capacity, the amount of information that can be attended at any given moment is finite. Because of this limitation, selective attention should prioritize based on attributes of biological importance. The ability to efficiently detect threat in the environment provides obvious survival advantages and is of high priority. Oncoming predators and looming foes posed potentially lethal outcomes for our ancestors. Consequently, an attentional system specialized for the rapid detection of threatening stimuli has been shaped over the course of our evolutionary history. The following sections provide an overview of the relevant empirical research on the attentional system as it pertains to the processing of threatening information.

Orienting of attention

At any given moment the environment presents us with an abundance of visual information, necessitating preferential selection of certain relevant sensory

inputs by attention. As what is relevant in the environment changes, so does the focus of attention. This moving focus is known as *attentional orienting*.

Traditionally, the orienting of attention has been categorized as being either overt or covert, depending on whether saccades are present, and is comprised of three distinct components (Posner & Peterson, 1990). These components include a) the disengagement of attention from that stimulus, b) the initial shifting of attention towards a new stimulus, and c) the engagement of attention with that stimulus. A wealth of research has been conducted investigating these components using what has become known as the *spatial cueing paradigm* (Posner, 1980). In the exogenous (reflexive) form of this task, a cue is presented to the left or right of fixation and may or may not predict the spatial location of a subsequent target, while in the endogenous (goal-directed) form, a central directional cue, such as an arrow, correctly or incorrectly indicates the position of the target. Trials in which the cue correctly predicts the target location are known as valid trials, while invalid trials are those in which the cue falsely predicts the position of the target, requiring disengagement from the erroneous location and an additional shift to acquire the target. While faster reaction times on valid trials are thought to reflect a benefit due to enhanced orienting, slower reaction times on invalid trials reveal a cost associated with attention being cued in the

direction opposite the target. This task has since been modified in a number of ways to assess the effects of emotional or threat-related cues on the ability to shift and disengage attention in anxious individuals, who display a robust attentional bias for threatening information (Eysenck, 1992; Mathews & MacLeod, 1994; Yiend & Mathews, 2001).

Threat-related attentional biases in anxious individuals

Threatening faces have been shown to capture attention in a reflexive manner by eliciting a shift in their direction. Evidence from visual search paradigms reveal an advantage in the rate and accuracy of detecting threatening faces amongst distractors compared to neutral or happy faces (Eastwood, Smilek, & Merikle, 2001; Fox, Lester, Russo, Bowles, Pichler, & Dutton, 2000; Hansen & Hansen, 1988; Ohman et al., 2001), as well as for snakes and spiders (Ohman, Flykt, & Esteves, 2001) and threatening postures (Bannerman, Milders, and Sahraie, 2010; Gilbert, Martin, and Coulson, 2010). It appears that attention is well suited for detecting threat in the environment, in ways that are particularly efficient and sometimes automatic (e.g., Pratto & John, 1991). However, an overly sensitized attentional system that biases selective attention toward threat may cause one to perceive the environment as more threatening than it actually is.

Individuals with anxiety have displayed such an attentional bias for threatening social stimuli in ways that are thought to contribute to and perpetuate the anxious state (Amir, Beard, Burns, and Bomyea, 2009; Eysenck, 1992; Macleod, Mathews, and Tata, 2002) and have been characterized as possessing 'hypervigilance' for threat (Eysenck, 1992).

Evidence for this heightened attention to threat in those with anxiety has been demonstrated using a variant of the Stroop Color-Naming Test known as the "Emotional Stroop Test" (Mathews and Macleod, 1985). During this task, subjects are instructed to respond to the color of emotionally toned words while ignoring the content. It was found that clinically anxious, as well as non-clinical individuals with high levels of self-reported anxiety, displayed increased color naming latencies in response to threat-related words relative to neutral words. Numerous adaptations of the Emotional Stroop Test have shown similar results for a broad range of stimuli and types of anxiety (Ray, 1979; Watts, McKenna, Sharrock, & Trezise, 1986). This has been assumed by theorists to represent the automatic drawing of attentional resources toward threatening stimuli.

Further support for the unequal allocation of attentional resources to threat in those with anxiety has been demonstrated using a variety of paradigms. In a seminal study by Macleod, Mathews, and Tata (1986), a novel probe

detection paradigm was used to measure attention bias toward threat in anxious individuals. In the original task, now commonly referred to as the “dot probe paradigm”, two words are presented vertically for a fixed period of time (usually 500 ms), followed by the appearance of a dot probe in one of the locations previously occupied by a word. One word was neutral (e.g., chair) while the other threat-related (mutilated). It was found that individuals with anxiety responded faster to targets that replaced threat words, whereas non-anxious participants showed an attentional bias away from threat. This was taken as evidence that individuals with anxiety exhibit a preferential bias for attending to threat. In a meta-analysis of 172 studies, Bar-Haim, Lamy, Pergamin, Bakermans-Kranenberg, and van Ijzendoorn (2007) concluded that a broad range of paradigms provided sufficient evidence for threat-related attentional biases in anxious individuals.

Delayed disengagement from direct threat

In addition to drawing attentional resources, threatening information has been shown to delay attention from *leaving* the attended threat. This delay in disengagement has been commonly referred to as “attentional dwelling” (Fox et al., 2001, Fox, Russo, & Dutton, 2002), and occurs in response to threat-related

words (Fox et al., 2001), threatening pictures (Yiend & Mathews, 2001), and angry faces (Fox et al., 2001; Fox et al., 2002) in individuals with high levels of self-reported anxiety. Common paradigms used to investigate attentional dwelling include various modifications of the classic spatial cueing task (Posner, 1980), in which participants must disengage attention from a threatening psychophysical stimulus to locate or identify a spatially separate subsequent target. This paradigm rests on the notion that if threat-relatedness does in fact delay attentional disengagement, then the average time required to respond to spatially separate targets following threatening stimuli should be longer than the average response time to those same targets presented after non-threatening stimuli. This was exactly what was observed when Fox et al. (2002) found that on invalid trials (i.e., cue and target in different locations), high anxious individuals took longer to respond when the cue was an angry face, as opposed to a neutral or happy face, suggesting difficulty in disengaging attention from the threat-related facial expressions. Although this effect has been demonstrated with angry facial expressions repeatedly (Fox et al., 2007, Belopolsky, Devue, & Theeuwes, 2011), findings have not been as consistent with fear. Where Georgiou, Bleakley, Hayward, Russo, Dutton, Eltiti, & Fox (2005) found longer response times following fearful face cues, a subsequent study using the same

design found no such effect (Fox et al., 2007). These inconsistencies warrant further investigation into the question of whether the brain responds to threat-relatedness uniformly, or if fear and anger modulate attention orienting differently, and if so, why such differences occur. Do anxious individuals exclusively dwell on stimuli that present a firsthand threat like anger, or do they dwell on any threat-related information, such as observer-direct fear, which does not constitute an immediate threat? This matter can be illuminated by testing the delayed disengagement hypothesis using additional types of social stimuli, such as direct-facing fearful and angry human body postures.

At a theoretical level, Fox and colleagues (2001) speculate that this extended dwell time may reflect a subtle form of “cognitive freezing”, much like the freezing behavior commonly seen with animals in response to danger (see LeDoux, 1996). The most popular example may be that of a deer being “frozen in headlights” when unexpectedly confronted by an oncoming vehicle. Such a response might work to minimize superfluous movement while allowing time for more in-depth processing and planning an appropriate defense strategy. At the same time, in those hypersensitive attentional systems such a reaction may be continuously placing cognitive resources on negative stimuli, eventually leading to worry and rumination over the long term. In order to be able to fully

determine how routinely attention is being held by threat in real life conditions, one must know the exact forms of stimuli that elicit such a response. For example, if in addition to facial expressions, threat-related direct facing human body postures also keep attention, the frequency of threat-dwelling may be greater than previously imagined. Further studies are required to address such concerns.

Attentional cueing by averted eye gaze

Humans are inherently social in nature and require an attentional system that is suited for rapid processing of helpful social information. This information can be quickly extracted from monitoring the attentional systems of others, clueing one in on potential areas of interest and circumventing the laborious and time-consuming task of scanning an entire scene. In addition, the direction in which someone is looking is often predictive of intentions and their next likely action. Establishing what has been called “joint attention” by social cognition researchers requires following another’s attention to a destination of shared focus. In this way, another’s direction of attention provides a powerful socially informative cue that our brains presumably have been hard-wired to inspect.

Much of the experimental research concerning joint attention has used the same design as the endogenous form of the spatial cueing task. However, rather than a central arrow cue, a face with averted eye gaze is presented at fixation, followed by a target that can appear on either the gazed-at side or the opposite side. Evidence for gaze-cueing of attention has been indicated by faster reaction times to targets spatially congruent with gaze direction, even when gaze cues are non-predictive of target location (Driver et al., 1999; Friesen & Kingstone, 1998).

Threat-related gaze cues anxious facilitate attentional shifting

Since gaze direction can allow one to make inferences concerning another's mental state (Moore & Dunham, 1995), it can be used to detect social cues that signal the presence of a threat in the environment. Past studies have shown facilitated orienting in response to fearful faces with gaze averted in the direction predicted by the eyes in those with anxiety (Fox, Mathews, Calder, & Yiend, 2007; Mathews, Fox, Yiend, & Calder, 2003; Putman, Hermans, & van Honk, 2006). Whether angry expression with directed gaze cues attention similarly has yet to be seen conclusively. While Fox et al. (2007) observed a *reduced* cueing effect for angry faces relative to neutral expressions in anxious individuals, Holmes, Richards, & Green (2006) found the opposite; enhanced

cueing by averted eye gaze when the face expressed anger. Fox and colleagues (2007) have suggested that fearful gaze-cueing might be found more consistently because while averted fear clearly warns of an external source of threat, an angry face with averted gaze is more ambiguous (Adams & Kleck, 2002). The matter of whether or not averted anger and averted fear exert similar influences on orienting could be illuminated by further testing using additional forms of directional social stimuli, such as averted threatening human body postures.

Present Research

This project further explored the well known attentional bias for threatening information common to individuals reporting high levels of anxiety. More specifically, it examined the ways in which social threat may hold or guide attention, and how this influence is dependent upon factors such as stimulus direction (direct vs. averted) and emotionality (anger vs. fear). To date, most of the research regarding attentional orienting and social threat involves facial expressions with direct or averted eye gaze. This investigation aimed to extend current research by discovering how additional forms of threat-related social information, such as emotional human body postures in different orientations, influence orienting mechanisms. This knowledge is needed to identify which

specific stimulus features influence orienting behavior and how these influences interact with the anxious state. Such an understanding contributes to a more complete description of selective attention and emotion processing.

2. EXPERIMENT ONE

Threat-related postures hold attention

Background

At present there is no evidence as to whether delayed attentional disengagement occurs only in response to angry faces or generalizes to other forms of social stimuli expressing anger, in particular, direct facing angry body postures. Past research shows that faces are unique stimuli, often referred to as “special” in that they receive preferential visual processing (Farah, Wilson, Drain, & Tanaka, 1998) carried out by specialized neural modules like the fusiform face area (FFA) (Kanwisher, McDermott, & Chun, 1997). However, existing evidence points to angry direct postures being good candidates for the delayed disengagement hypothesis, since Gilbert, Martin, and Coulson (2010) showed that they are detected more readily than non-threatening postures during visual search. While this study also reported delayed disengagement, these findings may be attributed to angry posture distractors capturing attention more than non-threatening distractors, thus delaying search times. Their indirect

measure, along with the use of averted rather than direct posture stimuli further obscures the disengagement issue, since averted angry postures have recently been shown to cue attention rather than delay it (Azarian, Peterson, & Esser, under review). In addition, averted heads (Langton & Bruce, 1999), directional hand gestures (Langton, Watt, & Bruce, 2000), and threatening faces with averted eye gaze (Fox et al., 2007, Mathews et al., 2003) have also been shown to cue attention in the signaled direction. To avoid this potential confound we used only direct facing postures.

In addition to the consistent finding that angry facial expressions delay disengagement in high anxious individuals, fearful faces have shown similar effects (Georgiou et al., 2005), indicating that such behavior may be more generally related to threat rather than a single emotion. In fact, an experiment by Bannerman, Milders, and Sahraie (2010) that reported attentional capture by fearful postures also revealed impaired disengagement in an exogenous cueing at the shortest cue duration (20 ms). However, their study only looked at individuals reporting normal levels of trait anxiety, potentially missing any information regarding the modulatory role of anxiety so often seen in prior investigations. Furthermore, no other non-neutral expressions were tested, leaving open the possibility that it is simply emotional valence that holds

attention, especially considering that the subjects were not anxious. To insure that any effects found were specific to threat, we included happy postures in addition to neutral ones. Based on the aforementioned findings, we predicted that both angry *and* fearful postures would hold the eyes.

