TIME COURSE OF ATTENTIONAL BIAS IN ANXIETY:

MEASURING EYE GAZE FOR ANGRY FACES IN WOMEN AND MEN

A Dissertation

by

MILAGROS EVARDONE

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

August 2009

Major Subject: Psychology

TIME COURSE OF ATTENTIONAL BIAS IN ANXIETY:

MEASURING EYE GAZE FOR ANGRY FACES IN WOMEN AND MEN

A Dissertation

by

MILAGROS EVARDONE

Submitted to the Office of Graduate Studies of
Texas A&M University
in partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

Approved by:

Chair of Committee,	Gerianne M. Alexander-Packard
Committee Members,	Mark G. Packard
	Brandon Schmeichel
	Jeffrey Liew
Head of Department,	Leslie C. Morey

August 2009

Major Subject: Psychology

ABSTRACT

Time Course of Attentional Bias in Anxiety:

Measuring Eye Gaze for Angry Faces in Women and Men. (August 2009)

Milagros Evardone, B.S., University of Florida;

M.S., Texas A&M University

Chair of Advisory Committee: Dr. Gerianne M. Alexander-Packard

The time-course of the attentional bias to threat in women and men was examined in order to clarify the validity of the "vigilant-avoidant hypothesis" and extend findings with spider pictures (Rinck & Becker, 2006) to other ecologically valid stimuli. Two hundred thirty-one (104 men, 127 women) participants pre-selected for high and low trait anxiety completed a battery of mood measures and viewed a series of slides with competing angry versus friendly faces. For a subset of these participants (54 men, 50 women), fixations and gaze durations were recorded via an eye tracker. All participants completed a face recognition task and provided copy and live measures of digit ratio (2D:4D), a putative marker of prenatal androgen exposure. Consistent with results from Rinck and Becker (2006), it was predicted that highly anxious individuals would show a vigilant-avoidant pattern toward angry faces while lesser anxious individuals would attend equally to angry and friendly faces over time. In addition, it was hypothesized that the vigilant-avoidant pattern would be stronger in highly anxious women. For secondary hypotheses, it was expected that digit ratio would correlate positively with trait anxiety and that attentional patterns for threat would differ between those with low and high digit ratio.

Results did not support a heightened threat bias in high anxious versus low anxious individuals. Both groups showed an early bias for the angry female face during the first 1500 ms of presentation and a general avoidance for the angry male face over the course of 60 s. Although no association was found between trait anxiety and digit ratio, there was a negative correlation between reports of obsessive-compulsive symptoms and live left hand digit ratio in men. Moreover, early attentional patterns for angry faces appeared to differ between women with low and high digit ratio, suggesting that prenatal androgen action may lead to cognitive biases associated with the development and maintenance of anxiety.

DEDICATION

I would like to dedicate this dissertation to my parents, who have supported me throughout my graduate career. To my father, who has worked tirelessly every day of his life to provide me a better future. You have confronted recent health struggles with courage, faith, and humility and are a shining example of how to overcome life's little obstacles. I pray that you are in my life for many more years. Thanks for believing in me, and I hope you are proud of your little girl.

To my mother, who spent many months in a hospital to give birth to me and whose love and concern has guided me through the years. I could not be here without you. You are the epitome of a strong Latin woman. Gracias mami por tu apoyo, tus oraciones, y tu cariño. Te quiero mucho.

I would also like to dedicate this dissertation in memory of Mary Beth Farmer, whose life was unexpectedly cut short in May 2008. Thank you for working as a research assistant in our lab and devoting many hours to this research project. You were intelligent, beautiful, and talented, and I am sorry you did not get the chance to complete our graduate program. It is truly our loss.

ACKNOWLEDGEMENTS

I would like to extend my gratitude to my committee chair, Dr. Gerianne M. Alexander-Packard, for her guidance and mentorship throughout my graduate training and for her invaluable input on the experimental design and manuscript of this dissertation. I would also like to thank her for providing me the necessary laboratory space, equipment, and research funds to conduct this project. In addition, I would like to thank my committee members, Dr. Brandon Schmeichel, Dr. Mark Packard, and Dr. Jeffrey Liew, for their recommendations in the development of this project and their suggestions for the manuscript.

A special thanks to my fellow graduate student, Nora Charles, M.S., for devoting a considerable amount of time to behavioral testing and data entry and to Dilip Ananthula and Mahesh Babu Sabbavarapu for providing assistance with data extraction. To all the research assistants in the Brain and Gender Lab and to all those in the Department of Psychology who were involved in this research project, thanks for your vital contributions.

I would finally like to thank the College of Liberal Arts for providing me a dissertation fellowship that helped fund this research. These funds were essential for participant testing and research supplies and were much appreciated.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

INTRODUCTION

Cognitive and evolutionary theories agree that anxiety is associated with a processing bias for threat-related information, evolving from an adaptive fear mechanism designed to respond to real dangers in the environment (Beck & Clark, 1997; Mogg & Bradley, 2004; Öhman, 1993; Williams, Watts, MacLeod, & Mathews; 1997). Abnormal levels of anxiety, such as those associated with clinical disorders, are distinguished from normative levels by an increased sensitivity, or lowered threshold, for detecting, evaluating, and/or maintaining attention to threat. These theories have been extensively supported by research showing a moderate (*d* = .45), but robust, attentional bias for threat across clinically and non-clinically anxious groups (both children and adults), type of experimental paradigm (e.g., Stroop task, dot-probe task, cueing task, dichotic listening, and visual search), type of emotional stimuli (e.g., threatening words, scenes, or faces), and type of experimental design (e.g., subliminal vs. supraliminal) (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van Ijzendoorn, 2007). However, although an attentional bias for threat in anxiety appears to be firmly established, researchers continue to disagree on the specific components of attention (e.g., initial orienting/shifting, engagement, or disengagement) associated with this bias and the type of cognitive processes involved (e.g., automatic/pre-conscious vs. strategic/voluntary) (Beck & Clark, 1997; Mogg & Bradley, 2004).

This dissertation follows the style of *Journal of Abnormal Psychology*.

REVIEW OF LITERATURE

Typically, researchers using the emotional Stroop, dot-probe (or visual probe), and visual search tasks to study attentional biases in anxiety conclude that initial orienting and early engagement components are central to the threat bias (Bradley, Mogg, Falla, & Hamilton, 1998; Bradley, Mogg, & Millar, 2000; MacLeod, Mathews, & Tata, 1986; Öhman, Flykt, & Esteves, 2001; Williams, Mathews, & MacLeod, 1996). Anxious individuals are believed to be hypervigilant for danger in their environment and are thought to automatically and preferentially attend to threatening stimuli. In contrast, researchers typically using the cueing paradigm conclude that it is impaired disengagement from threat, not initial orienting to threat, which is associated with the development and maintenance of anxious states (Fox, Russo, Bowles, & Dutton, 2001; Fox, Russo, & Dutton, 2002; Yiend & Mathews, 2001). That is, once threat is detected and evaluated as a possible danger, anxious individuals have a particularly difficult time diverting attention away from it and are more distracted by it.

Evidence from Stroop Task

The emotional Stroop task was the first task to be extensively used in the study of attentional biases in anxiety. In the modified version of the Stroop (see Appendix A), emotional (negatively or positively valenced) and neutral words are printed in varying colors. Participants are asked to name the color of the word as quickly as possible, while ignoring the word itself and its emotional content (Mogg & Bradley, 2004). Studies with clinically and non-clinically anxious populations have generally found that anxiety is associated with longer response latencies for threatening versus neutral words, and this slower response appears only partially accounted for by the personal salience or relevance of the words (Williams et al., 1996). Overall, results from Stroop studies have suggested that threat-related information selectively captures attention in anxious individuals (Williams et al., 1996). Moreover, the Stroop interference effect appears to occur even when words are presented pre-attentively, in masked versions of the task, leading researchers to conclude that attention is automatically and unconsciously captured by threatening words (for review see Bar-haim et al., 2007; Williams et al., 1996).

Evidence from Dot-Probe Task

The upsurge of research using the Stroop in the 1980's gave way to new experimental paradigms to assess the allocation of attention in emotional disorders. Since its initial development by MacLeod et al. (1986), the emotional dot-probe task has been used in a number of studies finding an attentional bias towards threatening stimuli in various anxiety disorders (e.g., generalized anxiety and social phobia) and in high trait anxious and state anxious individuals. In this task, two stimuli (one neutral, one threatening) are simultaneously presented for a brief time period (with exposure times varying across studies but generally less than 1 second) and are followed by a probe appearing in either the location of the neutral or threatening stimulus (see Appendix A). Participants are instructed to respond as quickly as possible to either the location or the type of probe. Faster responding to probes replacing the threatening stimuli is associated with an attentional bias for threat (Bar-Haim et al., 2007).

Although studies using the dot-probe task have varied considerably in the type of stimuli used (words vs. pictures) and the duration of stimulus exposure (100 ms, 500 ms, 1250 ms), leading to some inconsistent findings, meta-analyses of research using this task have generally shown an attentional bias towards threat by high anxious individuals and away from threat by low anxious individuals (Frewen, Dozois, Joanisse, & Neufeld, 2008). Results are generally cited as evidence that anxious individuals show facilitated detection and early attentional engagement towards threat. For example, in the original dot-probe study, individuals with generalized anxiety (GAD) responded faster to probes following physical and social threat words, whereas non-anxious controls showed avoidance of threat words (MacLeod et al., 1986). Similarly, with stimulus exposures of 500 ms, individuals with high trait and both high and medium state anxiety exhibited greater vigilance for angry faces relative to neutral faces and greater avoidance of happy faces than low anxious individuals (Bradley et al., 1998; 2000). At 500 ms exposure, high trait anxious individuals also showed faster responding to threatening pictures from the International Affective Picture System (IAPS), but only for highly, not mildly, threatening pictures (Liu, Qian, Zhou, & Wang, 2006). This preferential attention to threatening stimuli, however, may only be found in trait anxious individuals with low levels of defensiveness or social desirability. In one study, individuals with high trait anxiety and low defensiveness showed the expected attentional bias for threatening faces, whereas those with high trait anxiety and high levels of defensiveness showed greater vigilance for happy faces (Ioannou, Mogg, & Bradley, 2004).

In contrast, other researchers using the dot-probe task have suggested that the selective attention to threat found in anxious individuals is due to impaired disengagement and not facilitated engagement towards threat. In one study, participants were slower to respond to probes replacing neutral pictures in threat-neutral pairs, suggesting that participants were still attending to the threat picture. However, reaction times for probes replacing threat pictures on threat-neutral pairs were not significantly different than reaction times for neutral baseline trials (Koster, Crombez, Verschuere, & De Houwer, 2004), suggesting no speeded effect in attending towards threat. This pattern of results suggests that the attentional bias was due to impaired disengagement, rather than initial orienting or early engagement components.

Still other research using the dot-probe task has concluded that the attentional bias towards threat involves a combination of the different components of attention. At 100 ms picture presentations, low trait anxious and high trait anxious individuals showed vigilance for highly threatening IAPS pictures, suggesting an automatic orienting towards threat in everyone (Koster, Verschuere, Crombez, & Van Damme, 2005). At 500 ms presentation, only high trait anxious individuals showed a bias toward mildly threatening pictures, suggesting that at longer stimulus presentations, the threat bias in anxious individuals is due to impaired disengagement (Koster et al., 2005). Thus, it appears that threatening information, particularly high threat, captures attention early (possibly for both high trait anxious and low trait anxious groups due to the adaptive nature of detecting dangers in the environment) and maintains attention for further processing.

Evidence from Cueing Task

Despite the large body of research supporting attentional biases with the Stroop and dot-probe tasks, these have been criticized for their inability to disentangle the various contributions of the attentional components to the threat bias. Some researchers argue that these tasks cannot discriminate whether threatening stimuli draw attention or whether they simply keep attention, once they are detected (Fox et al., 2001). To address these inadequacies, Fox et al. (2001) introduced an emotional version of the cueing paradigm, which is theoretically capable of distinguishing engagement and disengagement components. In the emotional cueing task, an emotionally valenced (positive or negative) or neutral cue (words or pictures) is presented on a screen for a brief time period (varies across studies but generally less than 500 ms) and is then removed (see Appendix A). After a brief intervening period (e.g., 50 ms), a target (a geometrical shape) is presented in the location previously occupied by the cue (i.e., valid trial) or in the opposite location (i.e., invalid trial). Participants are asked to respond as quickly as possible to either the location or the type of target. Faster responses to valid threat cue trials are attributed to facilitated engagement of attention, whereas slower responses on invalid threat cue trials are attributed to difficulty disengaging from threat (Fox et al., 2001).

Results from cueing paradigm studies generally support the hypothesis that attentional biases in anxiety are due to increased dwell time on threatening information rather than hypervigilance per se. For example, in the original version of this task, at 250 ms and 600 ms cue exposure, individuals scoring high in state anxiety showed slower responses to invalid trials for angry faces and threat words, thus suggesting difficulty disengaging from threat (Fox et al., 2001). However, at 100 ms cue exposure, both high and low state anxiety was associated with slower responses to invalid threat trials, suggesting that, at shorter presentation times, everyone attends to threatening stimuli (Fox et al., 2001). The only difference, then, is that low anxious individuals are more quickly able to disengage their attention from threat, whereas high anxious individuals' attention towards threat may be maintained due to increased rumination and worry (Verkuil, Brosschot, Putman, & Thayer, 2009). However, although high anxious individuals are slower to disengage from threat, they appear to eventually divert their attention from it. In one study, high trait anxious individuals displayed impaired disengagement for highly threatening IAPS pictures at 500 ms exposure, but this effect dissipated by 2000 ms (Yiend & Mathews, 2001). This suggests that threatening pictures hold an anxious individual's attention for some time but eventually this effect is reduced.

Other studies have found that high anxious individuals show a non-specific, impaired disengagement from emotional stimuli, rather than threat per se. For instance, high trait anxious individuals were slower to respond to invalid trials following both angry and happy faces presented for 250 ms, suggesting that they had particular difficulty disengaging from emotional stimuli in general (Fox et al., 2002). At slightly longer stimulus presentations, high trait anxious individuals did not show the expected inhibition of return effect for angry and jumbled angry faces, which the authors also attribute to delayed disengagement from both threatening and ambiguous stimuli (Fox et al., 2002). Similarly, clinically anxious participants under stress conditions were slower to disengage attention from pictures depicting threat and sadness/loss, which were presented subliminally (17 ms), but quicker to disengage from threatening pictures presented supraliminally (750 ms) (Ellenbogen & Schwartzman, 2009). The authors concluded that when under stress, anxious participants have particular difficulty diverting attention away from emotional stimuli in general, which is then followed by a robust avoidance of threat stimuli.

Although the majority of studies using the cueing paradigm have supported the impaired disengagement hypothesis, there has been some evidence that a combination of engagement and disengagement processes may be involved. One study found that at 100 ms cue presentation, high trait anxious individuals attended more to highly threatening IAPS pictures compared to low trait anxious individuals (Koster, Crombez, Verschuere, Van Damme, & Wiersema, 2006). After comparing reaction times on valid and invalid threat trials to reaction times for neutral trials, it was suggested that the bias at 100 ms was related to both facilitated engagement and impaired disengagement.

Evidence from Visual Search Task

Another task which has been commonly used to study attentional biases towards threat in anxious populations has been the visual search task. Although there are several variations of this task (e.g., target search and odd-one-out task), the visual search task generally involves detecting a particular target amongst a background of distracters (Rinck, Reinecke, Ellwart, Heuer, & Becker, 2005). Studies using this task have generally reported a threat advantage. That is, participants were faster to detect a threatening target amongst a background of neutral distracters than they were at detecting a neutral target amongst a background of threatening distracters (Öhman et al., 2001). For example, individuals scoring high in state anxiety and undergoing a stress manipulation are faster to detect angry schematic faces amongst a background of happy schematic faces (Juth, Lundqvist, Karlsson, Öhman, 2005). This effect has been interpreted as evidence for an automatic and initial orienting towards threat, which has evolutionary relevance.

In contrast, some studies suggest that anxious individuals are slower to detect neutral targets among threatening distracters and not necessarily faster at detecting threatening targets among neutral distracters (Rinck & Becker, 2005). This may interpreted as evidence that it is not initial orienting towards threat, but impaired disengagement from threat which leads to attentional biases in anxiety. For instance, phobic individuals demonstrated longer reaction times to targets when distracted by spider pictures (Gerdes, Alpers, & Pauli, 2008). Ostensibly, this effect was due to the distracting factor of the spider pictures, and thus the phobic individual's inability to shift attention away from them. Nevertheless, research using various versions of the visual search task, have found evidence for both speeded detection of threat and increased distraction by threat (e.g., spiders), suggesting that both engagement and disengagement components of attention are involved and may vary as a function of task-specific features (Rinck et al., 2005).