Past investigations of attentional disengagement have primarily relied on reaction times from button press responses to peripheral targets, which can only infer disengagement and may be insufficiently sensitive to subtle effects. Given the tight coupling of covert attention and saccades (Belopolsky & Theeuwes, 2009; Deubel & Schneider, 1996), along with the fact that an eye movement first requires a covert shift of attention to the point of destination (Deubel & Schneider, 1996; Peterson, Kramer, & Irwin, 2003), oculomotor disengagement provides a more direct measure of the time of attentional disengagement (Brockmole & Boot, 2009). In light of these points, our investigation also employed eye tracking to more directly measure attentional disengagement by determining the time it takes an individual to initiate a saccade away from an engaged posture stimulus. We adopted a previously used design (Belopolsky, Devue, & Theeuwes, 2011; Georgiou, Bleakley, Hayward, Russo, Dutton, Eltiti, & Fox, 2005) that includes a central posture display followed by a peripheral target letter that may appear either to the left or to the right of the stimulus, 100 or 500

milliseconds after stimulus onset. This central display design is superior to other commonly used tasks (e.g., exogenous spatial cueing task, dot-probe task) that require one to first orient toward the social cue. Since in our task the social cue is already at fixation, we have eliminated the need to shift attention toward it. Thus, the current study design and methodology offers a number of advantages to traditional approaches.

The present study is a logical extension of previous research. If other forms of social stimuli beyond faces, such as threat-related postures, are shown to delay attentional disengagement in anxious individuals, then it is presumable that attentional dwelling is more frequent and pervasive than previously imagined. Whether this automatic behavior increases the anxious state through dwelling on negative aspects of the environment (Fox et al., 2002), or is adaptive, allowing for more elaborate processing in order to execute an appropriate defense (Belopolsky, Devue, & Theeuwes, 2011) has yet to be seen conclusively. If eye tracking reveals attentional dwelling in response to threatening postures only in high anxious individuals, this may implicate a causal role in maintaining the anxious state.

Methods

Participants

Twenty-two undergraduates (14 female) with ages ranging from 18-27 (mean age=20) were recruited from the George Mason University community. Sample size was chosen based on previous oculomotor disengagement studies. Eleven subjects had trait anxiety scores of 45 or above on the State Trait Anxiety Inventory (STAI-T) and were assigned to the high anxiety group, while eleven scored 35 or below and were assigned to the low anxiety group. All participants had normal or corrected-to-normal vision.

Materials and Apparatus

Posture stimuli were created depicting fearful, angry, happy and neutral expression, and a pilot study confirmed all were correctly recognized above 80%. There were 3 different examples of each emotion from 3 different male actors, giving 36 unique posture stimuli. The choice of male gender was based on previous findings showing such stimuli evoke greater arousal when fear and anger is expressed (Kret et al., 2011b; Kret and de Gelder, 2010b). Grayscale images had the faces blurred and were presented in the center of screen, subtending $7 \times 19^\circ$ visual angle at a viewing distance of 60 cm. Target dots subtended 1° of visual angle and were presented 10° to either the left or right of fixation. Stimuli were presented on a MacPro (2x2 Ghz Dual-Core Intel Xenon)

equipped with a 20-inch CRT monitor operating at 75 Hz with a resolution of 1024 x 768. This computer was networked to a Dell Pentium 4 that collected eye tracking data in conjunction with an Eyelink 2 eye tracker (SR Research, Ontario, Canada), which sampled at a rate of 250 Hz with 0.2 spatial resolution. Examples of stimuli depicting each emotion are displayed in Figure 1a.



Figure 1. Examples of direct postures expressing each emotional type.

Procedure

Each trial began with a central fixation cross that was displayed for 1000 ms followed by a posture stimulus. The target then appeared in a non-predictive fashion to the left or to the right of the posture either 100 ms or 500 ms after its

appearance. The target and the posture remained on the screen until a saccade was made or until 2000 ms passed. An example of a trial with an angry posture expression is illustrated in Figure 1b. Participants were asked to keep their eyes in the center of the screen until the target appeared, to which they were instructed to make an eye movement towards as fast and as accurately as possible. If a saccade was made prematurely, the message “you moved your eyes too soon” appeared on the screen and that trial was recycled and randomly inserted later in to the experiment. Participants completed one practice block of 12 trials, followed by 1 experimental block of 288 trials.

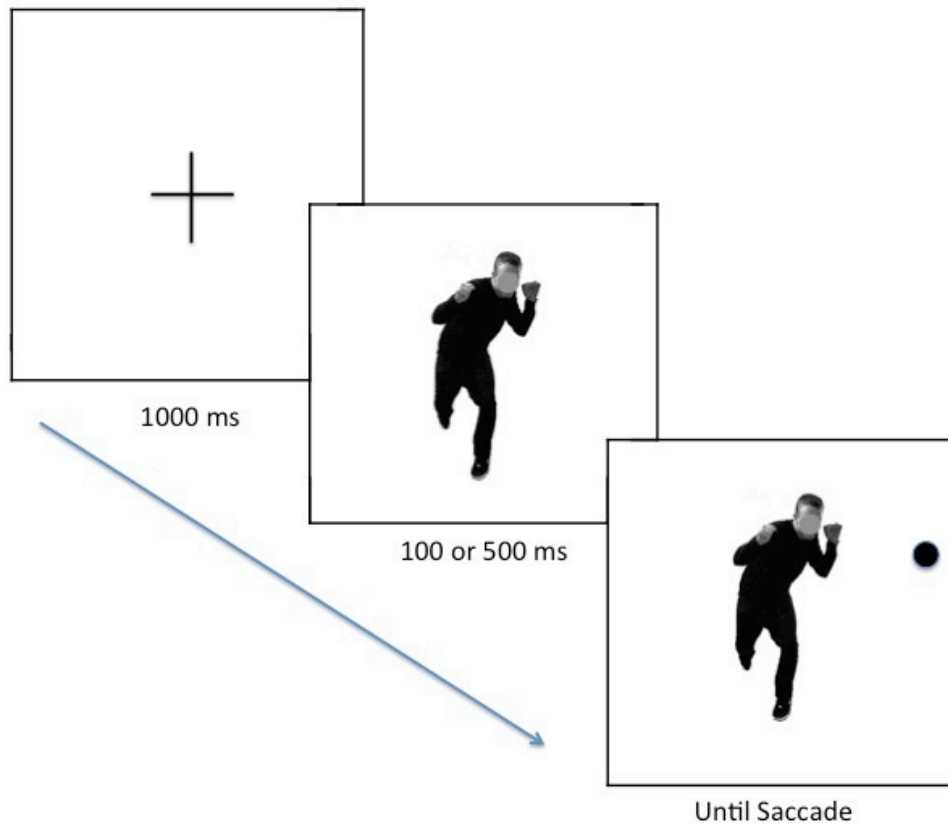


Figure 2. Example of an anger trial (not to scale).

Design

We first carried out two preliminary mixed 2 (anxiety) \times 2 (expression) \times 2 (SOA) ANOVAs to determine whether significant differences existed between threat-related expressions (fearful and angry), and between neutral expressions (neutral and happy). If the analysis showed no significant differences then fearful and angry expressions would be collapsed into a threat category, and neutral and happy expressions would be collapsed into a non-threat category. We then

carried out a 2 (anxiety: low and high) x 2 (expression: threat and non-threat) x 2 (SOA: 100 and 500 ms) mixed ANOVA with anxiety as a between-subjects factor, and the average time taken to initiate a saccade towards the target as the dependent variable.

Results

Saccade latencies less than 80 ms or greater than 500 ms were discarded from analysis. A 2 (anxiety level: high or low) x 2 (expression: fear or anger) x 2 (SOA: 100 or 500 ms) mixed ANOVA with anxiety as a between-subjects factor showed only a main effect of SOA, $F(1,20) = 4.5, p = .047, \eta^2_p = .183$, with no significant main effects of emotion, $F(1,20) = 1.1, p = .31, \eta^2_p = .051$, or anxiety, $F(1,20) < .01, p = .96, \eta^2_p < .001$. A 2 (anxiety: high or low) x 2 (expression: neutral or happy) x 2 (SOA: 100 or 500 ms) mixed ANOVA yielded no significant main effects or interactions. Thus, fear and anger were collapsed together (threat), and neutral and happy were collapsed together (non-threat) for each individual SOA. We carried out a 2 (anxiety level: high or low) x 2 (expression: threat or non-threat) x 2 (SOA: 100 or 500 ms) mixed-ANOVA with anxiety as a between-subjects factor that yielded no significant main effect of emotion, $F(1,20) = .37, p = .56, \eta^2_p = .018$, anxiety level, $F(1,20) = .11, p = .74, \eta^2_p = .006$, or SOA, $F(1,20) = 3.4, p =$

= .08, $\eta^2_p = .146$. The only significant effect was an interaction between emotion, anxiety, and SOA, $F(1,20) = 4.5$, $p = .046$, $\eta^2_p = .184$. Pairwise comparisons revealed that in anxious individuals, saccade RTs following threat-related postures were slower than RTs following non-threat-related postures, $t(10) = 4.0$, $p = .003$, $\eta^2_p = .61$, at the 100 ms SOA. This is represented in Figure 2. No other comparisons reached significance ($p > .09$). Mean saccadic reaction times for each emotion at each SOA divided into anxiety groups are displayed in Figure 3.

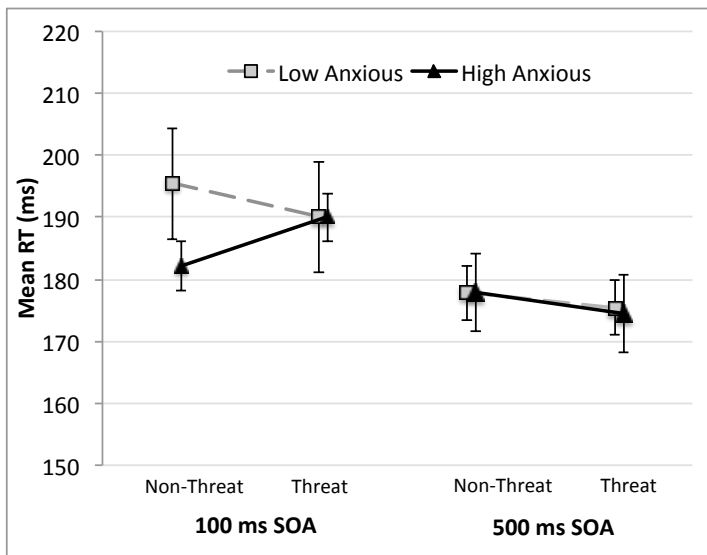


Figure 3. Saccade reaction times (in ms) as a function of trait anxiety, SOA, and expression. Error bars represent a 95% confidence interval.

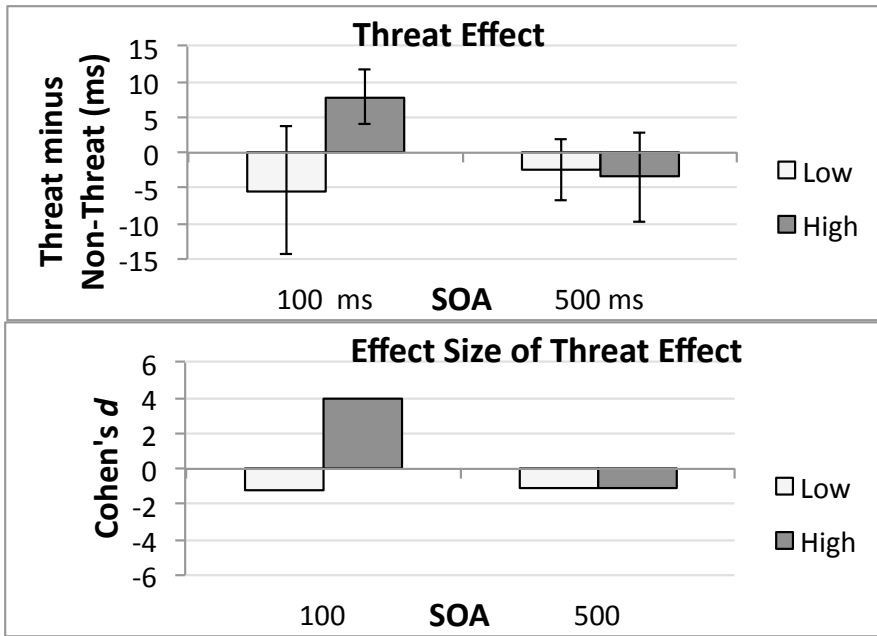


Figure 4. Threat effect sizes as a function of trait anxiety, expression, and SOA. Error bars represent a 95% confidence interval.