Vigilant-Avoidant Hypothesis

Consistent with the idea that both engagement and disengagement components of attention are involved in attentional biases towards threat, another proposed theory, the "vigilant-avoidant" hypothesis, suggests that anxious individuals initially orient and engage attention towards threat via automatic processing and then avoid threat through strategic processes (Mogg & Bradley, 2004; Williams et al., 1997). In other words, anxious individuals selectively attend to threat, but in order to reduce their state anxiety, they cope by avoiding the unpleasant or feared stimulus. This avoidance behavior then precludes the extinction of anxiety and maintains the anxious cycle. For example, for socially anxious individuals, social interaction with other individuals is anxiety-provoking due to the potential for embarrassment and negative evaluation. Interestingly, in a novel task assessing avoidance behavior, the Approach-Avoidance Task, it was found that socially anxious individuals were more likely to push away (avoid) individual pictures of smiling and angry faces, compared to pictures of puzzles, and were more likely to push away groups of angry-happy faces than non-anxious controls (Heuer, Rinck, & Becker, 2007; Lange, Keijsers, Becker, & Rink, 2008). This avoidance of other people, however, is believed to maintain their anxiety of social interaction because they are unable to learn that these situations may not result in the anticipated negative consequences.

Because the paradigms typically used to study attentional biases (described above) only assess attention at specific time intervals (e.g., 100 ms, 500 ms), they present only a snapshot of attentional processes. In addition, as stimulus presentation times have varied considerably across studies, results in support of the "vigilant-avoidant hypothesis" have been mixed. Some studies support only the vigilance component (Bradley et al., 1998; Ioannou et al., 2004), others the avoidance component (Stirling, Eley, & Clark, 2006) and yet others, find evidence for both (Koster et al., 2005; 2006). Further, although some studies may not directly support avoidance behavior, they note a decline in the strength of the attentional bias over longer presentation times or stimuli exposures, suggesting possible future avoidance (Bradley et al., 1998; Ioannou et al., 2004; Liu et al., 2006). For instance, at 500 ms, high trait anxious individuals show increased attention to threatening stimuli compared to low anxious individuals, but by 1250 ms, this bias is no longer found (Bradley et al., 1998; Ioannou et al., 2004). It is possible that with presentation times longer than 1250 ms, high anxious individuals will continue to decrease their attention to threatening stimuli, leading to avoidance behavior. In general, however, short presentation times ($\leq$ 500 ms) have been associated with vigilance and longer presentation times ($\geq$ 1000 ms) have been associated with avoidance.

Evidence from Eye Tracking Studies

Given the limitations of the attentional paradigms in evaluating the time-course of attentional biases in anxious individuals, recent innovative studies have used eye movement measures or eye tracking technology to clarify results and assess the validity of the "vigilant-avoidant hypothesis." The eye tracking method has several advantages over traditional attentional paradigms: 1) It provides a continuous, real time measure of an individual's attention to competing stimuli, allowing one to assess the relative contributions of orienting and engagement components and 2) Shifts in covert attention tend to be closely followed by a corresponding shift in eye gaze (i.e., overt attention), thus making eye tracking a more accurate measure of attention (reviewed in Nummenmaa, Hyönä, & Calvo, 2006; Wadlinger & Isaacowitz, 2006).

Nevertheless, despite the promising nature of eye tracking technology, studies using this measure to assess attentional biases in anxiety have also produced mixed results. Some studies provide direct support for the "vigilant-avoidant hypothesis (Calvo & Avero, 2005; Garner, Mogg, & Bradley, 2006; Rinck & Becker, 2006); others provide partial support (Calvo & Lang, 2004; Hermans, Vansteenwegen, & Eelen, 1999; Mogg, Garner, & Bradley, 2007; Rohner, 2002; 2004); and a third group provides no support (Caseras, Garner, Bradley, & Mogg, 2007; Calvo, Avero, & Lundqvist, 2006; Freeman, Garety, & Phillips, 2000; Mühlberger, Wieser, & Pauli, 2008). For studies offering full support, spider-fearful individuals were found to preferentially attend to spiders compared to other animal pictures for the first 500 ms, followed by avoidance of spiders after 1500 ms (Rinck & Becker, 2006); high socially anxious individuals (under stress conditions) were found to initially orient to emotional faces (happy and angry) compared to neutral faces at approximately 350 ms, followed by avoidance of these at approximately 700 ms (Garner et al., 2006); and high trait anxious individuals were found to selectively attend to both positively and negatively valenced IAPS pictures compared to neutral pictures for the first 500 ms, followed by avoidance of harm scenes at 2000 ms (Calvo & Avero, 2005).

For studies offering partial support for the vigilance-avoidance hypothesis, some describe initial orienting without avoidance, while others describe avoidance without hypervigilance. First, individuals from a non-clinical sample were found to look faster at both threatening and injury scenes compared to neutral scenes (Calvo & Lang, 2004). However, at 500 ms, preferential attention was maintained for threatening pictures, while injury scenes were almost immediately avoided. After 500 ms, attention for threatening pictures declined and a bias was no longer seen (Calvo & Lang, 2004), but no direct evidence of avoidance was reported. Similarly, individuals with GAD shifted their gaze more quickly and more frequently toward angry faces relative to neutral faces, but at 1000 ms picture exposure, no avoidance of angry faces was noted (Mogg, Millar, & Bradley, 2000). In a third study, high anxious individuals initially oriented their gaze to both angry and fearful faces but differed from low anxious individuals only on intense negative facial expressions. No difference was found for mild negative expressions and no avoidance behavior was reported (Mogg et al., 2007). Conversely, high trait anxious and spider-fearful individuals initially attended more to threatening stimuli (i.e., angry faces and spiders) compared to non-threatening stimuli (i.e., neutral faces and flowers) for the first 1000 ms and 500 ms, respectively (Hermans et al., 1999; Rohner, 2002). However, this bias was not significantly different from low trait anxious or non-fearful participants, thus failing to replicate a traditional vigilance effect. In both studies, only high anxious and phobic individuals showed avoidance of threatening stimuli after 1800 ms and 2000 ms, respectively (Hermans et al., 1999; Rohner, 2002). Consistent with the latter results, high trait anxiety has also been associated with memory-based attentional avoidance of angry faces in favor of happy faces (Rohner, 2004).

The eye tracking research reported thus far is contrasted with a group of studies showing neither a selective vigilance nor a secondary avoidance of threatening or negative information in anxious individuals. Compared to low trait anxious individuals, high trait anxious individuals did not initially orient or maintain attention for emotional scenes depicting sadness or loss (Caseras et al., 2007). Similarly, although individuals detected angry faces faster than other emotional faces (amongst a background of neutral faces) in a visual search task, this effect could not be explained by early fixation on angry faces (Calvo et al., 2006). Rather, it appeared that individuals initially shifted their gaze, and hence attended to, all emotional faces compared to neutral faces. This suggests that the facilitated detection of angry faces in this task was due to more efficient processing of threatening stimuli, not vigilance for them. Moreover, in a study examining visual scan paths, individuals with GAD did not show the increased scanning behavior or attention to threatening scenes that would be predicted by the hypervigilance hypothesis (Freeman et al., 2000). Finally, in a study examining eye movements during a virtual reality social situation, it was found that all individuals tended to show a bias for happy virtual persons than angry persons, whereas socially anxious individuals initially avoided all emotional expressions (Mühlberger et al., 2008). To summarize, there appears to be some evidence from eye tracking, though inconsistent, suggesting that anxious individuals initially shift and maintain their attention on threatening information and then actively avoid these stimuli (after about 1000 ms) to lower their discomfort.

Mixed findings from eye tracking may be attributed to methodological differences across studies. Research has varied considerably in the populations sampled (clinical vs. non-clinical, trait vs. state anxiety), the type (e.g., schematic vs. real faces, IAPS pictures) and manner (e.g., one picture at a time, competing stimuli) in which stimuli are presented, and the format of the viewing situation (e.g., free viewing vs. viewing while completing dot-probe task), to name a few. Because the use of eye tracking is fairly new to the study of attentional biases in anxiety, more studies are needed using this measure before any conclusions can be drawn from this growing body of literature.

Sex Differences in Attentional Biases?

Another possible factor, which may account for differences across studies, is the sex of participants. It is known that anxiety is two times more prevalent in women than in men and that sex differences exist in symptom presentation and clinical course (Armstrong & Khawaja, 2002; Craske, 2003; Howell, Castle, & Yonkers, 2006; Pigott, 2003), with women generally having increased severity, comorbidity, and poorer outcomes. However, less than a handful of studies have assessed, or even considered, sex differences in the study of attentional biases for threat. Though researchers have acknowledged that sex may contribute to differences in cognitive bias (Rink & Becker, 2005), this potential confounding factor has not been directly addressed. Most studies have relied on generally small samples (approx. $n = 50$) and involved primarily women. When men are included, no effort has been made to determine whether different patterns of attention exist by sex.

Several pieces of evidence suggest that attentional biases may be stronger in women than in men, particularly for emotional facial expressions. First, women appear to have enhanced face and emotion processing compared to men (Craske, 2003). Given women's superior ability to classify facial expressions, their attention may be more quickly captured by threatening faces, whereas men may perceive stimuli as more ambiguous or may erroneously classify facial expressions, thereby reducing the effect of threatening stimuli. Consistent with this possibility, brain areas associated with emotion processing show various sex differences. For example, when viewing unpleasant pictures, women compared to men exhibited greater right hemisphere activation overall, and greater specific activation of the right superior temporal plane, left superior temporal gyrus/insula, left motor cortex, right supplementary motor area, left lingual gyrus, and vermis (Hofer et al., 2006). Significantly, sex differences in brain activation have also been found for facial expressions. From childhood into adulthood, girls showed decreased left amygdala activation and increased right prefrontal activation to affective faces, but no developmental changes were found in boys (Hamann & Canli, 2004). In addition, emotional face processing has been associated with greater overall neural activation in men compared to women (Hamann & Canli, 2004), with bilateral frontal activity and increased amygdala activation in women, and with unilateral, right sided activity in men (Hall, Witelson, Szechtman, & Nahmias, 2004). There is also evidence that the interaction of emotion and cognitive processing leads to differences in brain activation in men and women. When negative mood is induced and participants are asked to complete a working memory task, men show greater activation of prefrontal and superior parietal regions while women show greater activation of emotion-related regions, such as the amygdala and the orbitofrontal cortex (Koch et al., 2007). Although somewhat inconsistent, these findings demonstrate that sex differences exist in brain areas associated with emotion and cognitive processing, which may then influence patterns of attentional biases in emotional disorders.

Evolutionary perspectives also suggest that women should have increased sensitivity to threat-related information. In line with their role as caregivers, it appears more adaptive for females to have increased awareness and avoidance of threat, as this results in protection of the offspring from possible dangers (Craske, 2003). Active confrontation of threat, rather than avoidance, may result in children being left unattended, and thus vulnerable to peril. Gender socialization and parenting styles discouraging women from experiencing a wide array of activities and facing fear-provoking situations also appear to support greater avoidance behaviors in women (Craske, 2003).

The hypothesis of differential patterns of attentional biases in women and men is most proximally supported by the few studies, which have explored attentional allocation to threatening stimuli by sex. In one study, there was a marginally significant interaction between picture valence (neutral, high threat, and mild threat) and trait anxiety (low vs. high) for men ($N = 16$) (Koster et al., 2006). However, most likely due to insufficient power, further investigation did not reveal any significant differences between high and low trait anxious men on engagement or disengagement components (Koster et al., 2006). Similarly, in a visual search task with real faces, women compared to men showed faster detection of happy faces than angry faces when the eyes of stimuli were looking forward and not diverted (Juth et al., 2005). In a follow-up experiment, women also showed faster overall detection of emotional schematic faces than men (Juth et al., 2005). Results from these two studies provide preliminary evidence suggesting that the direction or time-course of attentional biases may differ by sex, thus leading to greater anxiety vulnerability in women.

PURPOSE AND HYPOTHESES

Given the mixed results in the literature concerning the time course of attentional biases towards threat, this research further evaluated the validity of the "vigilant-avoidant hypothesis" and examined whether differing patterns of attentional biases exist for women and men. Further, this study aimed to extend procedures by Rinck and Becker (2006) to other anxious samples and other ecologically valid stimuli. Fixations and gaze durations for angry faces compared to friendly faces were measured by means of eye tracking methodology in a non-clinical, student sample pre-selected for high and low trait anxiety. A non-clinical sample was selected because attentional biases in non-clinical samples are potentially more informative about processes relating to the etiology and maintenance of anxiety, which may later contribute to the development of anxiety disorders. In addition, facial stimuli were selected over other emotional stimuli because faces are generally processed faster than objects (Palermo & Rhodes, 2007), their processing is not language-dependent (unlike word stimuli), and faces appear to be particularly salient social stimuli for high trait anxious individuals (Rohner, 2002). Given results from previous attentional paradigms and eye tracking studies, it was hypothesized that high trait anxious individuals would initially orient and selectively attend to angry faces relative to friendly faces, after which they would avoid the angry faces in favor of the friendly faces. This pattern of attentional bias was not expected to occur in low trait anxious individuals, who were predicted to attend equally to angry and friendly faces across time. Further, the “vigilant-avoidant” pattern was expected to be more pronounced in women than in men.

As a secondary aim, the current study assessed the possibility that hormonal factors contributing to the development of sex differences in normative behavior (Cohen-Bendahan, van de Beek, & Berenbaum, 2005) would also contribute to the sex differences observed for anxiety, including differences in attentional biases. In general, sexually dimorphic behaviors in humans and other species appear influenced by an androgen-dependent differentiation of brain structures early in prenatal development (Breedlove, 1994). This suggests that prenatal androgen action may also influence sex differences in abnormal behaviors (Alexander & Peterson, 2001), such as the female vulnerability to anxiety. In fact, the 2D:4D ratio (ratio of the second to fourth digit length), a putative measure of prenatal androgen action (Manning, Scutt, Wilson, & Lewis-Jones, 1998; McIntyre, 2006), has been associated with a number of sexually dimorphic behaviors, including male-linked (Manning, Baron-Cohen, Wheelwright, & Sanders, 2001; Martel, Gobrogge, Breedlove, & Nigg, 2008; Stevenson et al., 2007; Voracek, 2008) and female-linked psychopathology (Bailey & Hurd, 2005a; Klump et al., 2006). Significantly, larger digit ratios, suggestive of weaker prenatal androgen exposure, have also been associated with anxious behavior and anxiety disorders in boys (de Bruin, Verheij, Wiegman, & Ferdinand, 2006; Williams, Greenhalgh, & Manning, 2003) and degree of trait anxiety and neuroticism in adulthood (Evardone & Alexander, 2009; Fink, Manning, & Neave, 2004). As a result, it was hypothesized that larger digit ratios would be associated with higher trait anxiety and that differences in attentional biases towards threat would exist between individuals with larger and smaller digit ratios.

METHODS

Participants

Introductory Psychology students at Texas A&M University were prescreened for high versus low trait anxiety (HTA vs. LTA) using the State-Trait Anxiety Inventory (STAI; Spielberger, 1983). Those scoring in the extremes (upper and lower 25%), within each sex, were invited to participate in the study. Cut offs for men were < 32 or > 45, and cut offs for women were < 34 or > 48. A final sample of 231 participants (104 men, 127 women) completed experimental procedures. There were no group differences in age. However, there was a greater percentage of Hispanic/Latino men compared to women and a greater percentage of African-American women compared to men (see Table 1). For a subset of these participants (54 men, 50 women), eye tracking data was obtained during the slide show presentation. Only participants providing informed consent were included in the study. Participants received either 2 credits towards their course requirement, or $10 compensation if their course requirement had been completed.

Materials and Apparatus

To extend procedures by Rinck and Becker (2006) to other ecologically valid threat cues, the visual stimuli consisted of 9 angry faces, 9 friendly male faces, 9 friendly female faces, and 9 friendly child-like faces. Stimuli were constructed with the Faces 3.0, Interquest, Inc. software. Consistent with facial features central to the expression of threat and threat value of eye whites (Lundqvist, Esteves, & Öhman, 1999; Whalen et

Table 1
Participants' Demographic Characteristics

		Men (n = 104)	Women (n = 127)
Age, yrs		18.98 (.99)	18.88 (1.16)
Race			
	White/Caucasian	75.96 %	81.89 %
	Hispanic/Latino	15.38 %	7.09 %
	Black/African-American	0 %	4.72 %
	Asian	8.65 %	6.30 %
Anxiety Group			
	Low Trait Anxiety	49 %	46.5 %
	High Trait Anxiety	51 %	53.5 %

al., 2004), all angry faces displayed the same wide open eyes, v-shaped eyebrows, and frown. In contrast, friendly faces displayed smaller eyes, eyebrows raised in the middle, and a smile. To control for ethnicity/race and novelty of face, all faces were made to resemble Caucasian individuals, with no facial hair. All other features (e.g., hair, nose, face shape) for both angry and friendly faces were varied to create unique individuals.

During the experiment, stimuli were presented on a 19 in. (for 79 participants) or a 24 in. (for 25 participants) computer monitor using the GazeTracker software (ERICA Inc. for Applied Science Laboratory). Nine individual slides of 2 x 2 matrices, with one angry face and one friendly face of each type, were shown (see Figure 1). One slide served as a practice trial and the remaining eight slides served as experimental trials, which were presented in random order. For the experimental trials, half of the angry faces and child-like faces were male (4) and half were female (4). Face position was counterbalanced across the trials, so that by the end of the experiment, one angry face of each sex had appeared in each of the four positions on the matrix. In addition, 32 new pictures (all friendly) of unique individuals were created and used in a subsequent recognition task.

Participants' eye movements and gaze during the slide display were recorded using an Applied Science Laboratory Eye Tracking System (Model 504 for 50 participants; Model R6 for 54 participants) with remote optics. The eye tracker uses an infrared light beam to obtain pupil and corneal reflections and measures gaze position with an accuracy of less than 1° and a precision of better than 0.5° of visual angle. The

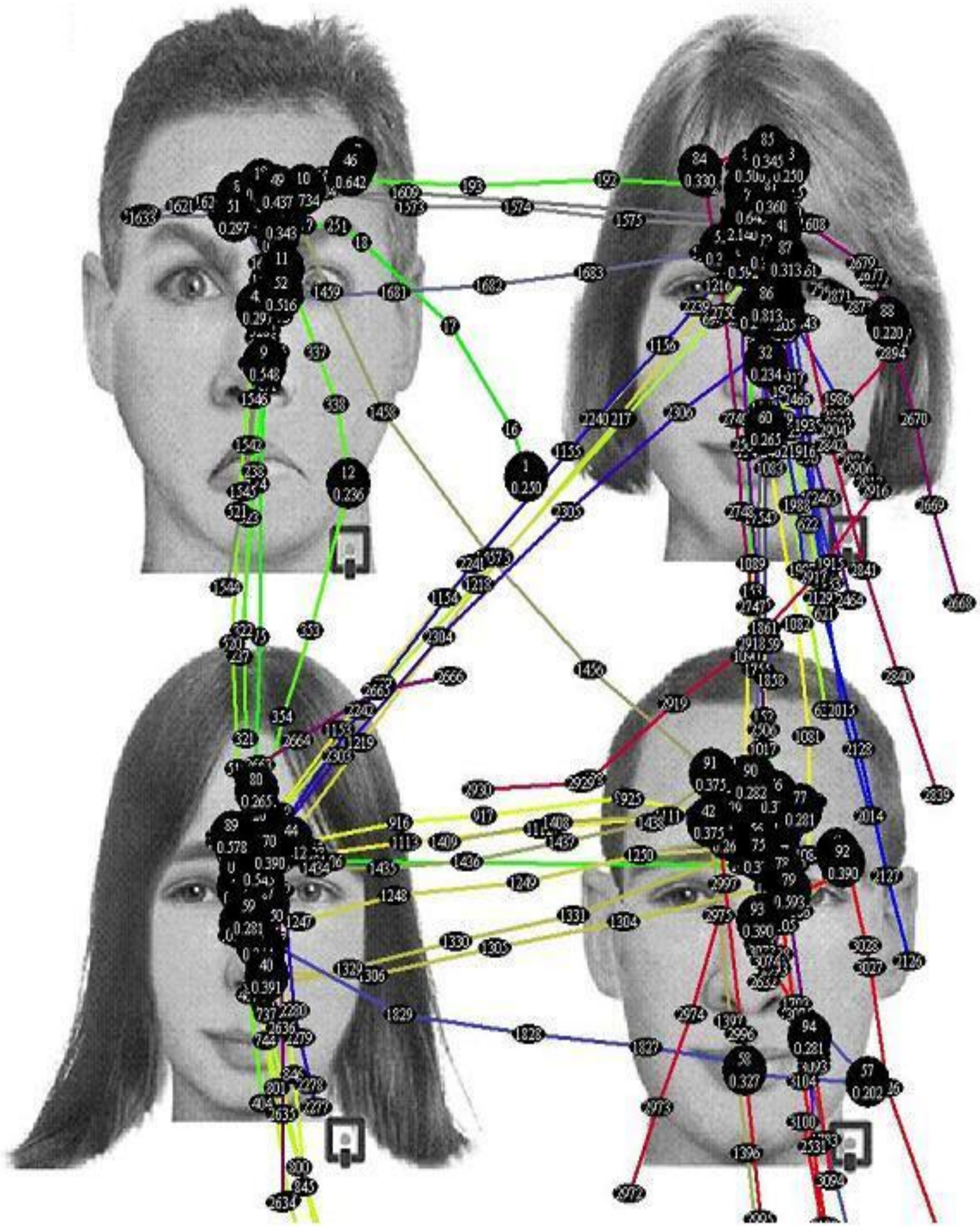


Figure 1. Presentation Slide with Sample Participant's Fixations and Fixation Trail.

eye tracker was positioned directly below the computer monitor. To minimize disruptions in eye tracking by head movements, participants wore a magnetic headtracker (Flock of Birds®, Ascension Technology). Data obtained by the eye tracker (e.g., number of fixations, gaze durations) was collected using the GazeTracker software.

Measures

Visual Analogue Scale. The visual analogue scale consists of seven pairs of opposite adjectives (i.e., sad-happy, anxious-calm, tired-energetic, confused-oriented, afraid-relaxed, angry-content, bored-excited) separated by a 100 mm horizontal line. Negatively valenced items are to the extreme left and positively valenced items are to the extreme right. Participants are asked to draw a dash along the line reflecting their current mood state. To determine whether viewing the slide show altered participants' mood, the VAS was administered immediately before and after the slide show. Scores on each item for time 1 were subtracted from scores on time 2 to provide a measure of change. Negative change scores reflect a more negative mood after the slide show.

State-Trait Anxiety Inventory. The STAI (Spielberger, 1983) is composed of 40 items and 2 scales (20 items per scale). On the State Scale, participants are asked to describe how they are feeling "right now, that is, at this moment." Responses are given on a 4-point scale ranging from 1 = "Not at all" to 4 = "Very Much So." On the Trait Scale, participants are asked to describe how they "generally feel." Responses are on a similar 4-point scale ranging from 1 = "Almost Never" to 4 = "Almost Always." Half the items on each scale are scored in the positive direction and half in the reverse direction. Scores on the 20 items are summed to provide an overall scale score. In the standardization sample of college and high school students, military recruits, and working adults, the STAI demonstrated high internal consistency on both scales ($\alpha >$ .90) and high test-retest reliability (r = .65-.86) for the Trait Scale. As expected, low test-retest reliability (r = .33) was found for the State Scale. The STAI-Trait Scale also appears to be highly correlated (r = .70-.85) with other widely used measures of anxiety, such as the Manifest Anxiety Scale (MAS) and the Anxiety Scale Questionnaire (ASQ), and is moderately to highly correlated with the STAI-State Scale (r = .59-.75).

Beck Depression Inventory. The Beck Depression Inventory (BDI; Beck, Steer, & Brown, 1996) consists of 21 items assessing affective, cognitive, and physiological symptoms of depression. Responses are given on a scale from 0 to 3, with 0 representing the absence of a symptom and 1-3 indicating increasing symptom levels. Scores on individual items are summed to provide a total depression score. The BDI shows high internal consistency (α = .89-.93) and test-retest reliability (r = .73-.93) (Beck et al., 1996; Wiebe & Penley, 2005). It is also highly correlated with other widely used measures of depression, including the Revised Hamilton Psychiatric Rating Scale for Depression (HRSD-R; r = .71) (Beck et al., 1996).

Personality Assessment Inventory-Anxiety Scale. The Personality Assessment Inventory (PAI; Morey, 1991) Anxiety Scale includes three subscales (24 items total) measuring cognitive (ANX-C), affective (ANX-A), and physiological (ANX-P) components of anxiety. Respondents choose whether symptoms are “Totally False,” “Slightly True,” “Mainly True,” or “Very True” of them. Scores on each item are weighted on a scale from 0-3. Items in the ANX-C scale focus on ruminative worry and impaired concentration; items in the ANX-A scale measure tension and fatigue caused by perceived stress; and items in the ANX-P scale evaluate somatic symptoms of anxiety. The Anxiety-Full Scale of the PAI has shown high internal consistency (α = .89-.94) and test-retest reliability (r = .88). It also appears to be moderately to highly correlated with other widely used measures of anxiety, such as the BAI (r = .62), the Fear Survey Schedule (FSS) (r = .49), STAI-State (r = .62), and STAI-Trait (r = .73).

Personality Assessment Inventory-Anxiety-Related Disorders Scale. The PAI Anxiety-Related Disorders Scale (Morey, 1991) includes three subscales (24 items total) measuring obsessive-compulsiveness (ARD-O), phobias (ARD-P), and traumatic stress (ARD-T). Responses are given on the same 4-point, weighted categories used in the Anxiety Scale. The ARD-O scale contains items assessing inflexibility, perfectionism, and the presence of intrusive thoughts and behaviors; the ARD-P scale evaluates fear of common objects and situations (e.g., “fear of heights”); and the ARD-T scale probes for a history of trauma and determines whether these events are presently causing distress. The Anxiety-Related Disorders Scale of the PAI has shown high internal consistency (α = .76-.86) and test-retest reliability (r = .83-.85). It also appears moderately correlated with other widely used measures of anxiety, such as the BAI (r = .48-.53), FSS (r = .66), Mississippi PTSD Scale (r = .81), Maudsley Obsessive-Compulsive Inventory (r = .62), STAI-State (r = .42) and STAI-Trait (r = .51).

Marlowe-Crowne Social Desirability Scale. The Social Desirability Scale (SDS; Crowne & Marlowe, 1960) consists of 33 true/false items assessing an individual’s need for approval or level of defensiveness. The SDS shows high internal consistency (α = .76-.86) and is mildly to moderately correlated with the Edwards Social Desirability Scale (r = .40) (O'Grady, 1988).

Bem Sex-Role Inventory. The Bem Sex-Role Inventory (BSRI; Bem, 1981) consists of 60 items assessing masculinity and femininity as separate dimensions. Men typically score higher on the masculine scale, and women typically score higher on the feminine scale, with effect sizes ranging from d = .44 to d = .96 (Murphy, 1994; Rammsayer & Troche, 2007). The BSRI has shown high internal consistency (Masculinity: α = .86-.95, Femininity: α = .82-.92) and test-retest reliability (Masculinity: r = .90, Femininity: r = .90, Androgyny: r = .93) (Bem, 1974; Holt & Ellis, 1998). It is also highly correlated with other gender role measures, such as the Personality Attributes Questionnaire (PAQ) (Masculine Scales: r = .78, Feminine Scales: r = .71) (Lippa, 1991).

Digit Ratio. Two independent coders measured the lengths of the 2nd (index) and 4th (ring) fingers from hand copies of participants' right and left hands. Finger-lengths, from the basal crease to the tip of the finger, were measured using digital calipers and measurements were recorded in mm. Experimenters also obtained direct measurements of participants' 2nd and 4th fingers at the end of the experimental session.

Procedure

Prior to the experimental session, invited participants were reminded to wear glasses or contact lenses if their vision required correction. Upon arrival for individual testing sessions, participants' visual acuity was measured using the standard Snellen chart located at a distance of 6 m. They then completed a demographic questionnaire, including race/ethnicity classifications, questions concerning previous injuries to fingers, and date of last menstrual period and oral contraceptive use (in women). Handedness was also be assessed by asking participants what hand they predominantly write with. To assess participants' mood prior to the experimental task, they were asked to complete a brief visual analogue scale. They were then seated approximately 22-23 inches from the computer monitor and eye tracker, and their visual responses were calibrated using a 9-point calibration. After calibration, a fixation cross appeared at the center of the screen for 1 s, followed by the practice slide for 60 s. The experimental trials were then begun and participants were instructed to view the slides freely. At the start of the experimental slide show, a fixation cross appeared at the center of the screen for 1 s, followed by the 8 experimental slides, which were displayed for 60 s. To allow for readjustments of the eye tracker and ensure proper data collection, a fixation cross appeared between each slide for 1 s. Following completion of the experimental task, participants completed a second visual analogue scale, the STAI, the BDI, the SDS, the BSRI, and the ANX and ARD scales of the PAI.

Because it is unclear whether anxiety is associated with biases in later stages of information processing, such as memory (Rinck & Becker, 2005), participants also completed a face sorting task assessing their recognition of faces. They were provided a series of 64 face pictures (32 identical to experimental faces and 32 new faces), all displaying friendly expressions. They were instructed to sort these pictures into 6 bins according to the following recognition scale: 1 = "definitely old," 2 = "old," 3 = "maybe old," 4 = "maybe new," 5 = "new," 6 = "definitely new." Finally, experimenters obtained direct measurements of participants' 2nd and 4th fingers from both their left and right hands and made a photocopy of their hands for later coding. After completion of these procedures, participants were fully debriefed and thanked for their participation.

Design

To investigate the time course of attentional biases in eye tracking analyses, the 60-s presentation time for each trial was divided into six intervals of 10 s each. In addition, for a more detailed analysis, the first 3 s of presentation on each trial was divided into six intervals of 500 ms each. For each of these time intervals, the number and duration of fixations for the angry face and for each of the friendly faces in each matrix were measured. Durations of individual fixations for each picture were then summed to obtain a measure of gaze duration, the variable of interest. Number of fixations and gaze durations were included as separate dependent variables in statistical analyses as they typically provide different information about visual attention. Fixations generally provide a measure of visual interest, whereas gaze durations portray the individual's processing effort (Rayner, 1998). Further, to evaluate whether HTA individuals initially orient to angry faces, the very first picture fixation on each trial was analyzed in detail. The percentage of first fixations for angry compared to each of the friendly faces and the mean duration of first fixations across the 8 experimental trials were computed.

RESULTS

Questionnaires

Table 2 lists the within sex means for HTA and LTA groups. Four participants (1.73%) failed to complete all questionnaire measures, so analyses were based on varying sample sizes. The expected sex differences were found on measures of gender-typical traits: the BSRI Masculine (d = .62) and Feminine Scales (d = .80). Women reported more feminine, and less masculine traits than men. The expected sex differences were also found for measures of anxiety: trait anxiety (d = .33) and the PAI ANX Scale (d = .40), ANX-A (d = .49), ANX-C (d = .38), and ARD-P subscales (d = .55). Women reported higher anxiety levels on each of these measures. No significant sex difference was found on state anxiety, BDI-II, the PAI ARD Scale, ARD-O, ARD-T, and ANX-P.

As expected, HTA participants reported higher anxiety levels on all measures of anxiety (d's = .42 - 2.54), as compared to LTA participants. They also reported greater depressive symptoms on the BDI-II (d = 1.42) than the LTA group. In addition, HTA individuals reported less masculine traits on the BSRI (d = .73) and lower social desirability on the Marlowe-Crowne (d = .81) than LTA individuals.