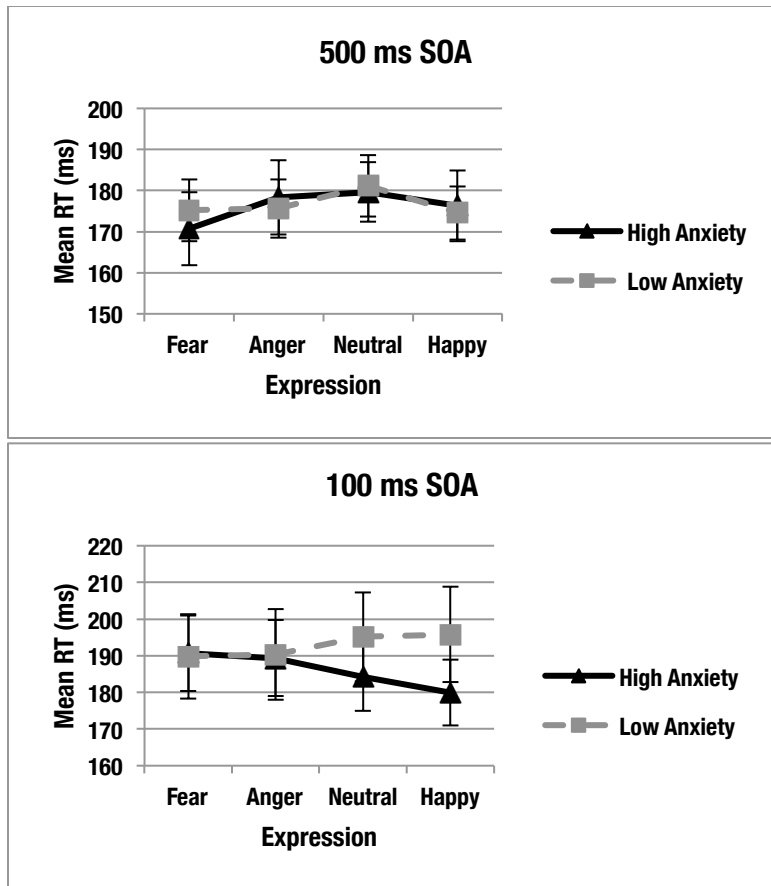


Figure 5. Saccade reaction times (in ms) as a function of trait anxiety, SOA, and expression. Error bars represent the standard error of the mean.

Discussion

Our results are straight forward and in agreement with previous literature. Once attended, threatening postures automatically postpone movement of the eyes, but only in those reporting high levels of trait anxiety. When presented with a posture cue at central fixation, participants took longer to initiate a saccade in the direction of a peripheral target when the cue expressed

fear or anger. This inability to immediately look away suggests that attentional disengagement is delayed by the threatening information encoded in the posture expression, resulting in an attentional dwell. Tracking the eyes allowed us to closely trace the time course of attentional orienting by identifying the exact moment of oculomotor disengagement. It is important to note that emotion was task-irrelevant, so any orienting differences between expression types can be said to be automatic and involuntary.

These findings expand upon previous research by demonstrating that extended dwell times occur not only in response to threatening faces (Fox et al., 2001, Fox et al., 2002), but to social threat more generally, as displayed here with direct facing threat-related postures. This suggests that threatening postures and faces influence perception and attention similarly. Both receive preferential processing in that they not only capture attention faster (Gilbert et al., 2010; Ohman et al., 2001b), but also hold attention longer. Thus, both angry and fearful postures add to a variety of stimuli that contribute to a robust threat-related attentional bias (Yiend, 2010).

It has been proposed that the tendency to reflexively dwell on threat may be a form of adaptive behavior (Belopolsky, Devue, & Theeuwes, 2011), whereby more time is allotted for processing the threat and developing an appropriate

defense strategy. This stands in contrast to the hypothesis that prolonged dwelling increases anxiety by keeping cognitive resources placed on the source of threat, over time leading to agitation and distress (Fox et al., 2001, Georgiou et al., 2005). Our results provide support for the latter, since deficient disengagement was observed only in trait-anxious individuals. Taking into account these findings, it may be that the ability to rapidly disengage attention from threat keeps anxiety low (Fox et al., 2001). Fox and colleagues (2001) have also proposed that this extended dwell time may reflect freezing behavior that we commonly see in animals in response to danger (see LeDoux, 1996).

Therefore, it is no surprise that the effect was present at the quicker SOA, since freezing would presumably be an automatic and reflexive response.

Furthermore, threat in the form of postures may have been a more salient indicator of an approaching danger than facial expressions at an earlier time in our evolutionary history, particularly before spoken language emerged and less attentional focus was placed on another's face.

If the eyes are automatically held by screen-sized, static, grayscale psychophysical stimuli when threat is displayed, it is tenable that the dynamic and interactive threatening stimuli of real social or confrontational situations modulate disengagement in a similar fashion. As such, involuntary dwelling on

negative aspects of the environment may be frequent and excessive in those with anxiety. Additionally, the on-screen stimuli of various forms of violent visual entertainment, such as violent television and video games, may also influence orienting and perhaps hold attention. Given the frequency of such stimuli in modern times, the resulting attentional patterns could keep one routinely mentally occupied with threatening information, placing extra demand on limited attentional resources and putting overall strain on the cognitive system.

Such reasoning is speculative, as are previous interpretations of lab-controlled results, and investigations that explore threat's impact on orienting in real-world environments are necessary. Whether an appropriate defense response or extended negative dwelling, threatening postures hold attention when anxiety is present and do so in a manner that is beyond one's control.

3. EXPERIMENT TWO

Directional threat-related postures facilitate overt orienting

Background

The wealth of evidence supporting the cueing properties of eye gaze has led some to believe in the existence of an “eye-direction detector” (Baron-Cohen, 1995), placing all emphasis on the morphology of the eye as the instrument of shared attention. However, neurophysiological evidence exists that supports a more dynamic “direction-of-attention detector” sensitive to conjunctions of eye, head, and body orientations (Langton, Watt, & Bruce, 2000; Peret & Emery, 1994). The present study is novel in that it is the first to use the gaze-cueing paradigm to determine whether averted human body postures cue attention in a fashion similar to averted gaze, directional head cues (Langton & Bruce, 1999) and hand gestures (Langton & Bruce, 2000). Should averted postures trigger an attentional shift in the signaled direction, this would implicate a more general social cueing mechanism in support of a “direction-of-attention” detection system.

Although it has been well demonstrated that fearful expression with averted eye gaze enhances orienting in the cued direction in anxious individuals (Fox, Mathews, Calder, & Yiend, 2007; Mathews, Fox, Yiend, & Calder, 2003; Putman, Hermans, & van Honk, 2006), angry expression with averted gaze has lacked such consistently, having showed reduced cueing relative to a neutral condition in a study by Fox and colleagues (2007). It is thought that this may be due to averted anger being a more ambiguous indicator of threat compared to averted fear (Adams & Kleck, 2002; Fox et al., 2007). However, we believe the case to be quite different with angry postures, since an offensive stance clearly indicates an engagement with an agent of attack in the immediate proximity. Based on the assumption that attentional cueing occurs when a directional social cue implies an imminent danger, in the present study we expected to see facilitated orienting of attention in the cued direction by both fearful and angry averted postures in those with high levels of anxiety.

While past findings have been consistent with the notion of a neural system that combines information specifically from gaze direction and facial expression (Adams & Kleck, 2003, 2005; Mathews et al., 2003; Fox et al., 2007) to enhance orienting, similar cueing effects by threat-related postures would predict the presence of a more flexible module that can additionally extract and

integrate information about emotional expression and the direction of attention solely from posture orientation. This investigation adds to a small but growing body of research that demonstrates that threatening postures capture (Bannerman et al., 2012) and delay attention (Azarian, Esser, & Peterson, under review; Bannerman et al., 2012) by asking whether such postures cue attention as well.

Methods

Participants

Twenty-six undergraduates (15 female) with ages ranging from 18-29 (mean age=21) were recruited from the George Mason University community. Sample size was chosen based on previous oculomotor disengagement studies. Thirteen subjects had trait anxiety scores of 45 or above on the State Trait Anxiety Inventory (STAI-T) and were assigned to the high anxiety group, while thirteen scored 35 or below and were assigned to the low anxiety group. All participants had normal or corrected-to-normal vision.

Materials and Apparatus

Emotional posture stimuli were created depicting anger, fearful, happy, and neutral expression, and a pilot study confirmed all were correctly recognized

above 80%. Three different examples of each emotion were created from three different male actors, yielding 36 unique averted posture stimuli, which were then mirrored to give a set of 72 left and right facing stimuli. Male postures were used since they have been shown to elicit arousal more strongly than females when expressing fear or anger (Kret et al., 2011b, Kret and de Gelder, 2010b). Images subtended a $7 \times 19^\circ$ visual angle and were made grayscale with the faces blurred. Postures were presented centrally at a viewing distance of 60 cm. Target letters subtended $.3^\circ$ of visual angle and were presented 14° to either the left or right of fixation, thus requiring a saccade and foveation for identification. A MacPro (2x2 Ghz Dual-Core Intel Xenon) equipped with a 20-inch CRT monitor operating at 75 Hz with a resolution of 1024 x 768 was used to present stimuli. A Dell Pentium 4 was used in conjunction with the MacPro to collect data using an Eyelink 2 eye tracker (SR Research, Ontario, Canada), sampling at a rate of 250 Hz with a 0.2 spatial resolution. Examples of stimuli depicting each emotion are displayed in Figure 1a.



Figure 6. Examples of averted postures expressing each emotional type.

Procedure

Trials started with a fixation cross displayed centrally for 1000 ms that was replaced by a posture stimulus. A non-predictive target letter (x or p) then appeared either on the left or the right of the posture, 200 ms or 500 ms after posture onset, which remained on the screen until a response was made or 2000 ms passed. An example of a trial with an angry posture expression is illustrated in Figure 1b. Participants were instructed to fixate the central posture until the target appeared, then they should saccade toward as quickly and accurately as possible, while responding to the target letter with a keypress response (“z” key for an “x” target, “/” key for a “t”). The keypress response was included

to keep the participant engaged, and to ensure that the eyes went to the target. If an eye movement was made before target appearance, the message “you moved your eyes too soon” appeared and that trial was recycled and inserted randomly at a later point in the experiment. Participants completed one experimental block of 288 trials, preceded by one practice block of 12 trials.

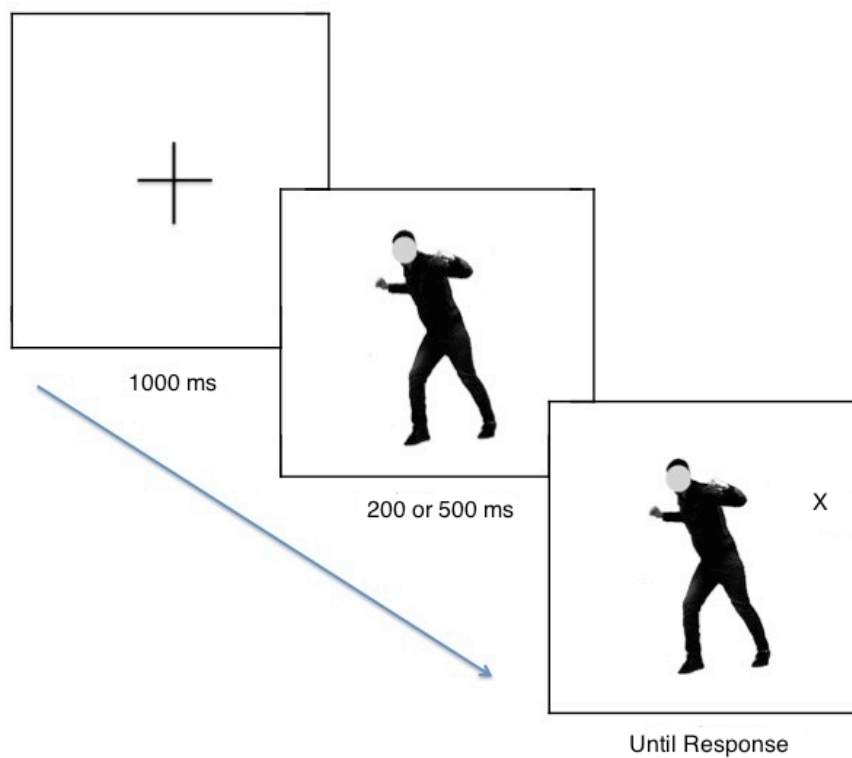


Figure 7. Example of an incongruent anger trial (not to scale).