Interactions of sex by anxiety group were also found for scores on the PAI ANX-P subscale and the BSRI Feminine Scale. To explore each interaction, separate ANOVAs were computed for each sex and anxiety group. HTA women reported greater physiological symptoms of anxiety than HTA men, F (1, 119) = 4.76, p < .05, and LTA

Table 2

Mean (SD) Questionnaire Scores for Participant Groups

Measures	Men		Women		Sex Difference?	Anxiety Difference?
	LTA	HTA	LTA	HTA		
STAI – State	28.33 (5.95) N = 51	38.25 (8.82) N = 53	29.76 (7.50) N = 59	41.03 (9.30) N = 66	No	Yes
STAI – Trait	29.45 (4.97) N = 51	46.66 (9.01) N = 53	31.98 (6.20) N = 59	50.91 (7.28) N = 66	Yes	Yes
PAI Anxiety Scale	44.36 (8.44) N = 50	57.76 (11.01) N = 53	46.86 (9.39) N = 59	64.84 (12.83) N = 68	Yes	Yes
ANX-A	43.08 (8.79) N = 50	55.57 (9.87) N = 53	46.52 (8.88) N = 59	63.86 (12.99) N = 68	Yes	Yes
ANX-C	44.14 (7.83) N = 50	56.74 (11.72) N = 53	47.64 (11.44) N = 59	62.12 (11.08) N = 68	Yes	Yes
ANX-P *	48.55 (9.09)[a] N = 50	58.64 (10.46)[b] N = 53	47.42 (9.39)[a] N = 59	63.75 (14.36)[c] N = 68	No	Yes
PAI Anxiety Related Disorders Scale	48.70 (9.93) N = 50	59.21 (13.71) N = 53	49.79 (8.89) N = 59	63.86 (12.51) N = 68	No	Yes
ARD – O	55.06 (12.40) N = 50	56.84 (12.63) N = 53	52.93 (10.42) N = 59	60.25 (10.89) N = 68	No	Yes
ARD – P	43.76 (6.78) N = 50	55.76 (8.83) N = 53	48.42 (8.82) N = 59	62.99 (11.63) N = 68	Yes	Yes
ARD – T	47.58 (7.98) N = 50	57.50 (14.54) N = 53	48.13 (9.13) N = 59	58.02 (14.33) N = 68	No	Yes
BDI-II	5.04 (4.06) N = 51	13.91 (9.68) N = 53	5.56 (4.25) N = 59	16.24 (8.19) N = 66	No	Yes
BSRI Masculine	5.63 (.80) N = 51	4.91 (.63) N = 53	4.99 (.69) N = 59	4.61 (.73) N = 68	Yes	Yes
BSRI Feminine *	4.50 (.67)[a] N = 59	4.63 (.57)[a] N = 66	5.19 (.48)[b] N = 59	4.94 (.67)[c] N = 68	Yes	No
Marlowe-Crowne	16.06 (4.89) N = 51	13.02 (5.57) N = 53	16.88 (4.67) N = 59	12.29 (4.05) N = 68	No	Yes

Note. Scales with * have significant sex by anxiety group interaction, $p < .05$.
For interaction effects, means with the same letter name are not significantly different.

women, F (1, 125) = 55.62, p <.001. In addition, HTA men reported greater physiological symptoms than LTA men, F (1, 101) = 27.14, $p < .001$. On the BSRI, HTA women reported less feminine traits compared to LTA women, F(1, 125) = 5.47, $p < .05$, but more feminine traits compared to HTA men, F (1, 119) = 7.08, $p < .01$. In turn, LTA women reported more feminine traits than LTA men, F(1, 108) = 38.91, $p < .001$, who did not differ from HTA men, F(1, 102) = 1.210, *ns*.

Eye Tracking Analyses for the 60-Second Presentation

A 2 (Sex) x 2 (Anxiety Group) ANOVA was conducted for the average percentage of time tracked on each slide. There were no significant differences between men and women or anxiety groups in percentage of time tracked (LTA men: M = 90.55%, HTA men: M = 92.06%, LTA women: 93.53%, and HTA women = 93.10%). A 2 (Sex) x 2 (Anxiety Group) ANOVA was also conducted for average total number of fixations per slide. A marginal main effect for anxiety group emerged, F(1, 100) = 3.29, $p < .10$., $d = .36$. HTA participants (M = 88.35, SD = 21.30) had a greater number of total fixations across the 8 slides than LTA participants (M = 79.57, SD = 26.71). Marginal effects are reported here and where else they occur because they offer potentially informative data.

To examine the time course of attentional patterns towards threat in high anxious and low anxious men and women, similar analyses were conducted as reported in previous research (Rinck & Becker, 2006). Accordingly, the 60-s slide presentation was divided into 6 equal time intervals (1-10s, 10-20s, 20-30s, 30-40s, 40-50s, and 50-60s). Separate 2 (Sex) x 2 (Anxiety Group) x 4 (Face Type) x 6 (Time Interval) Mixed Design

ANOVAs were conducted for the number of fixations and gaze durations during the 60-s slide presentation. Sex (Men, Women) and anxiety group (HTA, LTA) were between-subjects factors and face type (Friendly Male, Angry Face, Friendly Female, Child) and time interval (1-10s, 10-20s, 20-30s, 30-40s, 40-50s, 50-60s) were within-subjects factors. Due to violations of sphericity, the multivariate approach for Repeated Measures ANOVA was used in these analyses.

Number of Fixations Analyses - Combined Angry Face. Table 3 lists the mean fixations for anxiety groups within each sex. A main effect of interval, $F(5, 96) = 9.05$, $p < .001$, and a marginal main effect of anxiety group, $F(1, 100) = 3.88$, $p < .10$, were found. Bonferroni post-hoc comparisons showed that a significantly greater number of fixations occurred during the 0-10s interval ($M = 3.64$, $SD = 1.06$, $p < .001$) and the 10-20s interval ($M = 3.51$, $SD = 1.07$, $p < .01$) as compared to the 20-30s ($M = 3.24$, $SD = 1.04$) interval, which in turn had significantly more fixations than the 30-40s ($M = 2.92$, $SD = 1.35$, $p = .001$), 40-50s ($M = 2.84$, $SD = 1.28$, $p < .001$) and 50-60s ($M = 2.93$, $SD = .1.34$, $p < .01$) intervals. Number of fixations were highest at the start of the slide presentation and decreased steadily through the 40-50s interval, with a non-significant increase during the 50-60s interval. There was also a tendency ($d = .39$) for HTA participants ($M = 3.37$, $SD = 1.02$) to have a greater number of fixations at each interval than LTA participants ($M = 2.98$, $SD = 1.02$).

In addition, an interaction of sex by anxiety group by interval, $F(5, 96) = 2.37$, $p < .05$, was found. To further explore this interaction, separate ANOVAs were done for each sex. For men, the ANOVA resulted in significant main effects of interval, $F(5, 48)$

Table 3

Mean (SD) Number of Fixations by Face Type, Group, and 10-Second Interval During the 60-Second Presentation

Face Type	1-10 s	10-20 s	20-30 s	30-40 s	40-50 s	50-60 s
Friendly Male						
LTA Men	3.38 (1.42)	3.15 (1.32)	3.13 (1.42)	2.50 (1.69)	2.45 (1.64)	2.63 (1.62)
HTA Men	3.26 (.98)	3.56 (1.33)	3.61 (1.70)	3.14 (1.57)	2.83 (1.24)	3.28 (1.64)
LTA Women	3.06 (1.21)	3.75 (1.68)	2.88 (1.46)	2.68 (1.79)	2.76 (1.76)	2.59 (1.56)
HTA Women	3.55 (1.35)	4.12 (1.75)	3.65 (1.64)	2.94 (1.81)	3.44 (2.04)	3.08 (1.81)
Angry (Male and Female)						
LTA Men	3.50 (1.30)	3.35 (1.59)	3.08 (1.88)	2.36 (1.73)	2.59 (1.86)	2.56 (1.88)
HTA Men	3.78 (1.10)	3.50 (1.26)	2.89 (1.09)	3.24 (1.48)	2.96 (1.25)	3.03 (1.39)
LTA Women	3.46 (1.68)	2.98 (1.37)	3.15 (1.78)	2.76 (1.88)	2.55 (1.75)	2.84 (1.94)
HTA Women	4.31 (1.59)	3.25 (1.65)	3.38 (1.73)	3.07 (2.37)	2.88 (2.36)	2.90 (2.54)
Friendly Female						
LTA Men	3.53 (1.54)	3.20 (1.50)	2.80 (1.20)	2.37 (1.56)	2.24 (1.44)	2.62 (1.80)
HTA Men	3.73 (1.14)	3.63 (1.10)	3.37 (1.01)	3.24 (1.46)	3.06 (1.42)	3.14 (1.48)
LTA Women	3.82 (1.61)	3.22 (1.74)	3.33 (1.82)	3.53 (2.09)	3.17 (1.84)	2.98 (1.74)
HTA Women	4.29 (1.47)	3.48 (1.57)	3.12 (1.52)	3.47 (2.18)	2.86 (1.75)	2.82 (1.80)
Child						
LTA Men	3.32 (1.16)	3.05 (1.38)	3.17 (1.50)	2.70 (1.66)	2.58 (1.53)	2.63 (1.72)
HTA Men	3.92 (1.38)	3.85 (1.42)	3.65 (1.31)	3.25 (1.29)	3.25 (1.34)	3.36 (1.57)
LTA Women	3.38 (1.48)	3.80 (1.93)	3.04 (1.87)	2.74 (1.75)	2.69 (1.73)	2.94 (1.79)
HTA Women	3.84 (1.27)	4.28 (1.61)	3.50 (1.70)	2.62 (1.71)	3.15 (1.82)	3.43 (2.10)

Note. LTA = Low Trait Anxious, HTA = High Trait Anxious.

= 6.49, $p < .001$, and anxiety group, $F(1, 52) = 4.05$, $p < .05$, and the anxiety by interval interaction was marginally significant, $F(5, 48) = 2.18$, $p < .10$. As depicted in Figure 2, HTA men generally had a higher number of fixations across the 6 time intervals than LTA men and both showed decreases in number of fixations from 0-10s to 40-50s. In addition, after examining the differences between anxiety groups at each interval, HTA men had a significantly higher number of fixations on the 30-40s interval than LTA men, $F(1, 52) = 5.27$, $p < .05$. For women, only a main effect of interval was found, $F(5, 44) = 3.60$, $p < .01$. The anxiety group by interval interaction was not significant, $F(5, 44) = .88$, *ns*. As illustrated in Figure 2, HTA and LTA women showed a decline in number of fixations from 0-10s to 30-40s, and then remained fairly constant during the last 20 s.

Results for the number of fixations also produced a marginal interaction of interval by face type, $F(15, 86) = 1.75$, $p < .10$. To further explore this interaction, Repeated Measures ANOVAs were done for each interval, with face type as a within-subjects factor. The 0-10s interval produced a main effect of face type, $F(3, 101) = 5.57$, $p < .001$. Bonferroni post-hoc comparisons showed that number of fixations for the friendly male face ($M = 3.32$, $SD = 1.24$) was significantly lower than number of fixations for the angry face ($M = 3.77$, $SD = 1.45$, $p < .05$) and the friendly female face ($M = 3.84$, $SD = 1.45$, $p < .01$). The remaining intervals did not show any significant differences in number of fixations by face type.

Gaze Duration Analyses – Combined Angry Face. Table 4 lists the mean gaze durations for anxiety groups within each sex. A main effect of interval, $F(5, 96) = 8.49$, $p < .001$, was found. Bonferroni post-hoc comparisons showed that gaze durations (in s)

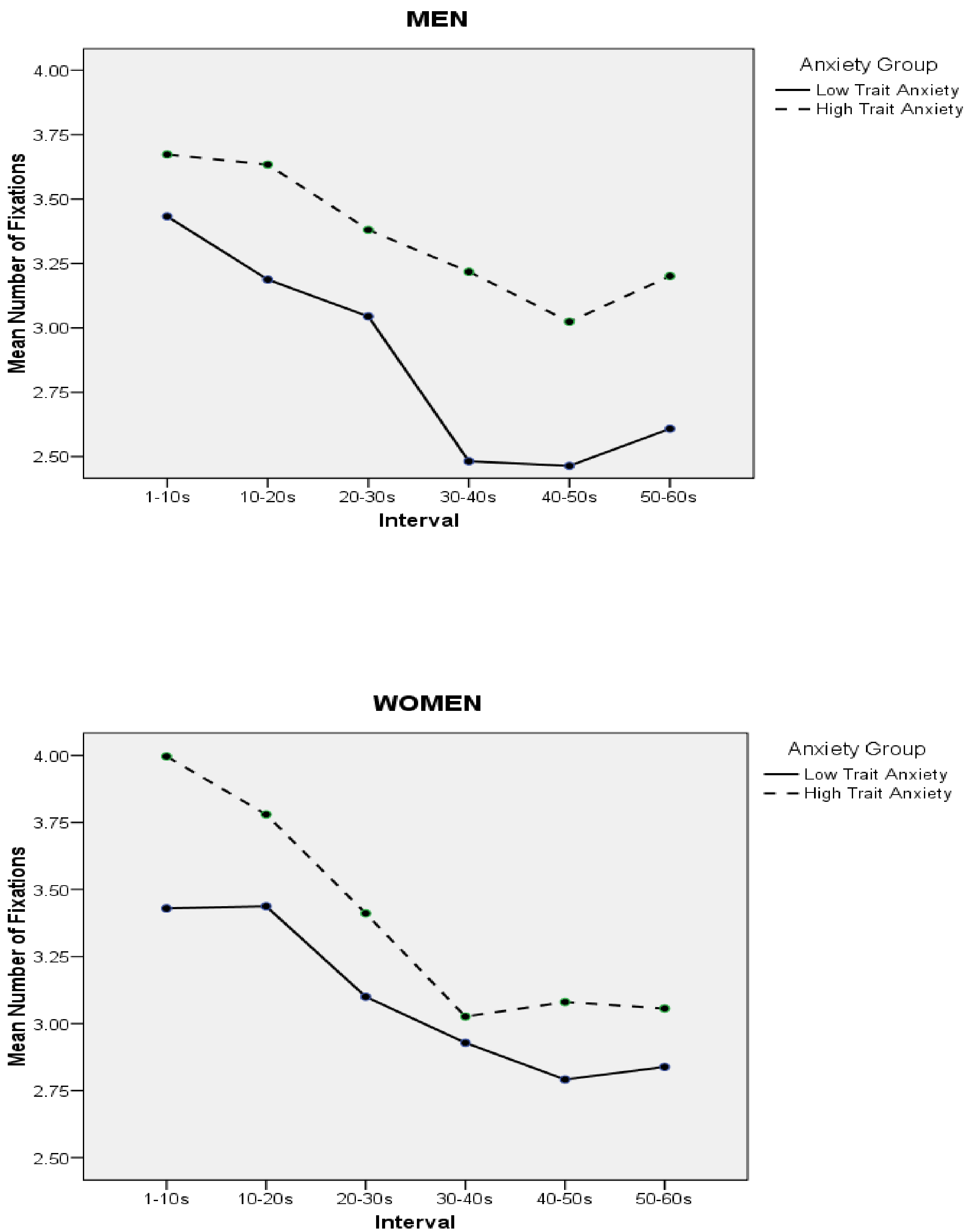


Figure 2. Mean Number of Fixations for LTA and HTA Men and Women During the 60-Second Slide Presentation.

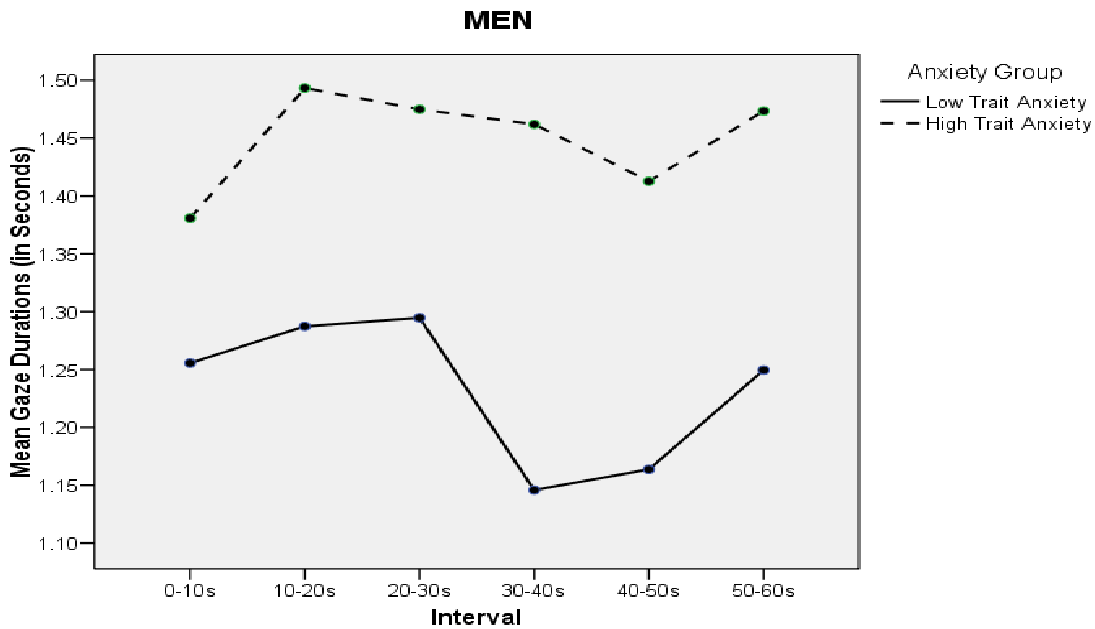
Table 4
Mean (SD) Gaze Durations in Seconds by Face Type, Group, and 10-Second Interval During the 60-Second Presentation

Face Type	1-10 s	10-20 s	20-30 s	30-40 s	40-50 s	50-60 s
Friendly Male						
LTA Men	1.25 (.59)	1.28 (.62)	1.33 (.67)	1.14 (.84)	1.18 (.86)	1.27 (.85)
HTA Men	1.27 (.45)	1.48 (.66)	1.50 (.68)	1.43 (.73)	1.28 (.63)	1.47 (.80)
LTA Women	1.05 (.42)	1.45 (.70)	1.26 (.81)	1.13 (.88)	1.13 (.75)	1.14 (.76)
HTA Women	1.21 (.50)	1.55 (.61)	1.42 (.64)	1.27 (.82)	1.39 (.84)	1.36 (.86)
Angry (Male and Female)						
LTA Men	1.24 (.44)	1.34 (.63)	1.23 (.70)	1.06 (.78)	1.17 (.88)	1.16 (.84)
HTA Men	1.42 (.45)	1.44 (.54)	1.24 (.51)	1.43 (.66)	1.37 (.67)	1.39 (.61)
LTA Women	1.21 (.63)	1.14 (.56)	1.24 (.75)	1.12 (.84)	1.07 (.78)	1.25 (.85)
HTA Women	1.50 (.57)	1.24 (.75)	1.32 (.66)	1.32 (1.14)	1.26 (1.17)	1.26 (1.23)
Friendly Female						
LTA Men	1.29 (.60)	1.25 (.67)	1.24 (.67)	1.04 (.65)	1.10 (.72)	1.33 (.90)
HTA Men	1.40 (.50)	1.48 (.46)	1.52 (.53)	1.59 (.72)	1.45 (.76)	1.48 (.88)
LTA Women	1.34 (.62)	1.26 (.68)	1.34 (.78)	1.40 (.86)	1.33 (.87)	1.31 (.82)
HTA Women	1.47 (.54)	1.30 (.62)	1.28 (.71)	1.38 (.82)	1.18 (.72)	1.15 (.80)
Child						
LTA Men	1.24 (.50)	1.28 (.57)	1.38 (.74)	1.34 (.82)	1.21 (.73)	1.23 (.87)
HTA Men	1.43 (.54)	1.57 (.63)	1.64 (.63)	1.40 (.55)	1.54 (.64)	1.54 (.76)
LTA Women	1.18 (.54)	1.48 (.84)	1.27 (.77)	1.13 (.68)	1.14 (.79)	1.37 (.82)
HTA Women	1.38 (.51)	1.60 (.67)	1.36 (.70)	1.13 (.79)	1.33 (.86)	1.39 (.85)

Note. LTA = Low Trait Anxious, HTA = High Trait Anxious.

were significantly lower during the 0-10s interval (*M* = 1.31, *SD* = .41) than during the 10-20s interval (*M* = 1.39, *SD* = .44, $p < .001$) and were significantly lower during the 40-50s interval (*M* = 1.26, *SD* = .58) than during the 50-60s interval (*M* = 1.32, *SE* = .61, $p = .001$). Gaze durations increased from the first 10 s to the second 10 s and then decreased steadily through the 40-50s interval. During the last 10 s, there was an increase and return to initial gaze durations.