Design

We carried out a 2 (anxiety) x 4 (expression) x 2 (congruency) x 2 (SOA) ANOVA to determine whether significant differences existed between threat-related expressions (fearful and angry), and between neutral expressions (neutral and happy). If the analysis showed no significant differences then fearful and angry expressions would be collapsed into a threat category, and neutral and happy expressions would be collapsed into a non-threat category. We then carried out a 2 (anxiety: low and high) x 2 (expression: threat and non-threat) x 2 (SOA: 100 and 500 ms) mixed ANOVA with anxiety as a between-subjects factor, and the average time taken to initiate a saccade towards the target as the dependent variable.

Results

Saccadic reaction times were defined as the time it took for an eye movement towards a peripheral target to be initiated. Trials with incorrect key responses and saccade latencies less than 80 ms were discarded since they were likely to be express saccades and not under voluntary control. Latencies longer than than 500 ms were also rejected because they were likely to be outliers given the average length of saccade latencies.

Analysis of manual response accuracy confirmed that all participants scored above 85%, thus none were excluded due to poor accuracy performance. Mean saccade RTs were entered into a 2 (anxiety: high or low) \times 4 (expression: fear, anger, happy, neutral) \times 2 (SOA: 200 or 500 ms) mixed ANOVA with anxiety as a between-subjects factor. There was a main effect of SOA, $F(1, 24) = 7.1, p = .013, \eta^2_p = .229$, and emotion, $F(3, 22) = 7, p < .001, \eta^2_p = .231$. A three-way interaction arose between emotion, SOA, and anxiety group, $F(3, 22) = 3.4, p = .023, \eta^2_p = .124$.

Two-tailed planned comparisons were carried out between congruent and incongruent trial saccadic RTs. Specifically, we were interested in testing the threat hypothesis: whether *both* fearful *and* angry postures led to a cuing effect for the high anxiety group. Because we had two groups and two SOAs, this leads to four sub-families of tests. Within a sub-family, we are interested in whether *both* fearful and angry postures lead to a significant cuing effect. The sub-family-wise error rate (sFWE) for this joint probability is low, at sFWE = 0.015 (joint probability of two tests reaching significance $[0.05^2]$ multiplied by the number of possible emotion pairs within a sub-family [6]). Because of this, the overall FWE across the four sub-families is $1-(1-sFWE^2)$, or 0.0298, and therefore no alpha corrections were necessary at the individual test level. As predicted, in

the high anxiety group congruent trials were significantly faster when the posture expressed fear, $t(12) = -2.6$, $p = .022$, $\eta^2_p = .365$, or anger, $t(12) = -3.4$, $p = .006$, $\eta^2_p = .486$, indicating spatial cueing in the direction signaled by the threat-related posture. This effect was only present at the 200 ms SOA. No other comparisons showed this RT benefit for trials with congruent cue-target pairings. Unexpectedly, at the 500 ms SOA, congruent trials were significantly slower than incongruent trials in the neutral condition in both the high, $t(12) = 2.6$, $p = .023$, $\eta^2_p = .362$ and low anxiety group, $t(12) = 2.9$, $p = .013$, $\eta^2_p = .416$. Possible reasons for this are explained in the discussion section. No other comparisons reached significance. Mean differences between congruent and incongruent trials were calculated for each emotion at each SOA, and for each anxiety group separately. This is depicted in Figure 2. To better visualize the data, mean differences between congruent and incongruent trials were calculated for each emotion, at each SOA, and for each anxiety group separately and depicted in Figure 3.

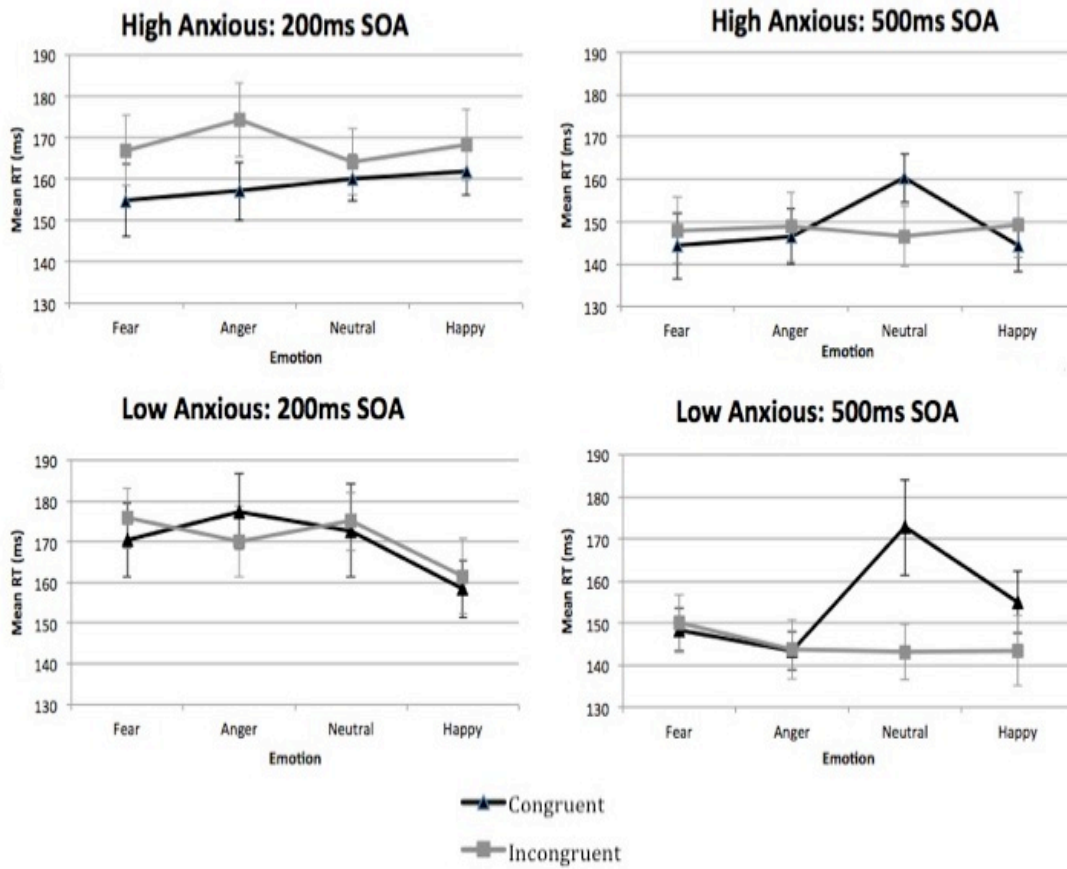


Figure 8. Saccade reaction times (in ms) for averted posture trials as a function of trait anxiety, congruency, and posture expression. Error bars represent the standard error of the mean.

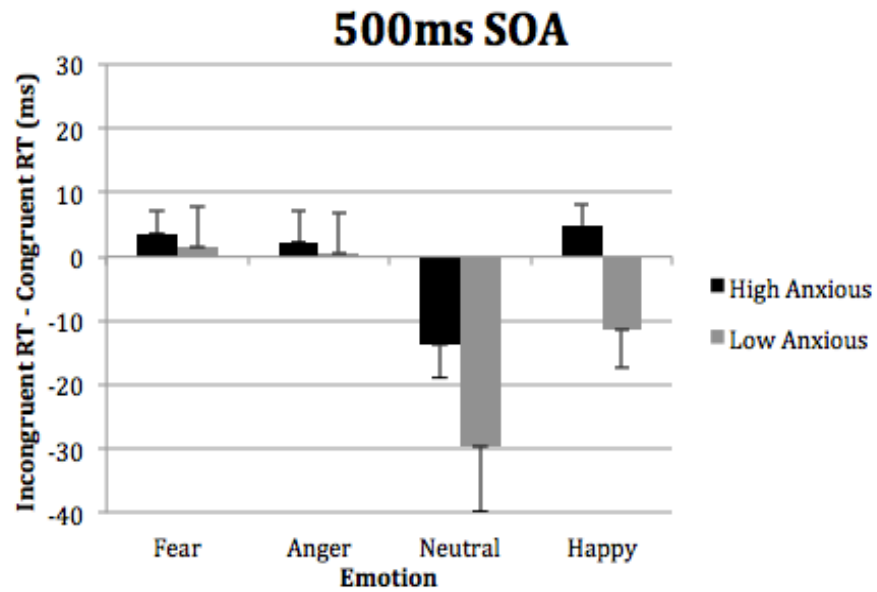
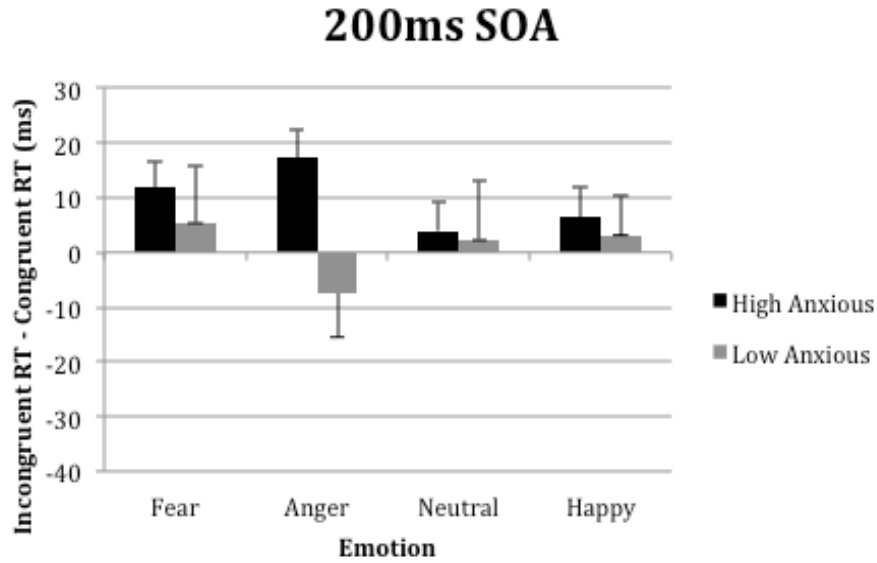


Figure 9. Mean congruency effect (i.e., difference between incongruent and congruent trial saccadic RTs) as a function of trait anxiety, expression, and SOA.

Discussion

Eye movements made towards targets showed shorter latencies when their position was congruent with the direction that a posture was facing, but only when the posture cue was threat-related (expressing fear or anger). This effect was only present in high anxious individuals, who have long been described as being “hypervigilant” for threat (Eysenck, 1992, Williams, Watts, MacLeod, & Mathews, 1997). Since a directional social threat cue implies danger in the vicinity, it is logical that those reporting anxiety would possess an automatic attentional response aimed at threat-detection. These results are in agreement with previous research that has shown threatening facial expressions with averted eye gaze to elicit shifts of attention in the gazed-at direction.

Faster saccadic RTs occurred on congruent trials even though the posture cues were not predictive of target location, suggesting that the observer’s shift of attention was triggered automatically. In addition, the posture’s emotion was always task-irrelevant, supporting the claim that the threat-related attentional shift was involuntary. This effect emerged at the shorter (200 ms) SOA and disappeared by 500 ms, as might be expected from a reflexive and automatic response (Baron-Cohen, 1994).

Prior to this study, attentional cueing by directional threat cues in anxious individuals had only been demonstrated with threatening faces that had averted

eye gaze (Fox et al., 2007; Mathews et al., 2003). It was largely unknown whether this effect generalized to other forms of emotional directional stimuli, since both eye gaze detection and facial expression analysis have often been thought of as unique, specialized processes carried out by specialized brain modules (Adams & Kleck, 2003). As such, Baron-Cohen (1994, 1995) proposed the existence of an “eye direction detector” that serves to detect eye-shaped stimuli and compute their direction. However, our results show that threatening postures similarly induce reflexive shifts of spatial attention in an observer, lending support to the notion of a more general “direction of attention detector” (Perret & Emery, 1994).

Although prior work on emotional cueing with faces and averted gaze has reported mixed conclusions regarding the matter, our results suggest that both fearful *and* angry social directional cues induce reflexive shifts of attention in an observer. However, we should point out that there are stark differences between averted emotional posture and gaze cues. Like eye gaze, posture orientation is indicative of where attention is being directed, since one is often attending to the direction that they are facing. But unlike threatening facial expressions, a threat-related posture expression may be more foretelling of a looming threat for the following reasons. Our fearful and angry postures often displayed clear offensive and defensive actions that are more expressive of an actual physical engagement

with something in the periphery that is likely on the attack. In the case of fear, arms were commonly shielding the body or face, while the angry postures frequently had arms arranged in a striking position. These cues may indicate a violent exchange, whereas an angry face with averted gaze can just be a sign of extreme disapproval of another. Consequently, it can be argued that threat-related posture expressions are more salient cues of danger than face cues, especially when there is an expression of anger. Our findings may differ from those of Fox et al. (2007) that showed reduced cueing by averted anger simply due to fundamental differences in the two types of stimuli. It should also be noted that it was the threat-relatedness of the posture that caused the cueing effects rather than emotion in general, since happy posture cues showed no benefit for targets appearing in locations congruent with posture direction.

Although our findings only indicate that postures cue attention when they express threat-related emotion and anxiety levels are high, whether directional neutral postures cue attention in the general population similarly under different conditions is inconclusive. Based on our finding that incongruent trials had much faster reaction times than congruent trials in the neutral condition at the longer SOA (500 ms), we have reason to believe that at another untested shorter SOA neutral postures may instead cue attention, relating to a phenomenon known a

“Inhibition of Return”. We further address this issue in Experiment 4, which was carried out to further interpret these unanticipated results.

Our results provide further evidence of a robust attentional bias for threatening information in individuals reporting high levels of anxiety (Eysenck, 1992; Mathews & MacLeod, 1994; Yiend & Mathews, 2001). Anxious individuals experienced involuntarily shifts of attention in the direction cued by threat-related postures while non-anxious individuals did not.

4. EXPERIMENT THREE

Averted heads reflexively shift attention and the eyes

Background

In Experiment Two we found that averted fearful postures caused reflexive shifts of attention in the signaled direction in anxious observers, in a manner similar to faces expressing fearful emotion with averted eye gaze. However, our results showed that averted angry postures also reflexively cued attention, which is in disagreement with the findings of Fox et al. (2007) that showed a reduced cueing effect by averted gaze when the face expressed anger relative to a neutral condition. We offer the following explanation, which was tested in Experiment Three. Fox et al. (2007) suggested that attentional cueing occurs because averted gaze with fearful expression clearly implies an immediate peripheral threat, while a facial expression of anger with averted gaze is a more ambiguous signal. We believe that we observed cueing by angry postures because unlike averted gaze with angry facial expression, they possess a less

ambiguous indicator of threat, since their offensive positions signify an unseen person in the periphery that is part of a violent physical exchange. As such, the unseen person could likely present a threat to the observer as well. Thus, an observer's attention would be cued when the directional social signal sufficiently implies an actual threat.

In order to determine whether this theory is true, it would be helpful to test further averted social stimuli. For this reason, we have chosen to use averted head cues as central directional cues. Averted heads have been shown to facilitate orienting in the direction that the head is facing (Langton & Bruce, 1999). However, whether there is enhanced orienting when the averted gaze is accompanied by a threat-related facial expression has not been studied. Like fearful averted postures and fearful facial expressions with averted gaze, an averted head with fearful expression would clearly signal a threat in the periphery. For this reason, we hypothesized that fearful head cues would facilitate the orienting of an observer's attention toward the cued side, as evidenced by faster RTs to targets. However, unlike averted angry postures, an averted head with angry expression is relatively ambiguous concerning the existence of a peripheral threat, much the same as angry facial expression with averted gaze is.

Following this logic, and in accordance with “self-relevance appraisal” theories, we would expect angry averted heads to not elicit enhanced cueing in an observer, regardless of anxiety state. Such a finding would support the notion of a neural module that integrates information from a social directional cue with the form that embodies the emotional expression in order to make a judgment regarding whether to facilitate orienting in the cued direction.

As in the first two experiments, the averted head cues were non-predictive of target location. Therefore, any saccadic reaction time benefits on congruent trials or costs on incongruent trials can be attributed to reflexive cue-directed orienting. To better compare our results with the those of Experiment Two, we again used a relatively short (200 ms) and long (500 ms) SOA.

Methods

Participants

Thirty-four undergraduates (24 female) with ages ranging from 18-30 (mean age = 20.6) were recruited from the George Mason University community. Eighteen subjects had trait anxiety scores of 45 or above on the State Trait Anxiety Inventory (STAI-T) and were assigned to the high anxiety group, while

sixteen scored 35 or below and were assigned to the low anxiety group. All participants had normal or corrected-to-normal vision.

Materials and Apparatus

Head cues with fearful, happy, angry, and neutral facial expression facing to the left and right from 3 male and 3 female actors were selected from the Karolinska Directed Emotional Faced (KDEF) database (Lundqvist, Flykt, & Ohman, 1988). Images were made grayscale images and presented in the center of screen, subtending $9 \times 13^\circ$ visual angle at a viewing distance of 60 cm. Target letters subtended $.3^\circ$ of visual angle and were presented 14° to either the left or right of fixation, thus requiring a saccade and foveation for identification. Stimuli were presented on a MacPro (2x2 Ghz Dual-Core Intel Xenon) equipped with a 20-inch CRT monitor operating at 75 Hz with a resolution of 1024 x 768. This computer was networked to a Dell Pentium 4 that collected eye tracking data in conjunction with an Eyelink 2 eye tracker (SR Research, Ontario, Canada), which sampled at a rate of 250 Hz with 0.2 spatial resolution.

Procedure

Each trial began with a central fixation cross that was displayed for 1000 ms followed by an averted head cue. A target letter (X or P) then appeared in a non-predictive fashion to the left or to the right of the head cue either 200 ms or

500 ms after its appearance. The target and the posture remained on the screen until a key response was given or until 2000 ms passed. An example of a trial with an averted head cue with angry facial expression is illustrated in Figure 1. Participants were asked to keep their eyes in the center of the screen until the target appeared, which they were instructed to make an eye movement towards as fast and as accurately as possible. If an eye movement was made before target appearance, the message "you moved your eyes too soon" appeared on the screen and that trial was recycled and randomly inserted later in to the experiment. Participants completed one practice block of 12 trials, followed by 1 experimental block of 288 trials.

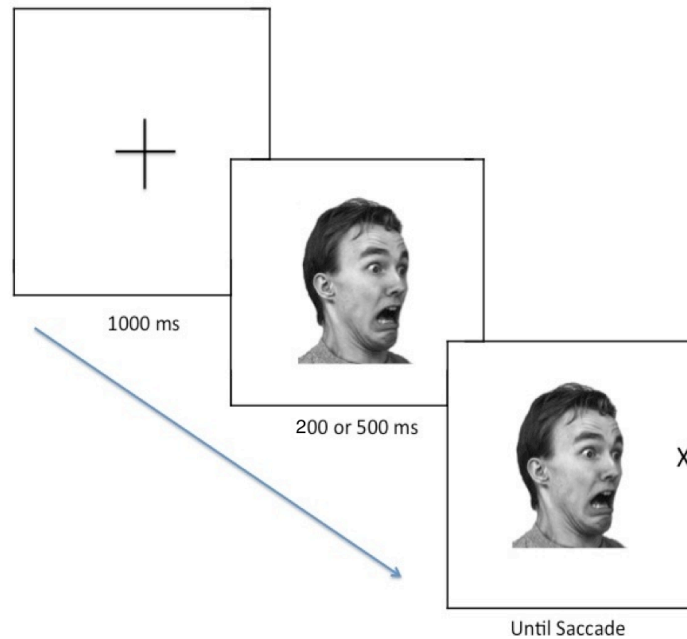


Figure 10. An example of a congruent fear trial.

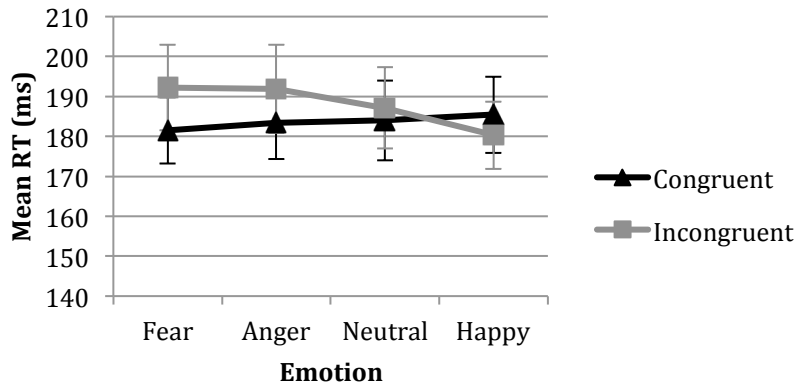
Results

Mean saccade latencies were entered into a 4 (emotion: fear, anger, happy, or neutral) \times 2 (anxiety: high or low) \times 2 (SOA: 200 or 500 ms) \times 2 (congruency: congruent or incongruent) mixed ANOVA with anxiety as a between subjects-factor. There was a main effect of SOA, $F(1, 32) = 79.4, p < .001$, such that participants responded faster overall at the long (500 ms) SOA, and a main effect of congruency, $F(1, 32) = 9.3, p = .005$, with faster responses to targets appearing on the side that the head was facing. The only interaction was between congruency, SOA, and anxiety group, $F(1, 32) = 4.2, p < .048$. Fear and anger were

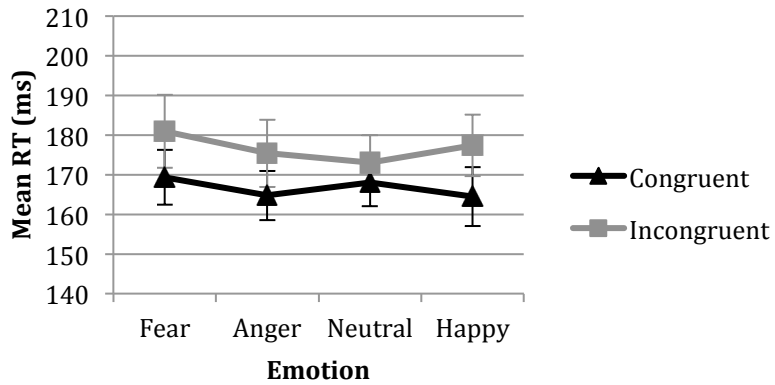
collapsed into “threat” while neutral and happy postures were collapsed into “non-threat” and planned comparisons were performed for congruent versus incongruent trials. For high anxious individuals, threat-related congruent trials were significantly faster than incongruent threat trials, $t(17) = -2.7, p = .014$, while for non-anxious individuals non-threat-related congruent trials were faster than non-threat incongruent trials, $t(15) = -3.1, p = .007$.

A t-test comparing mean saccadic RTs between congruent and incongruent trials showed that individuals were significantly faster when targets appeared on the faced side, (two-tailed, $p = .003$). We observed no effects of emotion and no interaction between emotion and anxiety level. Mean saccadic reaction times are displayed in Figure 2.

High Anxious: 200ms SOA



Low Anxious: 200ms SOA



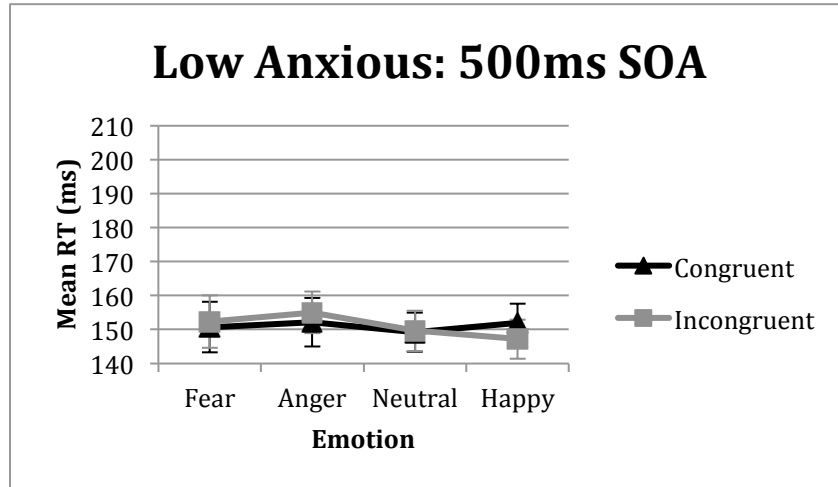
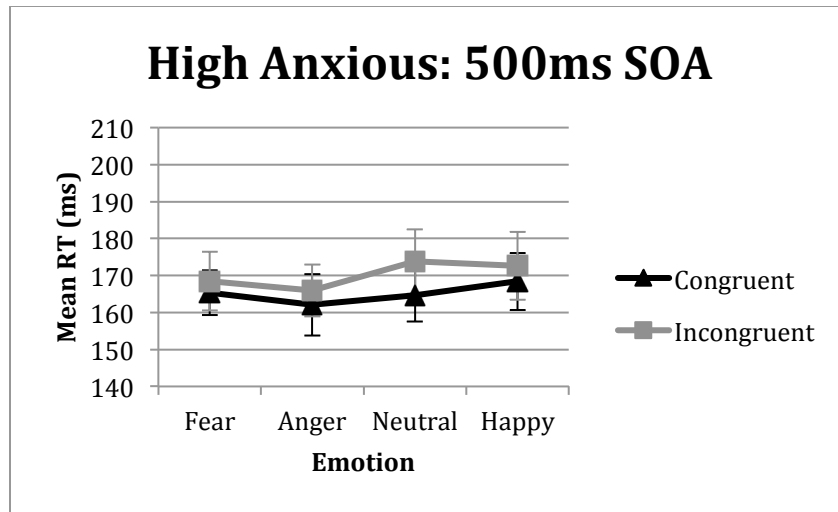


Figure 11. Saccadic reaction times (in ms) for averted head cue trials as a function of trait anxiety, congruency, SOA and posture expression. Error bars represent the standard error of the mean.