A marginal main effect of anxiety group, $F(1, 100) = 3.06$, $p < .10$, and a marginal interaction of sex by anxiety group by interval were also found, $F(5, 96) = 2.05$, $p < .10$. HTA participants (*M* = 1.39, *SD* = .40) had a tendency (*d* = .35) towards longer gaze durations than LTA participants (*M* = 1.24, *SD* = .51), suggesting that HTA individuals looked longer at the facial stimuli during each of the 6 intervals. To further explore the sex by anxiety group by interval interaction, separate ANOVAs were done for each sex. For men, the ANOVA resulted in a main effect of interval, $F(5, 48) = 5.03$, $p = .001$, and a marginal main effect of anxiety group, $F(1, 52) = 3.66$, $p < .10$. The interval by anxiety group interaction was not significant. As depicted in Figure 3, HTA men exhibited longer gaze durations than LTA men and both showed a similar pattern of gaze durations across the 6 time intervals. For women, the ANOVA showed a main effect of interval, $F(5, 44) = 4.11$, $p < .01$, and a marginal interaction of interval by anxiety group, $F(5, 44) = 2.35$, $p < .10$. As illustrated in Figure 3, HTA women showed a non-significant tendency for longer gaze durations during the 0-10s interval than LTA women, followed by a decrease in gaze durations from 20-40s, and remaining constant thereafter. In contrast, LTA women showed an increase in gaze durations during the 10-



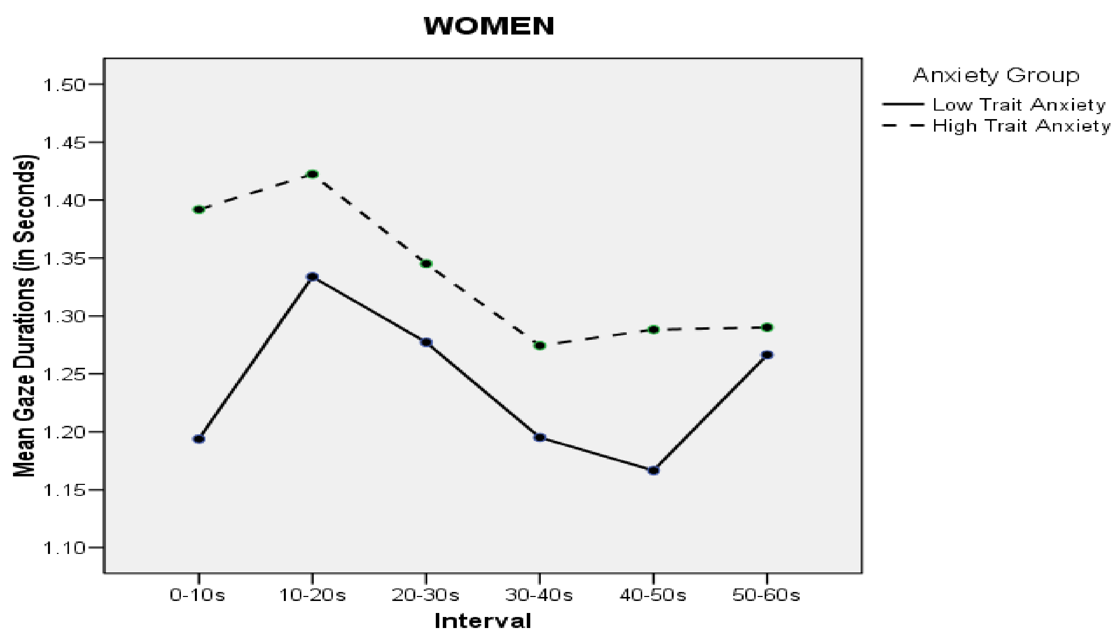


Figure 3. Mean Gaze Durations for LTA and HTA Men and Women During the 60-Second Slide Presentation.

20s interval, followed by a gradual decrease from 20-50s and an increase in the last 10 s.

Number of Fixations Analyses - Angry Male and Angry Female Faces. Analyses for the combined angry face reported above were based on the average of the 4 angry male faces and the 4 angry female faces. To determine whether sex of angry face influenced participants' attentional patterns towards threat, additional 2 (Sex) x 2 (Anxiety Group) x 5 (Face Type) x 6 (Interval) Mixed Design ANOVAs were done for the number of fixations and gaze durations.

For the number of fixations analyses, similar results were obtained as those reported above for the combined angry face. Table 5 lists the mean number of fixations for the angry male and angry female faces. The only additional findings beyond results obtained for the combined angry face were a main effect of face type, $F(4, 97) = 8.61$, $p < .001$, and the statistical significance of the interval by face type interaction, $F(20, 81) = 1.72$, $p < .05$. Bonferroni pairwise comparisons for face type revealed that participants' number of fixations for the angry male face ($M = 2.82$, $SD = 1.31$) was significantly lower compared to the friendly female ($M = 3.21$, $SD = 1.14$, $p < .05$) and child ($M = 3.26$, $SD = 1.15$, $p < .01$) faces, but did not differ from the friendly male face ($M = 3.15$, $SD = 1.15$, *ns*). In contrast, number of fixations for the angry female face ($M = 3.39$, $SD = 1.48$) did not differ from any of the friendly faces. Overall, participants appeared to attend less to male faces across the 6 intervals, particularly the angry male.

In addition, to further investigate the interval by face type interaction, Repeated Measures ANOVAs were done for each interval, with face type as a within-subjects factor. A main effect for face type was found for the 0-10s interval, $F(4, 100) = 8.16$,

Table 5

Mean (SD) Number of Fixations for Angry Male and Angry Female Faces During the 60-Second Presentation

Face Type	1-10 s	10-20 s	20-30 s	30-40 s	40-50 s	50-60 s
Angry Male						
LTA Men	3.28 (1.49)	3.30 (1.73)	2.95 (2.12)	2.37 (1.63)	2.19 (1.77)	2.12 (1.59)
HTA Men	3.36 (1.45)	2.95 (1.81)	2.64 (1.37)	3.00 (2.24)	2.34 (.99)	2.50 (1.65)
LTA Women	2.97 (1.88)	3.04 (1.71)	3.08 (2.60)	2.60 (1.95)	2.13 (1.82)	2.81 (2.25)
HTA Women	4.08 (1.66)	2.55 (1.68)	3.37 (2.23)	3.18 (2.48)	2.48 (2.59)	2.38 (2.83)
Angry Female						
LTA Men	3.72 (1.53)	3.40 (1.99)	3.20 (2.43)	2.36 (2.44)	2.98 (2.41)	3.00 (2.68)
HTA Men	4.21 (1.35)	4.04 (1.64)	3.14 (1.42)	3.47 (1.91)	3.57 (2.02)	3.56 (1.69)
LTA Women	3.96 (1.97)	2.93 (1.78)	3.22 (1.97)	2.92 (2.30)	2.97 (2.24)	2.88 (2.34)
HTA Women	4.55 (1.91)	3.95 (2.22)	3.38 (2.08)	2.96 (2.73)	3.27 (2.59)	3.42 (2.79)

Note. LTA = Low Trait Anxious, HTA = High Trait Anxious.

$p < .001$, the 10-20s interval, $F(4, 100) = 4.49$, $p < .01$, the 40-50s interval, $F(4, 100) = 5.76$, $p < .001$, and the 50-60s interval, $F(4, 100) = 3.60$, $p < .01$. These results are illustrated in Figure 4. Bonferroni post-hoc comparisons for the 0-10s interval revealed that fixations for the angry female face ($M = 4.11$, $SD = 1.70$) were significantly higher than fixations for the child ($M = 3.62$, $SD = 1.33$, $p < .05$) and friendly male faces ($M = 3.32$, $SD = 1.24$, $p < .001$), but did not differ from the friendly female face ($M = 3.84$, $SE = 1.45$, *ns*). In contrast, fixations for the angry male ($M = 3.43$, $SD = 1.65$) were not significantly different from any of the friendly faces. For the 10-20s interval, the angry female ($M = 3.60$, $SD = 1.94$) did not differ from any of the friendly faces. On the other hand, the angry male face ($M = 2.96$, $SD = 1.73$) had significantly less fixations than the friendly male ($M = 3.64$, $SD = 1.54$, $p < .05$) and child ($M = 3.75$, $SD = 1.63$, $p < .01$) faces, but did not differ from the friendly female face (M = 3.39, SD = 1.47, *ns*). For the 40-50s interval, number of fixations for the angry female ($M = 3.21$, $SD = 2.30$) once again did not differ from any of the friendly faces. In comparison, the angry male ($M = 2.29$, $SD = 1.85$) continued to obtain less fixations than the child ($M = 2.93$, $SD = 1.61$, $p < .05$), but no longer differed from the friendly male face ($M = 2.87$, $SD = 1.70$, *ns*). Finally, for the 50-60s interval, fixations for the angry female ($M = 3.23$, $SE = 2.38$) were significantly higher than for the angry male ($M = 2.44$, $SD = 2.11$), but neither differed from the friendly faces.

To summarize, there appeared to be differing patterns of attention towards the angry female and the angry male over the 60-s time course. Fixations for the angry female were highest, relative to the friendly male and child faces, during the first 10 s of

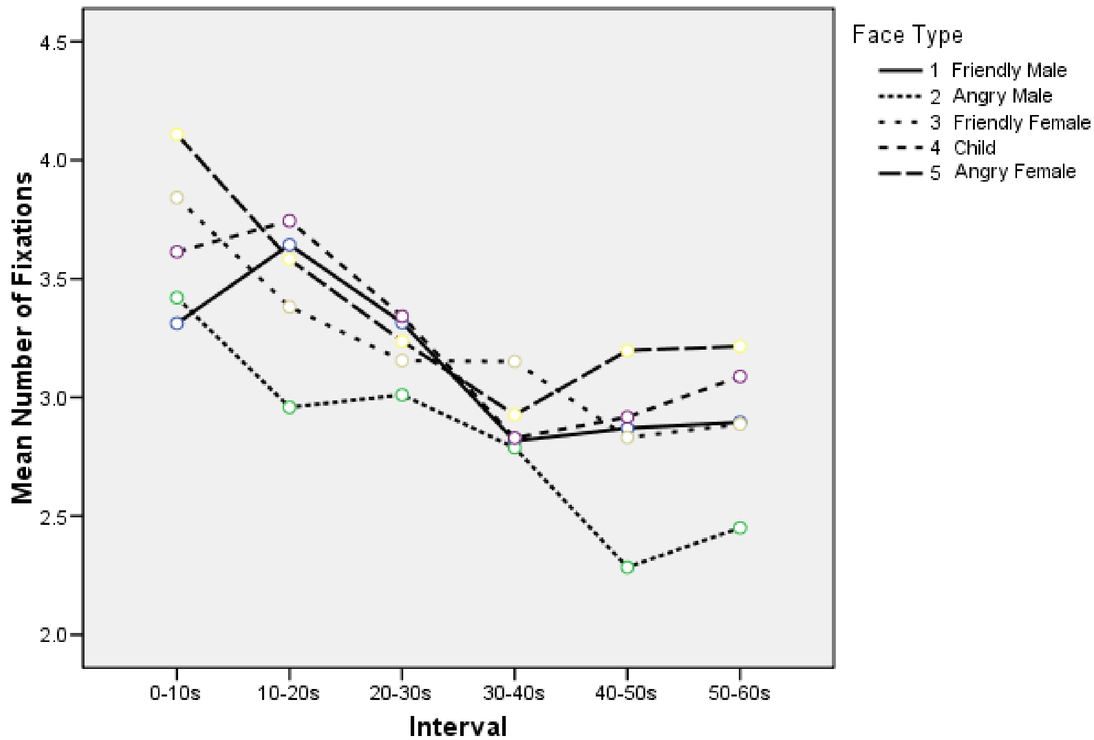


Figure 4. Mean Number of Fixations by Interval and Face Type (Angry Male and Angry Female) During the 60-Second Presentation.

slide presentation, suggesting heightened attention for the angry female early on. However, fixations for the angry female then decreased in manner similar to the other faces, with no significant differences over the remaining intervals. Fixations for the angry male were, in turn, generally lower than fixations for the friendly faces throughout the 60-s presentation and reached statistical significance during the 10-20s and 40-50s interval. This suggests that, to an extent, participants were avoiding the angry male face throughout.

Gaze Duration Analyses – Angry Male and Angry Female Faces. Similar results were obtained as reported previously for the combined angry face analyses. Table 6 lists the within sex means for gaze durations by anxiety group. The only additional findings beyond results for the combined angry face included a main effect of face type, $F(4, 97) = 9.87$, $p < .001$, and a marginal interaction of interval by face type, $F(20, 81) = 1.63$, $p < .10$. Bonferroni pairwise comparisons revealed shorter gaze durations for the angry male face ($M = 1.14$, $SD = .55$), as compared to all the friendly faces ($M = 1.31$, $SD = .53$; $M = 1.33$, $SD = .52$; and $M = 1.36$, $SD = .51$; all p's $< .05$), suggesting that participants spent less time looking at the angry male face than other faces across the 6 time intervals. In comparison, gaze durations for the angry female ($M = 1.41$, $SD = .69$) did not differ from any of the friendly faces.

Post-hoc analyses of the interval by face type interaction resulted in a main effect for face type during the 0-10s, $F(4, 100) = 7.37$, $p < .001$, 10-20s, $F(4, 100) = 5.02$, $p = .001$, 40-50s, $F(4, 100) = 5.99$, $p < .001$, and 50-60s intervals, $F(4, 100) = 6.16$, $p < .001$. These results are illustrated in Figure 5. Bonferroni comparisons for the 0-10s interval

Table 6

Mean (SD) Gaze Durations for Angry Male and Angry Female Faces During the 60-Second Presentation

Face Type	1-10 s	10-20 s	20-30 s	30-40 s	40-50 s	50-60 s
Angry Male						
LTA Men	1.13 (.49)	1.27 (.67)	1.19 (.83)	1.12 (.78)	1.01 (.81)	.97 (.72)
HTA Men	1.25 (.59)	1.21 (.68)	1.10 (.65)	1.27 (.85)	1.12 (.56)	1.09 (.73)
LTA Women	1.03 (.70)	1.18 (.64)	1.17 (.96)	1.03 (.82)	.91 (.78)	1.16 (.90)
HTA Women	1.43 (.64)	.99 (.69)	1.33 (.93)	1.38 (1.18)	.99 (1.19)	.93 (1.18)
Angry Female						
LTA Men	1.35 (.56)	1.42 (.84)	1.27 (.96)	1.00 (.95)	1.33 (1.15)	1.35 (1.20)
HTA Men	1.60 (.61)	1.67 (.73)	1.39 (.79)	1.58 (.92)	1.63 (1.01)	1.70 (.83)
LTA Women	1.38 (.78)	1.10 (.78)	1.31 (.93)	1.21 (1.07)	1.23 (.96)	1.33 (1.10)
HTA Women	1.58 (.68)	1.50 (.97)	1.32 (.77)	1.27 (1.31)	1.53 (1.37)	1.59 (1.49)

Note. LTA = Low Trait Anxious, HTA = High Trait Anxious.