Discussion

The results show that averted heads with threat-related expressions cause reflexive shifts of attention in an observer in the direction signaled by the head cue, as evidenced by relatively faster saccadic RTs on congruent trials that on

incongruent trials at the 200 ms SOA. These RT benefits occurred even though cues were non-predictive of target location, reflecting automatic orienting. This is in agreement with previous findings that have shown neutral averted head cues to cue attention in the general population (Langton & Bruce, 1999). However, the present study differed from past studies using head cues in that the faces expressed emotion (fearful, angry, and happy) in addition to neutral expression, and only very high and low anxious individuals were tested. Whereas prior investigations involving threat-related facial expressions with averted eye gaze (Mathews et al., 2003; Fox et al., 2007) found attentional cueing in response to directed fear (Mathews et al., 2003, Fox et al., 2007) but reduced cueing by directed anger, we found that, head cues expressing threat-related expression more generally (anger and fear) cued attention. This is in agreement with the results from Experiment Two, which showed that body postures expressing both fearful and angry averted postures facilitated orienting in the direction signaled by the posture. Non-anxious individuals showed a difference response, with facilitated orienting in response only to non-threatening cues at the 200 ms SOA.

It was previously explained that facilitated orienting of attention in anxious individuals occurs in response to a directional social cue when it signals an immediate threat in the environment. It appears that this emotional social cue

can take on many forms, including fearful faces with averted gaze, threat-related directional postures, and now threat-related head cues. Like postures, averted head cues may represent a highly salient signal of physical danger, since real threat often elicits a turn of head. The evidence reveals that threat-related cueing effects are robust, occurring in response to a variety of social stimuli, but differ depending on the exact form of social cue. This also means that the brain integrates information about the direction of attention and emotional expression in more complex ways than previously thought.

5. EXPERIMENT FOUR

Directional body postures guide the eyes

Background

In Experiment 2 we found that both high and low anxiety groups showed faster saccadic RTs on incongruent trials as compared to congruent trials at the longer SOA when the postures were neutral. Such an unintuitive result has been found extensively with classic exogenous cueing studies that used abrupt onset cues that could correctly (valid trial) or incorrectly (invalid trial) predict target location. These faster responses to invalid targets at longer SOAs occur due to a phenomenon known as “inhibition of return” (IOR) (Posner & Cohen, 1984), which causes a delayed response to targets appearing in the cued location that attention had been previously drawn to (Klein, 2000). This is assumed to occur so that attention can more effectively scan an environment rather than revisiting already attended locations. If IOR had in fact been the reason for faster RTs on incongruent trials when the posture cue was neutral, it would mean that at an

earlier untested SOA, neutral postures were causing the observer to reflexively shift attention in the cued direction. Since faces with averted eye gaze have been shown to shift attention in a reflexive manner similar to exogenous cueing (Friesen & Kingstone, 1998), and to elicit inhibition-of-return effects at long SOAs (Frischen & Tipper, 2004), it may be that averted postures do the same. We investigated this possibility in Experiment 4. As in the other experiments, posture cues were non-predictive of target location. To increase the possibility of revealing any attentional cueing effects by averted neutral postures we tested SOAs of 100, 200, 300, 400, and 500 milliseconds.

Methods

Participants

20 undergraduates (14 female) with ages ranging from 18-30 (mean age = 22.6) were recruited from the George Mason University community. All participants had normal or corrected-to-normal vision.

Materials and Apparatus

Directional body postures cues facing to the left and right from three male actors each expressing three different forms of neutral expression were created. Images were made grayscale and presented in the center of screen, subtending 7

x 19° visual angle at a viewing distance of 60 cm. Target dots subtended 1° of visual angle and were presented 14° to either the left or right of fixation, thus requiring a saccade and foveation for identification. Stimuli were presented on a MacPro (2x2 Ghz Dual-Core Intel Xenon) equipped with a 20-inch CRT monitor operating at 75 Hz with a resolution of 1024 x 768. This computer was networked to a Dell Pentium 4 that collected eye tracking data in conjunction with an Eyelink 2 eye tracker (SR Research, Ontario, Canada), which sampled at a rate of 250 Hz with 0.2 spatial resolution.

Procedure

Each trial began with a central fixation cross that was displayed for 1000 ms followed by an averted posture cue. A target dot then appeared in a non-predictive fashion to the left or to the right of the posture cue either 200 ms or 500 ms after its appearance. The target and the posture remained on the screen until a key response was given or until 2000 ms passed. Participants were asked to keep their eyes in the center of the screen until the target appeared, which they were instructed to make an eye movement towards as fast and as accurately as possible. If an eye movement was made prematurely, the message “you moved your eyes too soon” flashed on the screen and that trial was repeated and

randomly inserted later in to the experiment. Participants completed one practice block of 12 trials, followed by 1 experimental block of 180 trials.

Results

Saccadic reaction time was defined as the time it took for an eye movement to be initiated away from the center and toward a peripheral target dot. Mean saccade latencies were entered into a 5 (SOA: 100, 200, 300, 400, or 500 ms) \times 2 (congruency: congruent or incongruent) repeated measures ANOVA. There was a main effect of SOA, $F(4, 16) = 14.75, p < .001, \eta^2_p = .437$, and congruency, $F(1, 19) = 10.05, p = .005, \eta^2_p = .346$, such that participants were faster to respond to targets appearing on the side that the posture was facing. There were no interactions. Two-tailed t-tests were performed comparing mean saccadic RTs between congruent and incongruent trials for each SOA. Results show that congruent trials were significantly faster than incongruent trials at the 300 ms, $t(19) = -2.94, p = .008, \eta^2_p = .313$ and 400 ms SOA, $t(19) = -2.49, p = .022, \eta^2_p = .247$. Figure 2a and 2b display mean saccadic reactions times of congruent and incongruent trials by SOA. To better visualize the data, we have included Figure 3, which represents the effect of congruency, which is calculated by subtracting congruent trial saccadic RTs from incongruent trial saccadic RTs.

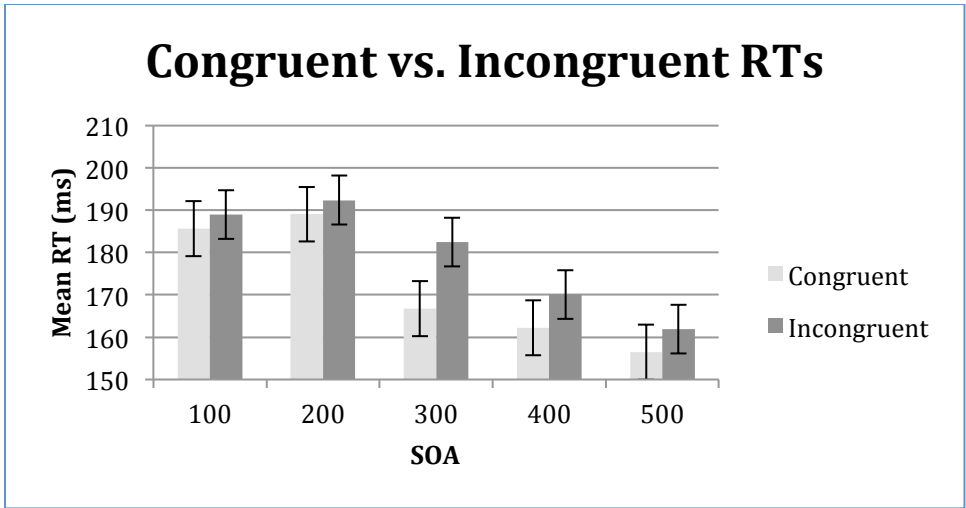


Figure 12. Saccade reaction times (in ms) as a function of congruency and SOA.

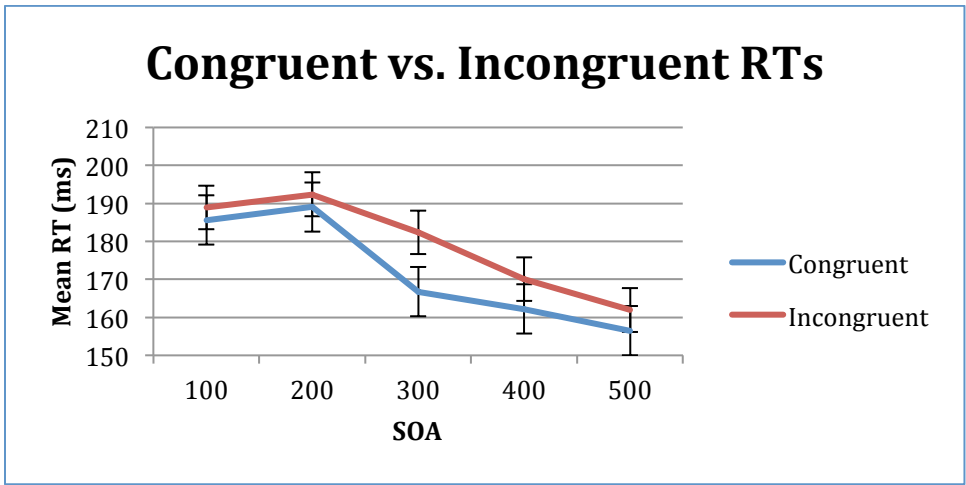


Figure 13. Saccade reaction time (in ms) as a function of congruency and SOA.

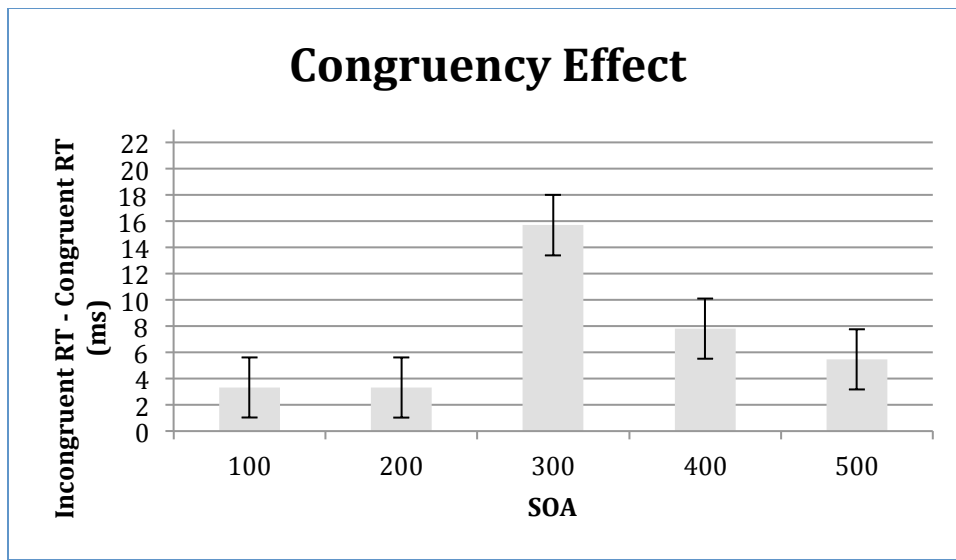


Figure 14. Mean congruency effect (i.e., difference between incongruent and congruent trial saccadic RTs)

Discussion

Results showed a main effect for congruency, followed by planned comparisons that revealed faster reaction times on congruent trials at the 300 ms and 400 ms SOAs, but not at the 100 ms, 200 ms, or 500 ms SOAs. This confirmed our main hypothesis that was based on the results of Experiment Two, which showed effects that resemble those seen with Inhibition of Return. Specifically, we predicted that if IOR was present at the 500 ms SOA, then attentional cueing had to be occurring at some earlier previously unexamined SOA. Indeed, we found attentional cueing specifically in between the short and long SOAs tested

in Experiment Two. However, this time we did not observe any IOR effects at the 500 ms SOA, thus failing to fully replicate the results of Experiment Two.