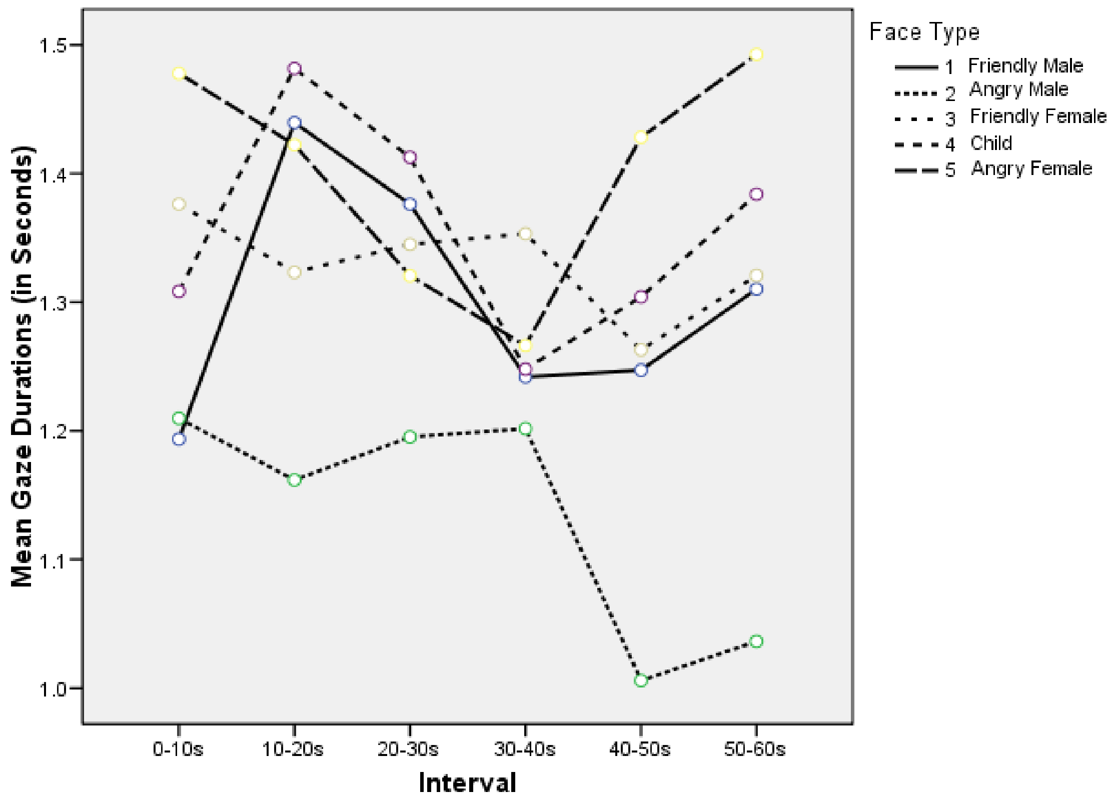


Figure 5. Mean Gaze Durations by Interval and Face Type (Angry Male and AngryFemale) During the 60-Second Presentation.

showed that gaze durations were significantly longer for the angry female face (M = 1.48, SD = .66) than the friendly male (M = 1.20, SD = .50, p < .001), but did not differ significantly from the child (M = 1.31, SD = .52, *ns*) or friendly female faces (M = 1.38, SD = .56, *ns*). Gaze durations for the angry male (M = 1.21, SD = .61) were not significantly different from any of the friendly faces. During the 10-20s interval, gaze durations for the angry female (M = 1.43, SD = .85) no longer differed from friendly faces. Instead, gaze durations were significantly shorter for the angry male (M = 1.16, SD = .67) than the friendly male (M = 1.44, SD = .64, p < .01) and child faces (M = 1.48, SD = .68, p < .01), but did not differ from the friendly female (M = 1.33, SD = .61, *ns*). For the 40-50s interval, gaze durations for the angry female (M = 1.44, SD = 1.13, p < .001) continued to show no differences from the friendly faces. In comparison, the angry male (M = 1.01, SD = .85) had significantly shorter gaze durations than the child face (M = 1.31, SD = .76, p < .05), but did not differ from the friendly male (M = 1.25, SD = .77, *ns*) or female faces (M = 1.27, SD = .77, *ns*). Lastly, for the 50-60s interval, no differences were again found between the angry female (M = 1.50, SD = 1.17) and the friendly faces. However, gaze durations continued to be significantly shorter for the angry male (M = 1.04, SD = .89) compared to the child (M = 1.39, SD = .82, p < .05) and did not differ from the friendly male (M = 1.32, SD = .81, *ns*) or female faces (M = 1.32, SD = .85, *ns*).

Overall, participants' pattern of gaze durations for the angry female and the angry male appeared to differ across the 60-s presentation, paralleling results for the number of fixations. For the angry female, participants appeared to look at it longer during the first 10 s of the presentation, compared to the friendly male, after which participants looked at this face for a similar amount of time as other faces. This suggests that some selective attention for the angry female face occurred at the beginning of the slide presentation and then dissipated over the remaining 50 s. In contrast, gaze durations were relatively low for the angry male throughout the 6 time intervals, but particularly so during the 10-20s, 40-50s, and 50-60s intervals, as compared to the friendly child. This suggests that participants had a general tendency to avoid the angry male throughout the 60-s presentation.

Summary of Results for 60-Second Presentation. Over the course of 60 s, participants exhibited differing overall patterns of fixations and gaze durations. While fixations were highest during the first 10 s and decreased gradually, gaze durations were the longest during the 10-20s interval, followed by a decrease in gaze durations until the 40-50s interval and an increase during the last 10 s. In general, HTA participants exhibited a near significant tendency to fixate more often and for longer durations then LTA participants per time interval. However, this trend appeared qualified by the participant's sex and the specific time interval. HTA men generally showed more fixations for the faces than LTA men, particularly during the 30-40s interval, but exhibited a similar decreasing pattern of fixations. HTA men also gazed longer at the faces across the 6 intervals than LTA men. In contrast, HTA and LTA women had similar decreasing patterns of fixations, while their patterns of gaze durations were more divergent. HTA women looked longer at faces during the first 20 s while LTA women looked longer at faces during the 10-20s and 50-60s intervals.

Results of the combined angry face analyses further showed that people were least likely to look at the friendly male face than the angry and friendly female faces during the initial 10 s of slide presentation, with no differences in number of fixations for each of the faces for the remaining intervals. However, when the angry male and female face were analyzed separately, it was found that participants fixated most often and for a longer period of time on the angry female during the first 10 s, while they showed a tendency to avoid the angry male face during the majority of the 60 s presentation.

Eye Tracking Analyses During First 3 Seconds of Presentation

Consistent with procedures by Rinck and Becker (2006), the early attentional bias towards threat was examined by dividing the first 3 s of the slide presentation into 6 intervals (0-500ms, 500-1000ms, 1000-1500ms, 1500-2000ms, 2000-2500ms, and 2500-3000ms). The same Mixed Design ANOVAs used for the entire 60-s presentation were then applied for the dependent variables: number of fixations and gaze durations.

Number of Fixations Analyses - Combined Angry Face. Table 7 lists the mean number of fixations for the within sex anxiety groups. An interval main effect, $F(5, 96) = 52.19$, $p < .001$, and a face type main effect, $F(3, 98) = 6.07$, $p = .001$, were found. Bonferroni post-hoc comparisons showed that participants' fixations during the 0-500ms interval ($M = .06$, $SD = .05$) were much lower than the number of fixations for the five subsequent intervals ($M = .17$, $SD = .09$; $M = .18$, $SD = .08$; $M = .19$, $SD = .07$; $M = .19$, $SD = .08$; and $M = .19$, $SD = .08$; all p's $< .001$), suggesting that participants did not have time to fixate during the first 500ms, or that if they did fixate, they fixated in areas

Table 7
Mean (SD) Number of Fixations by Face Type, Group, and 500 Millisecond Interval During the First 3 Seconds of Presentation

Face Type	0-500 ms	500-1000 ms	1000-1500 ms	1500-2000 ms	2000-2500 ms	2500-3000 ms
Friendly Male						
LTA Men	.067 (.081)	.14 (.11)	.16 (.16)	.14 (.14)	.18 (.17)	.13 (.15)
HTA Men	.054 (.093)	.12 (.10)	.16 (.14)	.13 (.15)	.16 (.17)	.20 (.19)
LTA Women	.031 (.055)	.17 (.13)	.14 (.15)	.15 (.11)	.20 (.18)	.17 (.17)
HTA Women	.058 (.081)	.14 (.13)	.21 (.15)	.17 (.15)	.19 (.19)	.20 (.14)
Angry (Male and Female)						
LTA Men	.043 (.093)	.20 (.13)	.24 (.20)	.21 (.14)	.18 (.16)	.20 (.15)
HTA Men	.063 (.093)	.17 (.13)	.18 (.12)	.16 (.12)	.20 (.15)	.21 (.15)
LTA Women	.078 (.089)	.24 (.16)	.22 (.14)	.17 (.15)	.16 (.16)	.14 (.16)
HTA Women	.087 (.092)	.27 (.16)	.28 (.22)	.24 (.24)	.21 (.17)	.25 (.18)
Friendly Female						
LTA Men	.067 (.095)	.15 (.12)	.16 (.15)	.14 (.14)	.17 (.15)	.19 (.16)
HTA Men	.063 (.080)	.16 (.13)	.17 (.15)	.19 (.16)	.19 (.23)	.20 (.17)
LTA Women	.073 (.082)	.13 (.14)	.16 (.18)	.19 (.17)	.19 (.16)	.19 (.21)
HTA Women	.063 (.073)	.17 (.15)	.16 (.13)	.22 (.17)	.26 (.16)	.24 (.17)
Child						
LTA Men	.077 (.133)	.14 (.14)	.19 (.15)	.19 (.16)	.16 (.14)	.17 (.15)
HTA Men	.054 (.079)	.17(.13)	.18 (.12)	.27 (.18)	.22 (.15)	.19 (.16)
LTA Women	.057 (.090)	.18 (.18)	.17 (.14)	.23 (.15)	.19 (.17)	.18 (.14)
HTA Women	.058 (.088)	.20 (.17)	.17 (.19)	.24 (.17)	.16 (.17)	.19 (.21)

Note. LTA = Low Trait Anxious, HTA = High Trait Anxious.

outside of the face look zones. Post-hoc comparisons for the face type main effect further showed that participants had significantly less fixations for the friendly male face (M = .14, SD = .07), as compared to the angry face (M = .18, SD = .09, p < .01) and the child face (M =.17, SD = .08, p < .05). Although the angry face obtained the highest mean number of fixations during the first three seconds of presentation, this did not differ significantly from the child or friendly female faces.

The number of fixations analyses also resulted in an interval by face type interaction, $F(15, 86) = 2.41$, $p < .01$. To explore the nature of this interaction, separate Repeated Measures ANOVAs were done at each level of time interval, with face type as a within-subjects factor. A main effect of face type was found for the 500-1000ms, F (3,101) = 8.32, p < .001, 1000-1500ms, $F(3, 101) = 3.18$, p < .05, and 1500-2000ms $F(3, 101) = 5.53$, p = .001, intervals. These results are illustrated in Figure 6. Bonferroni comparisons for the 500-1000ms interval showed that number of fixations for the angry face (M = .22, SD = .15) were significantly higher than fixations for the friendly male (M = .14, SD = .12, p < .001) and the friendly female (M = .15, SD = .13, p < .01). For the 1000-1500ms interval, fixations continued to be significantly higher for the angry face (M = .23, SD = .18) than the friendly male (M = .17, SD = .15, p < .05) and friendly female (M = .16, SD = .15, p < .05). In contrast, for the 1500-2000ms interval, no difference was found for the angry face and the other faces. However, fixations were highest for the child face (M = .23, SD = .16), which were significantly greater than fixations for the friendly male face (M = .15, SD = .14, p = .001).

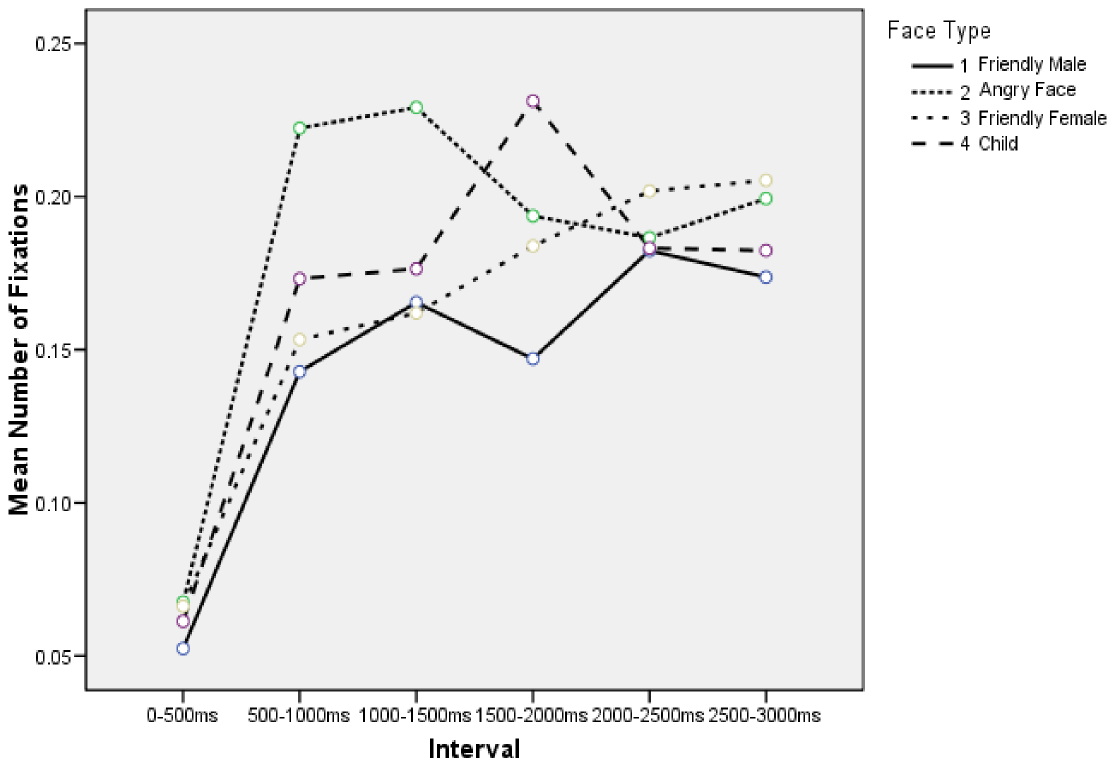


Figure 6. Mean Number of Fixations by Interval and Face Type for the First 3 Seconds of Presentation.

To summarize, number of fixations were equally low for all faces during the 0-500ms interval and then increased significantly during the 500-1000ms interval. Contrary to expectations, all participants, regardless of sex or anxiety level, exhibited increased vigilance towards the angry face from 500ms-1500ms. Then, participants' attention decreased for the angry face, and they fixated most often on the child face during the 1500-2000ms interval. Participants displayed equal attention for all face types during the last 1000ms.