As in the other experiments, posture cues were uninformative of subsequent target location. The fact that lateral attentional shifts occurred in response to non-predictive cues implies that such shifts were automatic and involuntary, since observers had no motivation to orient attention in the cued direction. In this regard, these shifts of attention mirror those that occur with traditional exogenous orienting tasks that use peripheral abrupt onset cues. However, unlike exogenous cueing, which usually occurs at relatively short SOAs (around 100 ms) (Posner & Cohen, 1984), neutral posture cueing appears to occur around 300 ms and tapers off by 500 ms.

This evidence further supports the idea of a neural module dedicated to recognizing not only to gaze direction, but one's direction of attention more generally. It is therefore more appropriate to think of it as an "attention direction detector" (Perret & Emery, 1994), rather than just an "eye direction detector" (Baron-Cohen, 1995). We propose that these posture-driven automatic attentional shifts represent an innate mechanism, much like gaze-cueing, which can be seen in infants as young as 10 months in response to their mother's gaze (Corkum & Moore, 1995). However, it is also possible that such specialization arises from

substantial social experience, as is most likely the case with hand gestures, which have also been shown to orient attention in adults (Langton & Bruce, 2000). This knowledge may allow us to see if and how experience can shape automatic and reflexive orienting behavior. Future eye tracking studies with infants and directional body postures could help illuminate this issue.

Directional postures are valuable social cues that can be used to extract information about the intentions and next likely action of another. We have acquired automatic mechanisms that exploit these cues by facilitating not only the orienting of attention, but also the speed of a planned saccade, as shown here by shorter saccadic latencies for trials with congruent cue-target pairings. Our study is novel in proving the latter, which is of critical importance because of its behavioral consequences. Identifying and fully processing a complex stimulus requires foveation, which can only occur through an alignment with the retina. Cueing studies involving covert attention alone do not reveal whether movement of the eyes is facilitated to the peripheral region of interest. Increasing the speed of foveation means decreasing the time necessary for an appropriate response, and here we see that directional posture cues facilitate this process.

We propose that determining the direction of another's attention from remote distances may be carried out more easily by observing posture direction

than gaze-direction, since it does not require having a clear view of one's pupils. Also, posture direction may be a better indicator of another's action than gaze, since a movement can only occur once the body is properly oriented in the desired direction. In older evolutionary times before spoken language had fully emerged, it is reasonable that posture direction and body language were dominant forms of social cues, which over time resulted in the evolution of the adaptive reflexive orienting responses seen in laboratory investigations.

6. GENERAL DISCUSSION

Summary of important findings

In the first experiment, postures directly faced the observer, while in the second and third experiments postures or head cues were averted, respectively. The results from the first study show that for anxious individuals, direct facing fearful and angry postures postpone the disengagement of attention as well as the eyes. No such effect was seen with neutral or happy postures. The second study showed that when facing the periphery, threat-related postures facilitate attentional orienting rather than delay it. That is, when fearful or angry postures were averted and presented at central fixation, both attention and the eyes were faster to leave the stimulus toward targets that were congruent with posture direction. Like the first experiment, neutral and happy postures did not appear to affect attentional orienting in anxious individuals. However, an effect was seen such that the mean average saccadic RT was shorter on incongruent trials compared with congruent trials. We hypothesized that this could be a sign of Inhibition of Return, and this was tested in the fourth experiment. In the third

experiment, in addition to averted head cues facilitated orienting overall, those with threat-related expressions elicited automatic shifts of attention in anxious individuals. These results show that not all threat-related social cues are treated equally by attention, since both fearful and angry postures enhanced orienting in anxious individuals. This might be explained by the notion that threat-related postures express threat more saliently than head cues, since it signals direct physical engagement and potentially violent action. The fourth experiment was motivated by an unexpected finding in Experiment Two, where incongruent trials exhibited faster mean saccadic reaction times than congruent trials in the neutral condition at the longer (500 ms) SOA. We suspected this may be due to Inhibition of Return (IOR), and if so, it would mean that at some earlier untested SOA neutral postures reflexively cued attention. Thus, we used the same task to test SOAs of 100, 200, 300, 400, and 500 ms. Results showed significant cueing at the 300 and 400 ms SOAs, which are in the expected range in line with our IOR hypothesis. However, this time we did not observe any IOR effects at the 500 ms SOA, failing to fully replicate the results of Experiment Two.

Importance of threat-stimulus direction

The results of Experiments One and Two have highlighted the importance

of the directionality of a threatening social stimulus, which appears to play a critical role in determining how attentional orienting is influenced when anxiety is present. It appears that the type of mechanism of orienting that is affected depends not only on the emotional and social content of the cue (i.e., a fearful body posture), but critically on the spatial orientation of that cue. In fact, our results show that the same emotional stimuli (threatening postures) positioned in different orientations (direct vs. averted) modulate attentional orienting in exactly opposite ways. While we found that direct-facing angry and fearful postures delayed the disengagement of overt attention, results showed that averted angry and fearful posture cues facilitated movement of the eyes away from that posture in the signaled direction. The stimuli used in both experiments were from the same actor set and had nearly identical expressions, so any differences pertaining to orienting can be attributed directly to stimulus direction.

So why do direct-facing postures hold the eyes while side-facing postures shift them? It has been proposed that the period of delayed attentional disengagement may allow for defense strategizing while reducing superfluous movement (Fox et al., 2002). With averted threat, such processes are not necessary, since the threat cue is not directed at the observer, presenting no

direct harm. It is more important that the self-relevant threat be located, which in this case would be the implied peripheral stimulus, i.e., the unseen surrounding stimulus responsible for eliciting emotion from the observed averted posture stimulus. As it would confer apparent survival advantages, selection pressures may have favored an automatic threat-detection system sensitive to the direction of a threatening social stimulus. In this way, the cognitive system may exploit the potentially informative nature of such social emotional directional cues. This is largely in agreement with the gaze-cueing literature, which has shown that fearful (but not angry) facial expressions with averted eye-gaze cue attention, while those same faces with angry expression and direct gaze delay it (Fox et al., 2007). Furthermore, our findings are the first to provide evidence that in addition to integrating information about gaze direction and facial expression (Adams & Kleck, 2003) to modulate orienting, the brain can also integrate information about posture direction and posture expression to compute one's emotional state and direction of attention. Such a property would paint a picture of a cognitive system that processes emotional and social information more dynamically and flexibly than previously thought.

Anger and fear's differential effects on orienting

The role stimulus direction plays in attentional orienting appears to be relatively straight forward, although the matter is not so clear when it comes assessing how orienting is affected by threat-related emotion, since there seems to be differential affects of fear and anger. For example, unlike fear, averted anger in the form of shifted eye gaze and facial expression does not appear to enhance orienting in anxious individuals, and may actually reduce it (Fox et al., 2007). However, our results demonstrate that for those individuals averted angry postures facilitate orienting. So when asking whether a certain emotion interacts with anxiety to modulate orienting, in addition to stimulus direction we must consider the form of social cue the emotion is embedded in. There have also been mixed results in the literature concerning whether direct faces with fearful expression delay attentional disengagement in anxious individuals, with some concluding that fear holds attention (Georgiou et al., 2005), while others found no such effect (Fox et al., 2007; Mathews et al., 2003). We report clear evidence that direct angry *and* fearful postures hold the eyes relative to non-threatening postures. Our findings conclude that there is no straightforward rule for determining how social emotional cues influence attentional orienting. There appears to be neural modules that assess stimulus features at a high level and in complex ways that require combining information about stimulus direction,

emotion type, and physical form. Hence, when we are trying to predict threat-related effects on visual attention, we must take into account not just independent features of the threat cue, but what those features taken together imply about the self-relevance of that threat.

Threat processing and the brain- Two Pathways

The visual processing of threat is related to the activation of the “fear system”, and is a complex topic that has received considerable attention from the neuroscience and psychology communities over the last few decades.

Converging evidence from behavioral and neurophysiological findings describes a dual pathway system composed of two processing streams. These pathways involve affective processing by the amygdala, and have different roles in regard to the stimulus properties they respond to and the neural activity they elicit.

There is a *direct* subcortical pathway for rapid and coarse-grained threat processing, which is thought to be a *reflexive* process (Adams, Franklin, Kveraga, Ambady, Kleck, Whalen, Hadjikhani, and Nelson, 2013), and an *indirect* cortical pathway that is slower and involved in more extensive, detailed processing, which is viewed as a *reflective* process. This reflexive versus reflective processing distinction may provide information regarding the neural underpinnings of the

threat-related attentional orienting modulations observed in Experiments 1 and 2, which occurred at short SOAs, and disappeared by 500 ms, and is discussed further in the following section.

A number of lesion studies show that damage to the direct thalamo-amygdala pathway disrupts fear conditioning (LeDoux et al., 1986; Iwata et al., 1986), while cortical lesions seem to have no effect (LeDoux & Sakaguchi, 1984). Although this was demonstrated with the auditory modality, it still signifies a distinction between cortical and subcortical threat processing pathways. In 2001, Morris and colleagues proposed that the direct subcortical pathway works independent of, but in parallel with, the indirect visual cortical pathway. Their conclusions came after curious findings from an examination of a patient with lesions in the primary visual cortex, who reported being blind to objects presented in certain visual areas. Interestingly, when the presented object was a fearful face image, activity was seen in the right amygdala, despite a lack of conscious perception. It could be said that this amygdala response was automatic. After analyzing the involved connectivity, the superior colliculus and pulvinar were seen to comprise this direct pathway.

Evidence from neuroimaging describes this direct thalamic pathway further, by showing how activity along this pathway correlates with

conditioning-related amygdala activity, while the cortical pathway's activity does not (Morris et al., 1999). While the direct pathway is associated with automatic responses from the fast and sometimes unconscious processing of innately threatening biological stimuli, cortical projections to the amygdala are thought to involve slower, more refined processing and analysis (see LeDoux, 1996). This difference in processing speeds is not surprising, given that the direct pathway includes 'old brain' subcortical routes that presumably operate at a more visceral level than the indirect visual pathway. In contrast to the direct route's retinal-collicular-pulvinar pathway (Morris et al., 1999; de Gelder et al., 1999), the longer indirect route's signals must traverse the thalamus, to the visual cortex, and then to the temporal lobe for recognition. After reaching this point, information is finally sent to the amygdala (LeDoux, 1996).

In an fMRI study by Vuilleumier et al. (2003), on the suspicion that the direct "quick and dirty" pathway processed grosser and less detailed feature information than the indirect pathway, they predicted greater activation for the amygdala and its direct pathway in response to fearful facial pictures filtered to retain low but not high spatial frequency information. Indeed, greater amygdala activation was found in response to low-frequency faces when compared to high-frequency faces, but only when they expressed fear. In addition, activation of

collicular and pulvinar regions occurred in response to low but not high spatial frequency faces.

From the evidence it is clear that two dissociable pathways exist: 1) The indirect subcortical path that corresponds to a reflexive, automatic, coarse-grain, type of processing, and 2) The indirect cortical path that corresponds to reflective, slower, fine-detailed processing. This processing pathway distinction may provide information regarding the explanation for the temporal dynamics of the threat-related attentional orienting effects observed in Experiments 1 and 2, which occurred at short SOAs, and disappeared by 500 ms.

Neural correlates of transient threat-related orienting effects

Various stimulus-onset-asynchronies (SOAs) that range from short to long duration periods can reveal the stages of processing in which cueing effects become visible, and those in which they are no longer present. For example, in a classic study conducted by Remington (1978), it was shown that exogenous luminance cues capture attention at relatively short durations, (~50 ms), while endogenous arrow cues enhance goal-directed shifts of attention only at longer duration intervals (~100 ms). Their task design tested multiple SOAs to understand the temporal dynamics of the attentional orienting effects. This in

turn can be informative of the nature of the effect; for example, whether it is reflexive or reflective. Effects present only at short cue durations traditionally implicate a response that is innate and automatic. A fast attentional response to threat-related posture stimuli would have obvious benefits to survival. Since the effects found in Experiments 1 and 2 occurred only at short SOAs, they appear to be associated with reflexive processing. Varying the SOA in orienting tasks with emotional cues can not only tell us about the time course of behavioral effects and their automaticity (or lack of); they can also reveal information about the functional stages of threat processing and the neural pathways involved.