Gaze Duration Analyses – Combined Angry Face. Similar results were obtained for the analyses of gaze durations. Table 8 lists mean gaze durations for the within sex anxiety groups. Main effects of interval, $F(5, 96) = 78.34$, $p < .001$, face type, $F(3, 98) = 5.02$, $p < .01$, and a marginal main effect of anxiety group, $F(1,100) = 2.84$, $p < .10$, were found. As with number of fixations, gaze durations (in ms) were significantly lower for the 0-500ms ($M = 16.20$, $SD = 14.94$, $p < .001$) and the 500-1000ms ($M = 52.20$, $SD = 27.02$, $p < .05$) intervals compared to the remaining intervals ($M = 62.60$, $SD = 31.38$; $M = 66.50$, $SD = 28.73$, $M = 66.80$, $SD = 28.22$, $M = 69.80$, $SD = 31.69$). This again suggests that participants did not have appropriate time to fixate on the screen, were scanning without fixating, or if they did fixate, they were looking at areas outside of the faces look zones. Moreover, Bonferroni post-hoc comparisons showed that gaze durations were shortest for the friendly male face ($M = 49.60$, $SD = 26.97$), and this differed significantly from gaze durations for the angry face ($M = 62.00$, $SD = 31.04$, $p < .01$). Although the angry face had the highest gaze durations, it did not differ significantly from the child and friendly female faces. There was also a non-significant

Table 8

Mean (SD) Gaze Durations in Milliseconds by Face Type, Group, and 500 Millisecond Interval During the First 3 Seconds of Presentation

Face Type	0-500 ms	500-1000 ms	1000-1500 ms	1500-2000 ms	2000-2500 ms	2500-3000 ms
Friendly Male						
LTA Men	17.10 (21.49)	42.00 (33.46)	54.60 (50.64)	51.50 (50.79)	62.40 (56.59)	56.50 (76.04)
HTA Men	13.50 (22.33)	35.60 (38.25)	54.60 (54.68)	50.90 (55.20)	55.50 (58.31)	83.10 (80.08)
LTA Women	9.00 (17.04)	47.70 (35.02)	41.00 (48.16)	51.90 (46.93)	73.00 (78.16)	56.90 (52.57)
HTA Women	14.50 (20.48)	43.60 (39.03)	80.80 (76.67)	53.60 (46.83)	71.60 (73.92)	67.70 (48.58)
Angry (Male and Female)						
LTA Men	10.90 (22.45)	66.80 (45.05)	75.50 (70.77)	70.80 (54.91)	69.10 (59.49)	75.60 (58.72)
HTA Men	16.40 (24.29)	55.20 (43.90)	66.60 (51.38)	58.00 (47.96)	73.80 (59.31)	82.70 (73.38)
LTA Women	21.10 (26.22)	70.20 (50.19)	71.90 (51.55)	61.70 (58.26)	50.90 (46.32)	52.90 (57.27)
HTA Women	23.00 (28.03)	79.70 (42.74)	100.70 (72.48)	78.50 (71.77)	65.90 (54.37)	89.50 (68.34)
Friendly Female						
LTA Men	18.30 (26.05)	48.60 (37.48)	58.30 (53.52)	55.10 (61.84)	58.80 (54.45)	63.40 (56.59)
HTA Men	15.10 (19.04)	45.10 (41.56)	58.30 (53.23)	72.30 (64.61)	71.50 (86.77)	68.30 (53.85)
LTA Women	18.20 (20.36)	38.10 (40.85)	48.80 (57.70)	60.00 (56.69)	63.40 (57.52)	67.20 (85.50)
HTA Women	15.80 (19.12)	53.40 (50.33)	54.90 (46.70)	75.50 (66.10)	84.20 (53.11)	79.50 (62.75)
Child						
LTA Men	21.80 (38.26)	43.80 (45.30)	63.40 (52.06)	69.90 (59.68)	72.70 (72.37)	63.50 (55.23)
HTA Men	14.20 (21.38)	56.00 (43.74)	56.30 (40.33)	99.70 (72.39)	77.30 (52.61)	67.70 (58.56)
LTA Women	14.90 (25.13)	51.10 (50.87)	54.40 (49.67)	76.10 (52.22)	59.90 (54.90)	63.20 (51.54)
HTA Women	15.40 (26.26)	59.90 (54.68)	60.70 (67.71)	76.40 (53.80)	56.40 (60.03)	74.30 (81.58)

Note. LTA = Low Trait Anxious, HTA = High Trait Anxious.

tendency (d = .32) for HTA participants (M = 58.70, SD = 18.06) to have longer gaze durations across the first 3 seconds of presentation than LTA participants (M = 52.40, SD = 20.70).

Similar to fixations analyses, an interaction of interval by face type, $F(15, 86) = 2.46$, $p < .01$, was also found. The same procedure for post-hoc analyses was followed, leading to a main effect of face type for the 500-1000ms, $F(3, 101) = 9.23$, $p < .001$, 1000-1500ms, $F(3, 101) = 2.84$, $p < .05$, and 1500-2000ms, F(3, 101) = 5.58, $p = .001$, intervals. Bonferroni comparisons revealed that gaze durations for the angry face (M = 67.70, SD = 45.65) were significantly longer than gaze durations for the friendly male (M = 42.00, SD = 36.31, $p < .001$) and friendly female faces (M = 46.40, SD = 42.56, $p < .01$) during the 500-1000ms interval. The same pattern continued into the 1000-1500ms interval, though the difference between the angry and friendly faces was no longer significant. Finally, during the 1500-2000ms interval, gaze durations did not differ for the angry face and other faces but were significantly longer for the child face (M = 81.00, SD = 60.72) as compared to the friendly male (M = 51.90, SD = 49.37, $p = .001$).

Overall, gaze durations were equally low for all face types during the first 500ms of slide presentation but then increased for all faces. Not only did participants look more often at the angry face during the 500-1000ms and the 1000-1500ms interval but they also spent more time looking at the angry face during these periods. However, this bias towards the angry face decreased at the 1500-2000ms interval and participants spent more time looking at the child face instead. No difference was found in attention towards the angry face versus other faces during the last 1000ms.

Number of Fixations Analyses - Angry Male and Angry Female Faces. Mixed Design ANOVAs were also done to examine whether early attentional patterns differed by sex of angry face. For the number of fixations analyses, the same pattern of results were obtained as reported for the analyses of the combined angry face. Table 9 lists the mean number of fixations for angry male and angry female faces by HTA and LTA participants, within each sex. There was an interval main effect, $F(5, 96) = 50.02$, $p < .001$, a face type main effect, $F(4, 97) = 6.56$, $p < .001$, and an interval by face type interaction, $F(20, 81) = 1.87$, $p < .05$. Differences in interval were the same as those reported above. However, for face type differences, Bonferroni comparisons showed that it was the angry female face ($M = .20$, $SD = .10$) that obtained the highest number of fixations across the first three seconds of presentation, differing significantly from the friendly male face ($M = .14$, $SD = .07$, $p < .001$) but not from the friendly female ($M = .16$, $SD = .08$, *ns*) or child faces ($M = .17$, SD = .08, *ns*). Fixations for the angry male were not significantly different than friendly faces overall. Thus, it appears that participants had some enhanced attention for the angry female face during the first 3 seconds of presentation, which did not occur for the angry male face.

Post-hoc analyses for the interval by face type interaction further showed a main effect of face type for the 500-1000ms, $F(4, 100) = 7.20$, $p < .001$, and the 1500-2000ms, $F(4, 100) = 4.32$, $p < .01$, intervals and a marginal main effect for the 1000-1500ms interval, $F(4, 100) = 2.43$, $p < .10$. These results are illustrated in Figure 7. Bonferroni comparisons showed that it was the angry female face ($M = .26$, $SD = .21$) that obtained the highest number of fixations during the 500-1000ms interval and

Table 9

Mean (SD) Number of Fixations for Angry Male and Angry Female Faces During the First 3 Seconds of Presentation

Face Type	0-500 ms	500-1000 ms	1000-1500 ms	1500-2000 ms	2000-2500 ms	2500-3000 ms
Angry Male						
LTA Men	.05 (.14)	.16 (.16)	.23 (.29)	.16 (.21)	.18 (.19)	.18 (.24)
HTA Men	.04 (.09)	.12 (.13)	.17 (.17)	.11 (.16)	.17 (.17)	.28 (.26)
LTA Women	.05 (.10)	.24 (.20)	.21 (.23)	.16 (.18)	.13 (.22)	.09 (.21)
HTA Women	.05 (.10)	.22 (.16)	.32 (.30)	.26 (.34)	.22 (.27)	.25 (.25)
Angry Female						
LTA Men	.04 (.09)	.24 (.21)	.24 (.23)	.25 (.21)	.17 (.20)	.22 (.22)
HTA Men	.09 (.12)	.23 (.19)	.19 (.20)	.21 (.20)	.23 (.27)	.14 (.20)
LTA Women	.10 (.16)	.24 (.24)	.23 (.19)	.19 (.22)	.19 (.21)	.19 (.20)
HTA Women	.13 (.15)	.33 (.22)	.25 (.20)	.21 (.23)	.20 (.22)	.24 (.25)

Note. LTA = Low Trait Anxious, HTA = High Trait Anxious.

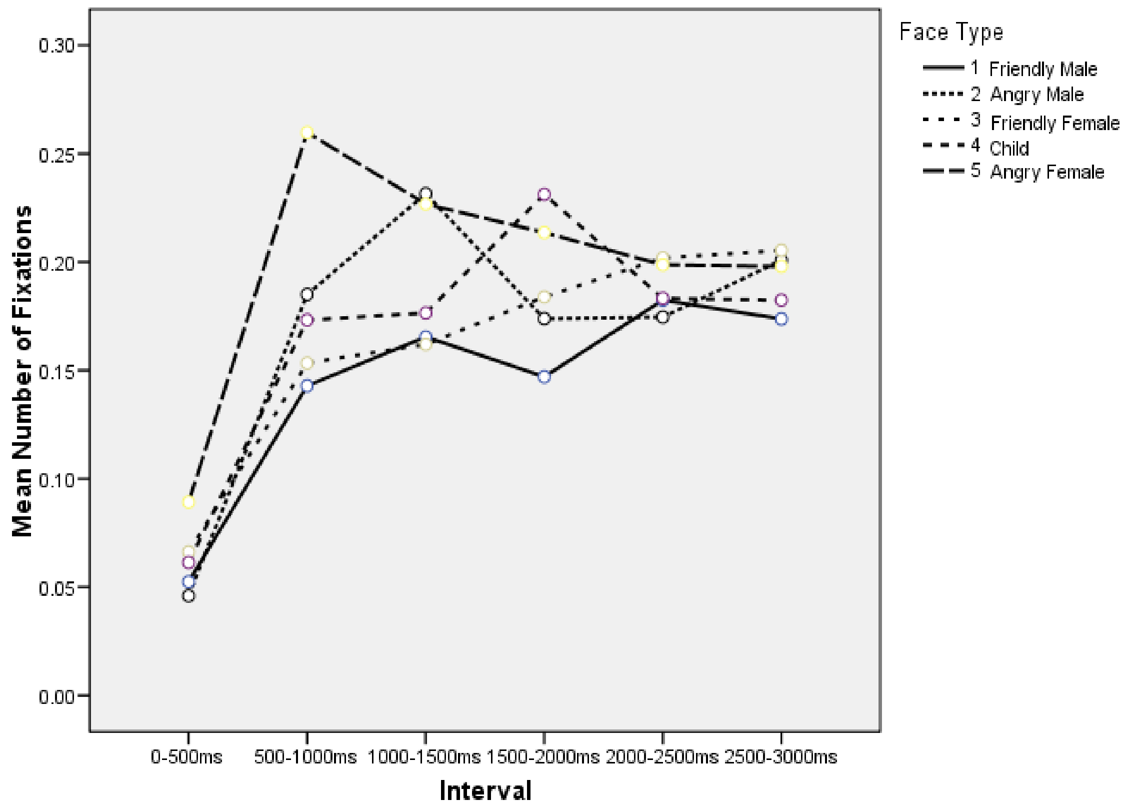


Figure 7. Mean Number of Fixations by Interval and Face Type (Angry Male and Angry Female) for the First 3 Seconds of Presentation.

differed from all friendly faces (*M* = .14, *SD* = .12; *M* = .15, *SD* = .13; *M* = .17, *SD* = .16, all *p*'s < .05). In comparison, fixations for the angry male face (*M* =.18, *SD* = .17) did not differ significantly from any of the friendly faces. By the 1000-1500ms interval, fixations for the angry female decreased and fixations for the angry male increased, such that no differences were found between them and friendly faces. Finally, during the 1500-2000ms interval, participants exhibited the greatest number of fixations for the child face (*M* = .23, *SD* = .16), which differed significantly from the friendly male face (*M* = .15, *SD* = .14, *p* = .001) but not from the angry male (*M* = .17, *SD* = .24), angry female (*M* = .21, *SD* = .22), and friendly female faces (*M* = .18, *SD* = .16).

To summarize, number of fixations were low for all faces during the first 500ms and then increased starting at the 500-1000ms interval. There appeared to be an early vigilance for angry faces, relative to friendly faces, which was most notable for the angry female during the 500-1000ms interval. This was followed by a marginal vigilance towards both the angry male and angry female during the 1000-1500ms interval, which dissipated after this time. Instead, participants fixated more often on the child face, relative to the friendly male, during the 1500-2000ms interval, and no differences were found for all faces during the last 1000ms.

Gaze Duration Analyses – Angry Male and Angry Female Faces. Results for the analyses of gaze durations (in ms) examining angry male and female faces separately parallel those for the combined angry face analyses. Table 10 lists the within sex anxiety group means for gaze durations for the angry male and angry female faces. As reported previously, main effects of interval, $F(5, 96) = 77.23$, $p < .001$, and face type,

Table 10

Mean (SD) Gaze Durations in Milliseconds for Angry Male and Angry Female Faces During the First 3 Seconds of Presentation

Face Type	0-500 ms	500-1000 ms	1000-1500 ms	1500-2000 ms	2000-2500 ms	2500-3000 ms
Angry Male						
LTA Men	13.10 (37.39)	50.50 (53.35)	80.40 (98.74)	50.60 (78.59)	71.40 (76.36)	55.50 (74.36)
HTA Men	9.20 (23.27)	38.30 (44.29)	67.80 (84.84)	43.20 (61.93)	68.40 (86.50)	102.90 (106.79)
LTA Women	12.50 (25.10)	66.60 (62.35)	62.10 (71.83)	56.00 (66.81)	39.40 (71.71)	27.20 (57.74)
HTA Women	14.80 (32.81)	64.30 (49.75)	105.80 (97.90)	79.60 (95.61)	65.20 (77.36)	96.60 (94.16)
Angry Female						
LTA Men	8.70 (20.91)	83.20 (74.68)	70.50 (69.57)	91.00 (77.55)	66.80 (72.74)	95.70 (100.61)
HTA Men	23.70 (33.68)	72.20 (59.42)	65.50 (74.65)	72.90 (82.44)	79.20 (81.63)	62.40 (115.91)
LTA Women	29.70 (48.9)	73.70 (74.29)	81.60 (71.77)	67.40 (81.88)	62.50 (69.81)	78.60 (98.65)
HTA Women	31.10 (37.22)	95.10 (66.60)	95.60 (80.79)	77.40 (90.80)	66.60 (74.86)	82.40 (103.59)

Note. LTA = Low Trait Anxious, HTA = High Trait Anxious.

$F(4, 97) = 5.15$, $p = .001$, and a marginal main effect of anxiety group, $F(1, 100) = 3.07$, $p < .10$, were found. Differences in gaze durations per interval and between HTA and LTA individuals were discussed in the combined angry face analyses. However, for the face type main effect, it was found that gaze durations were longest for the angry female face (*M* = 68.00, *SD* = 36.66), and this differed significantly from gaze durations for the friendly male (*M* = 49.60, *SD* = 26.97, $p < .001$) and friendly female faces (*M* = 54.00, *SD* = 30.43, $p < .05$) but not the child face (*M* = 57.20, *SD* = 30.03, *ns*). Gaze durations for the angry male (*M* = 56.10, *SD* = 40.02) were not significantly different than any of the friendly faces.

An interval by face type interaction, $F(20, 81) = 1.91$, $p < .05$, was similarly found for the analyses of gaze durations. Post-hoc Repeated Measures ANOVAs at each level of interval revealed a main effect of face type for the 500-1000ms, $F(4, 100) = .17$, $p < .001$, 1000-1500ms, F(4, 100) = 2.56, p < .05, and 1500-2000ms, $F(4, 100) = 4.76$, $p = .001$ intervals. These results are illustrated in Figure 8. Bonferroni comparisons for the 500-1000ms interval showed that gaze durations were significantly longer for the angry female face (*M* = 81.00, *SD* = 68.36), as compared to all the other faces, (*M* = 42.00, *SD* = 36.31; *M* = 46.40, *SD* = 42.56; *M* = 52.80, *SD* = 48.37; all *p*'s < .05). In contrast, gaze durations for the angry male (*M* = 54.40, *SD* = 52.98) were not significantly different than any of the friendly faces. For the 1000-1500ms interval, gaze durations for the angry female face (*M* = 78.00, *SD* = 74.21) were marginally longer than durations for the friendly female (*M* = 55.20, *SD* = 52.20, $p < .10$) but did not differ from the friendly male (*M* = 58.00, *SD* = 59.63, *ns*) or child faces (*M* = 58.70, *SD* = 52.54, *ns*).