As described previously, threat processing involves two pathways that both involve the amygdala. There is a direct, fast pathway and an indirect, slower pathway. We observed our threat-related attentional cueing effects (Exp. 2) in anxious individuals at the shorter (200 ms), but not the longer (500 ms) SOA. Similarly, the threat-related delayed disengagement effects (Exp. 1) occurred at only the short SOA (100 ms). Our results appear to support the idea that the direct, subcortical pathway, which is known to be involved in reflexive processing, corresponds to the reflexive cueing and disengagement effects seen in Experiments 1 and 2. The direct pathway is known to respond to biological stimuli that are innately threatening. Angry and fearful body postures would

certainly fit the description, seeing as how there are neural areas specifically dedicated to their processing present in primates, like the inferior temporal cortex and the superior temporal sulcus (de Gelder & Partan, 2009). In humans, evidence from neuroimaging studies show that those brain regions responsive to bodies and those to faces can be dissociated both anatomically and functionally. For example, the fusiform cortex includes the fusiform body area (FBA) and the fusiform face area (FFA), which have non-overlapping regions. Similarly, the nearby extrastriate body area (EBA) and the occipital face area (OFA) (Peelen, Wiggett, & Downing, 2006) respond to different stimuli. Therefore, our nervous systems are biologically prepared to respond to threatening postures with a fast and automatic amygdala response that enhances processing by modulating attentional orienting.

The finding that the anxiety-related orienting modulations elicited by threat-related postures occur at short cue durations, and disappear by longer ones, supports the idea of two distinct and dissociable neural pathways. Since the effects in our experiments were reflexive (occurred with non-predictive cues), and automatically (emotion was not task-related), it shares the essential features with the threat processing of the direct pathway. This describes an amygdala response that enhances threat processing by modulating orienting in favor of

threat detection. That is, it fosters faster orienting in the direction suggested by threat cues, and delays disengagement thereby allowing for detailed threat processing.

There is also a possibility that the indirect, cortical pathway plays a role in the observed threat-related orienting modulations. Although the direct pathway may be implicated in attentional effects at short SOAs, it is not completely clear why the effect disappears at longer ones. If these effects aid threat processing, which is advantageous to survival, why aren't they sustained?

The role of the indirect pathway is to assess the threat in a reflective manner and to adjust behavior accordingly. The responses of the indirect pathway "are thought to build upon a slower and more detailed account of the environment, thereby allowing for modulation of initial low road perceptions and behaviors" (Adams et al., 2013). This describes a threat-processing system that can suppress automatic orienting effects when higher cortical regions determine that no real threat is present. This could potentially be tested with real world stimuli in a virtual environment. Under such realistic conditions, one might expect the transient cueing effects seen in lab-controlled environments to be sustained.

The amygdala and threat: signal relevance theory vs. ambiguity theories

Brain imaging studies have shown greater amygdala activity in response to faces with threat-related expression. However, the amount of reactivity differs depending on two factors: 1) the type of threat-related emotion (anger or fear) being expressed by the face, and 2) the owner of that facial expression's direction of attention (direct or averted). For example, earlier studies have shown that *direct* fearful faces elicit a stronger amygdala response compared to angry faces (Whalen, Shin, McInerney, Fischer, Wright, & Rauch, 2001; Blair, Morris, Frith, Perret, & Dolan, 1999). Direct fear is a less clear signal of threat than direct anger, which presents an obvious harm to the observer. These findings brought Davis and Whalen (2001) to propose that the role of the amygdala is to enhance the processing of ambiguous threat-related stimuli so that an observer may quickly and appropriately respond to the potential danger. Similarly, a study conducted by Adams and Kleck (2003) showed greater amygdala activation in response to the more ambiguous direction-threat type pairings than did their more informative counterparts. They found that when the threatening stimulus served as a directional cue, fear with averted gaze elicited a greater response from the amygdala than angry facial expressions with averted gaze. These findings provided further support for Davis & Whalen's "Ambiguity theory".

However, recent results from a series of subsequent fMRI studies have suggested a pattern completely opposite of that seen before, casting doubt on the idea that greater threat-signal ambiguity is correlated with an enhanced amygdala response. Rather than seeing more activation in response to less obvious threat cues, enhancement was observed when the participant was faced with threatening face cues that provided greater clarity (Hadjikhani, Hoge, Snyder, & de Gelder, 2008; Sato, Yoshikawa, Kochiyama, & Matsumura, 2004). In other words, the amygdala was responding more to angry facial expressions with direct gaze, as well as fearful expressions with averted gaze. These findings spawned the aforementioned “Self-Relevance Appraisal” theories, which view the amygdala as an appraiser of stimulus relevance to the goals, needs, and motivations of the observer.

With numerous studies providing evidence for both Self-Relevance Appraisal and Ambiguity theories, it remained unclear whether amygdala activation was greater for ambiguous threat signals or those with clarity. A recent study by Adams et al. (2013) resolves this apparent contradiction. They found a stronger amygdala response with ambiguous threat signals at relatively longer presentation durations (1 sec), and with clearer threat signals are shorter durations (300 ms). We believe that the threat-related orienting effects we

observed are clear indicators of threat, which would be expected at the shorter durations.

One must still wonder why these orienting effects were only present in high anxious individuals. If amygdala activity was responsible for the observed delayed disengagement and cueing effects, then we would expect anxious individuals to possess more reactive amygdalas compared to non-anxious individuals. Indeed, an fMRI study that used fearful and angry faces with direct and averted gaze found an increased amygdala response in state anxious individuals compared to emotionally normal individuals (Ewbank, Fox, & Calder, 2010). Since the amygdala response works to enhance threat processing, it would seem that anxious individuals would possess beneficial threat detection properties that would be absent in non-anxious adults. An obvious question would be whether or not these anxiety-related orienting modulations are an overall benefit or disadvantage to the organism overall.

Threat-related orienting effects: Helpful or harmful?

In a study carried out by Macleod, Rutherford, Cambell, Ebsworthy, and Holker (2002), a modified version of the dot probe paradigm was used to experimentally manipulate attentional bias, demonstrating the potential for dot

probe-based training regimens. Non-anxious participants were chosen and randomly assigned to one of two groups that were trained on separate versions of the dot-probe task. In this task, pairs of words were presented simultaneously, one above the other on a computer screen. In the first group, a contingency was introduced so that during training trials the target always appeared in the location previously occupied by a threatening word (attend threat condition). The second group experienced the opposite pattern with targets always appearing in the location previously occupied by a neutral word (attend neutral condition). The task was comprised of 576 training trials and 96 test trials that were distributed across the session and served to provide a measure of attentional bias. In these test trials, probes were equally likely to appear behind threat-relevant or neutral words. The results showed that participants trained on the attend threat condition showed faster responses to targets that followed threatening words. The group trained on the attend-neutral condition displayed the opposite pattern of results, with faster responses occurring on trials in which targets followed neutral words. These training effects carried over in to novel words that were not presented during training trials. The subjects in the attend-neutral condition experienced less negative emotion in response to a subsequent

experimental stress task. These findings were taken as evidence that an attentional bias towards threat plays a causal role in the anxious state.

Following this study, various versions of dot-probe methodology have been employed in attention bias modification treatment (ABMT) protocols designed to treat anxiety through targeting cognitive biases towards threat. Amir, Beard, Burns, & Bomyea (2009) conducted a multiple-session attention training program similar to that of Macleod et al. (2002) with individuals diagnosed with GAD. Over the course of one month, individuals completed 2 training sessions per week, with each session consisting of 240 trials. On two-thirds of trials, targets appeared in the location of the neutral word. Results showed that compared to controls, participants with GAD showed a significant decrease in attention bias to threat, and also exhibited significantly less anxiety from pre- to posttraining on self-report scores and interviewer-assessed ratings. A novel feature of this study was the use of materials specifically matched to each participant's perception of threat. In 2011, Bar-Haim and colleagues conducted a similar study with clinically anxious children, using a modified version of the dot-probe task specifically designed to promote effective disengagement from threat. In this task, a single face was presented to the left or right of central fixation. On the majority of trials, a target appeared on the side

opposite of a threatening face. Results found a significant training effect improving the ability of anxious children to disengage from threat. In line with similar studies with adults (Eldar et al., 2008; MacLeod et al., 2002; Mathews & MacLeod, 2002), children displayed less vulnerability to stress induced by a subsequent stressor task. Hakamata et al. (2010) conducted a meta-analysis of twelve studies using ABMT, and concluded that it is effective in significantly reducing anxiety and threat-related attentional bias under a range of experimental conditions and diverse samples.

In summary, it appears that an attentional bias for threat, of the type seen in our orienting studies, provokes the anxious state. So when trying to determine whether these threat-related orienting modulations are good or bad for the individual, one must ask “good or bad in terms of what?” What may be good for survival, like hypervigilance for threat, may be bad for the long-term mental and emotional state of that person. Not only would such behavior exhaust resources over time, it may cause one to perceive an otherwise neutral environment as a potentially harmful one. Functions that may have been critical to survival in evolutionarily older times, like enhanced threat detection, may now be unnecessary. Given that most of us rarely experience true physical threats in our environment, frequent and automatic biasing of attention toward threatening

aspects of one's surroundings would only serve to agitate and further elevate the anxious state.

Real world implications and applications

Although it might seem that these threat-processing and threat-detection functions would always be beneficial, in modern times it may be an inappropriate use of limited cognitive resources since fearful or angry expression rarely signals true physical danger. Instead, threatening facial and posture expressions are most often experienced in various forms of visual entertainment, such as violent movies and television, where they appear with high frequency. As such, individuals may be spending more time mentally occupied with threatening information than before, potentially yielding an overly threat-conscious appraisal of surroundings and maintaining or even inducing a state of hyper-arousal. Over time these states may lead to long-term worry and rumination. It is easy to see how once adaptive threat-detection mechanisms can become maladaptive through hypersensitivity.

Our findings add to a large body of research that describes a multidimensional attentional bias for threatening information in anxious individuals that causes one to over-focus on threat. Since this threat-related bias

may prolong the anxious state by increasing focus on threatening aspects of the environment, there have been efforts to counteract these biases with attention training methods. It is logical to think that extinguishing the bias may ameliorate the anxious state by taking attention off of the negative. One such method that has shown promise is known as Attention Bias Modification Training (ABMT) based on the design of a dot-probe task originally developed to assess attentional biases in emotional disorders (MacLeod, Mathews, & Tata, 1986). This training regimen works by teaching those with anxiety to direct attention away from threat by presenting threatening and non-threatening visual images together on a screen with targets always appearing behind the non-threatening stimuli. Not only does it train them to orient towards non-threat, but also to disengage from threat more quickly. Studies have shown that after sufficient training individuals report decreased levels of anxiety (Amir et al., 2009). Typically emotional faces are used in these tasks, but our findings suggest that these types of training methods could benefit from using additional forms of threatening social stimuli, since anxious individuals also have trouble disengaging attention from fearful and angry postures. Considering the highly threatening nature of the violent expressions conveyed through body posture, it would seem that incorporating such stimuli into any attention training paradigms would reap rewards.

Identifying and characterizing the various forms of threat-related attentional biases may not only have therapeutic value by informing clinical approaches to anxiety maintenance, but also contribute to our knowledge of selective visual attention, which is incomplete without taking into account how important individual differences affect attentional behavior. The implications of this research have broad appeal and should be of interest to anyone studying attention, social cognition, emotion, or clinical psychology. Our findings not only shed light on basic cognitive processes like attention and perception, but also explain how emotional stimuli interact with emotional states to influence behavior involved in social exchanges.

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Positions and Employment

2007: Research Assistant, Old Dominion University, Norfolk, Va. Bioelectrics research exploring effects of nanosecond scale pulses on the nervous system.

2008: Research Assistant, George Mason University, Fairfax, VA. Apolipoprotein E, Attention, and Alzheimer's Disease. Longitudinal study dealing with the genetics, behavioral changes, and neurophysiological changes associated with Alzheimer's Disease.

Presentations

2012: Azarian B, Peterson M, Green T. Where's the threat? Angry postures reflexively cue anxious individuals. Poster presented at: Society For Neuroscience Conference; 2012 Nov 9-13; New Orleans, LA.

2013: Azarian B, Esser E, Green T, Peterson M. The eyes don't lie: Fearful averted postures. Poster presented at: Society for Neuroscience Conference; 2013 Nov 9-13; San Diego, CA.

2014: Azarian B. An Introduction to Mind and Searle. Presentation at: The Foundations of Consciousness Guild; Krasnow Institute for Advanced Study; 2014 Mar 3; Fairfax, VA.

Selected peer-reviewed publications

Azarian, B., Esser, E. G., & Peterson, M. (In Press) Watch out! Directional threat-related postures cue attention and the eyes. *Cognition & Emotion*.

Teaching Experience

2013- Spring Semester- George Mason University
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