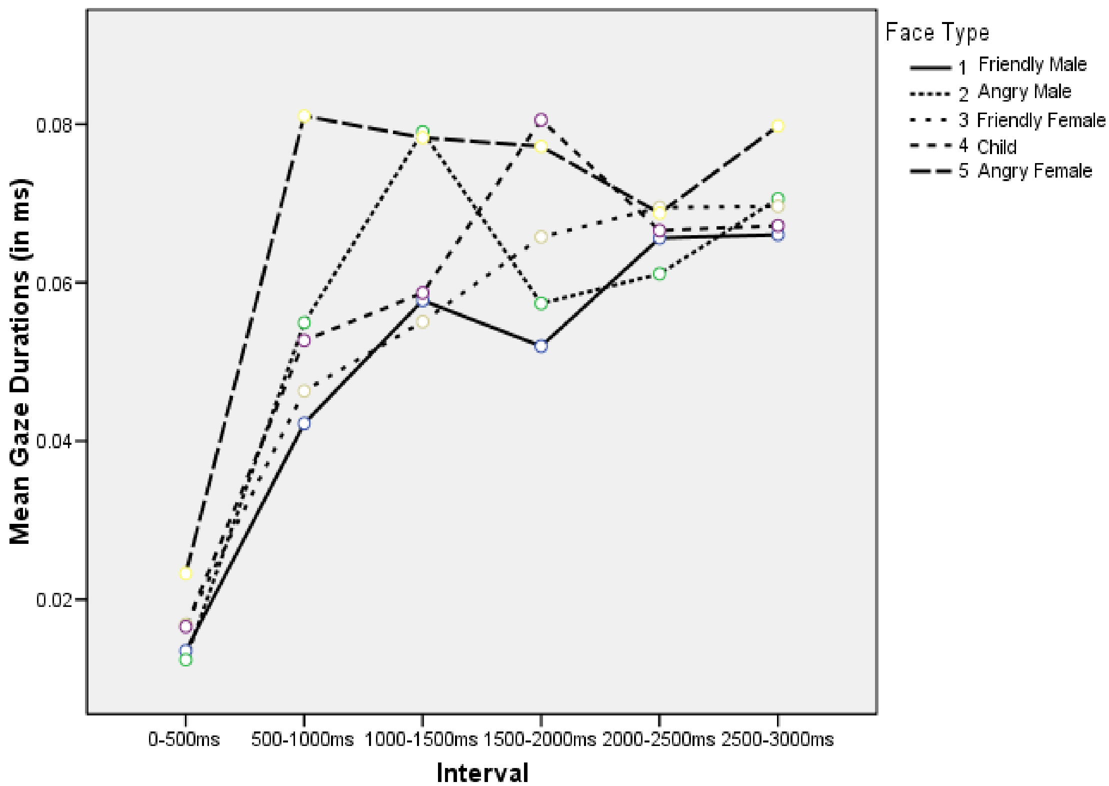


Figure 8. Mean Gaze Durations by Interval and Face Type (Angry Male and Angry Female) for the First 3 Seconds of Presentation.

In addition, although gaze durations for the angry male (*M* = 79.10, *SD* = 89.51) increased during this time interval and appeared to equal durations for the angry female, there was no significant difference between them and friendly faces. Finally, for the 1500-2000ms interval, gaze durations were highest for the child face (*M* = 81.00, *SD* = 60.72) and differed significantly from gaze durations for the friendly male face (*M* = 51.90, *SD* = 49.37, *p* = .001), but not the angry male (*M* = 57.10, *SD* = 76.88, *ns*), angry female (*M* = 77.30, *SD* = 82.55, *ns*), and friendly female faces (*M* = 66.00, *SD* = 62.24, *ns*).

Gaze durations were equally low for all faces during the first 500ms of slide presentation and increased for all faces during the 500-1000ms interval, particularly for the angry female. All participants looked longest at the angry female during this interval, suggesting vigilance was affected by sex of angry face. Attentional bias for the angry female occurred 500ms earlier than for the angry male. Although gaze durations for the angry male increased during the 1000-1500ms interval and matched durations for the angry female, these did not differ significantly from the friendly faces. Nonetheless, gaze durations for the angry male decreased more so than gaze durations for the angry female during the 1500-2000ms interval, suggesting that participants looked away from angry male soon after they fixated on it. In addition, participants spent more time looking at the child face during the 1500-2000ms interval, and no differences were found in gaze durations for each face type during the last 1000ms.

Summary of First 3 Second Analyses. Analyses of the early attentional patterns yielded a relatively low number of fixations and gaze durations over the first 3 s of presentation, but particularly for the first 500ms. In addition, HTA individuals showed a marginal tendency to gaze longer at the faces than LTA individuals. While in the combined angry face analyses, the friendly male face was looked at the least during the 3 s time span, the analyses of the angry male and female faces separately, showed that it was the angry female that was looked at more often and for a longer period of time than the friendly faces.

Results for the first 3 seconds of presentation also provided partial support for the vigilant-avoidant hypothesis, albeit in all participants, regardless of sex and anxiety level. Fixations and gaze durations were equally low during the first 500ms. However, participants exhibited increased vigilance for the angry face, particularly the angry female, during the 500-1000ms interval. During the next 500ms, fixations and gaze durations for the angry male increased and the angry female decreased, leading to similar vigilance for both. Fixations and gaze durations for the angry face then decreased over the 1500-2000ms interval, particularly for the angry male, such that no difference existed with the friendly faces. Rather, it was the child face that obtained the greatest attention, as compared to the friendly male face. Finally, no differences in attention for each face type were found during the last 1000 ms, which although not evidence for direct avoidance of angry faces, does show that vigilance disappears within the first 3 s.

First Fixation Analyses

Early attentional biases were further examined by recording the very first picture fixation for each of the 8 slides. The number of first fixations was counted for each face type and then divided by 8 to determine the percentage of first fixations for the friendly male, angry (male and female), friendly female, and child faces. Separate 2 (Sex) x 2 (Anxiety Group) x 4 (Face Type) Mixed Design ANOVAs were then conducted for the percentage of first fixations and first fixation durations.

Percentage of First Fixations Analyses – Combined Angry Face. Results revealed a main effect for face type, $F(3, 98) = 3.67$, $p < .05$, and a marginal face type by anxiety group interaction, $F(3, 98) = 2.66$, $p < .10$. Bonferroni post-hoc comparisons for face type showed that percentage of first fixations was significantly higher for the angry face ($M = 17.79$, $SD = 15.65$) than the friendly male face ($M = 12.38$, $SD = 12.00$, $p = .01$). In fact, the highest percentage of first fixations was for the angry face, suggesting that participants were more likely to look at the angry face first across the 8 slides. However, post-hoc exploration of the face type by anxiety group interaction showed that this pattern of results was driven primarily by LTA participants. No significant differences were found for percentage of first fixations for each face type in HTA participants. In contrast, LTA participants fixated more often on the angry face ($M = 19.75$, $SD = 16.58$, $p < .01$) and the child face ($M = 16.75$, $SD = 12.78$, $p < .05$) as compared to the friendly male face ($M = 10.00$, $SD = 10.41$).

First Fixation Duration Analyses – Combined Angry Face. The only noteworthy finding of this analysis was a marginal main effect of face type, $F(3, 98) = 2.68$, $p < .10$. Bonferroni comparisons revealed a non-significant tendency ($d = .36$) for participants to fixate less time (in ms) on the angry face ($M = 168.20$, $SD = 132.16$) than the friendly female face ($M = 229.51$, $SD = 202.16$, $p < .10$). If participants fixated on the angry face first, they looked away from it quicker.

Percentage of First Fixations Analyses – Angry Male and Angry Female Faces. To determine whether sex of angry face influenced percentage and duration of first fixations, 2 (Sex) x 2 (Anxiety Group) x 5 (Face Type) Mixed Design ANOVAs were also completed. Table 11 lists the mean percentage of first fixations and fixation durations for each face type for the within sex anxiety groups. A main effect of face type, $F(4, 97) = 3.24$, $p < .05$, and a marginal interaction of face type by anxiety group were found, $F(4, 97) = 2.26$, $p < .10$. Although results parallel those of the combined angry face analyses, they provide additional information. Bonferroni post-hoc comparisons revealed that participants' percentage of first fixations was highest for the angry female face ($M = 19.95$, $SD = 20.43$), which differed significantly from percentage of first fixations for the friendly male ($M = 12.38$, $SD = 12.00$, $p < .01$), but not the friendly female ($M = 15.38$, $SD = 13.52$, *ns*) or child faces ($M = 14.90$, $SD = 13.39$, *ns*). As illustrated in Figure 9, all participants were more likely to look at the angry female first across 4 slides, particularly more so than the friendly male face. In comparison, percentage of first fixations for the angry male ($M = 15.63$, $SD = 17.83$) did not differ from any of the friendly faces, suggesting that an initial orienting bias was only present for angry females.

Post-hoc evaluation of the face type by anxiety group interaction showed that for the LTA group, percentage of first fixations for the angry female ($M = 21.50$, $SD = 20.83$) was significantly greater than for the friendly male face ($M = 10.00$, $SD = 10.41$, $p = .01$) while percentage of first fixations for the angry male ($M = 18.00$, $SD = 19.59$,

Table 11
Mean (SD) Percentage and Mean Durations of First Fixations in Milliseconds

	Friendly Male	Angry Male	Angry Female	Friendly Female	Child
Percentage of First Fixations					
LTA Men	13.46% (11.69)	19.23% (22.70)	18.27% (21.86)	16.35% (16.11)	16.35% (13.12)
HTA Men	15.18% (12.43)	15.18% (15.72)	18.75% (19.98)	14.73% (13.20)	14.73% (15.24)
LTA Women	6.25% (7.37)	16.67% (15.93)	25.00% (19.51)	14.58% (11.46)	17.19% (12.67)
HTA Women	13.94% (13.84)	11.54% (16.17)	18.27% (20.69)	15.87% (13.49)	11.54% (12.21)
Duration of First Fixations					
LTA Men	172.77 (134.56)	157.92 (176.06)	172.50 (190.70)	276.27 (303.12)	235.69 (167.07)
HTA Men	217.50 (157.02)	189.18 (201.57)	177.32 (178.39)	196.36 (171.18)	212.46 (160.01)
LTA Women	150.46 (214.79)	148.29 (135.29)	234.92 (169.27)	225.38 (129.67)	239.79 (125.89)
HTA Women	221.77 (235.82)	112.04 (154.44)	154.92 (175.27)	222.27 (160.66)	157.77 (153.49)

Note. LTA = Low Trait Anxious, HTA = High Trait Anxious.

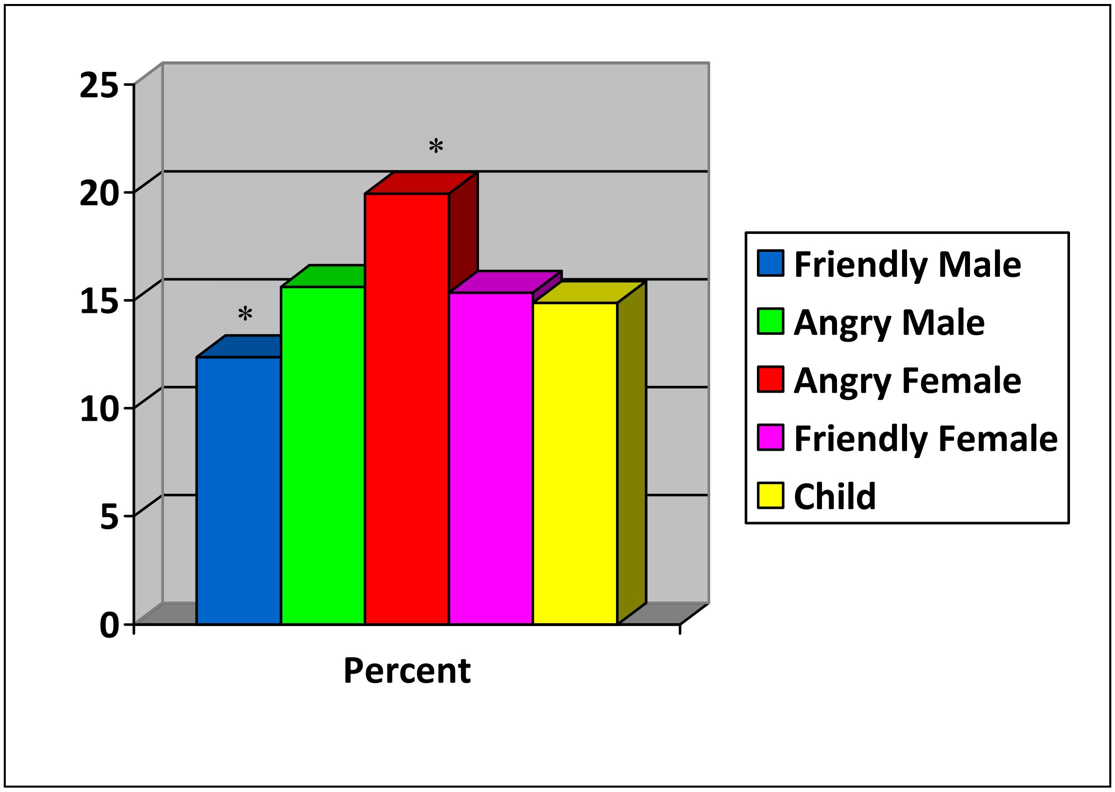


Figure 9. Percentage of First Fixations by Face Type.

$p < .10$) was marginally greater than the friendly male face. In contrast, although the angry female face obtained the highest percentage of first fixations for the HTA group, there was no significant difference in the frequency of first fixations for any of the faces. Thus, it appears that results of the face type main effect were primarily driven by the LTA participants, who were more likely to look first at the angry female across 4 slides and marginally more likely to look first at the angry male across 4 slides.

First Fixation Duration Analyses – Angry Male and Angry Female Faces. A main effect of face type was found, $F(4, 97) = 2.60$, $p < .05$. Bonferroni post-hoc comparisons revealed that fixation durations were shortest for the angry male face (M = 152.64, SD = 169.83), and this was significantly lower than fixation durations for the friendly female face (M = 229.51, SD = 202.16, $p < .05$), but not the child (M = 210.90, SD = 154.32, *ns*) or friendly male faces (M = 191.91, SD = 188.56, *ns*). In comparison, fixation durations for the angry female face (M = 183.81, SD = 178.57, *ns*) did not differ significantly from any of the friendly faces. If participants looked first at the angry male face, they spent less time looking at this than other faces, particularly the friendly female face. That is, attention was quickly diverted away from the angry male. However, although participants were more likely to look first at the angry female, they did not seem to look at it for less time than other faces.

Post-Eye Tracking Tasks

Visual Analogue Scale. In general, after the face viewing task, participants became less happy, less oriented, less content, more tired, and more bored, yet more calm (all p's $< .001$). No change was found in the afraid-relaxed item.

To determine whether mood change differed by participant groups, change scores for each VAS item were computed by subtracting scores from time 1 from scores on time 2. Separate 2 (Sex) X 2 (Anxiety Group) ANOVAs were done for each VAS change item. Men and women did not differ in mood change before and after the face viewing task. However, a significant difference was found between HTA and LTA groups, $F(1, 226) = 4.77$, $p < .05$, on the VAS – Tired/Energetic item. HTA participants described feeling less tired after viewing the emotional face slide show ($d = .25$) than LTA participants. A significant interaction between sex and anxiety group also emerged for this item, $F(1, 226) = 7.67$, $p < .01$. HTA men ($M = -5.34$, $SD = 17.10$) described feeling less tired following the emotional face slide show than LTA men ($M = -17.84$, $SD = 22.41$, $p < .01$). In contrast, LTA men reported feeling more tired than LTA women ($M = -8.41$, $SD = 19.57$, $p < .05$), who did not differ from HTA women in reports of tiredness. ($M = -9.89$, $SD = 17.15$, *ns*).

Face Recognition Task Analyses. To examine whether performance on the face recognition task differed for HTA and LTA men and women, recognition scores were computed by subtracting participants' mean scores for old faces from their mean scores for new faces. The larger this difference the more correct and more confident participants were in their ratings of old and new faces. A 2 (Sex) X 2 (Anxiety Group) Between-Subjects ANOVA, with recognition score as the dependent variable, revealed a main effect of sex, $F(1, 226) = 6.66$, $p < .05$, and no difference between the HTA and LTA groups. As expected, women ($M = 1.82$, $SD = .73$, $n = 127$) were more correct and more confident in their memory for the faces than men ($M = 1.59$, $SD = .60$, $n = 103$), whereas level of trait anxiety did not influence overall memory for faces. Second, to determine whether participants differed in their memory for angry faces (portrayed as friendly faces during the recognition task), a 2 (Sex) x 2 (Anxiety Group) ANOVA was conducted, with mean scores for angry faces as the dependent variable. No differences were found between HTA and LTA men and women on recognition of angry faces.

Digit Ratio Analyses

Sex Difference in Digit Ratio. Table 12 lists the within sex means for digit ratio derived from hand copies and live measurements. Digit ratio measures were missing for 2 men and 6 women, and 4 outliers were deleted prior to analyses (2 men, 2 women), leaving a sample of 100 men and 119 women. As expected, women exhibited higher digit ratios than men on right, $F(1, 215) = 13.70$, $p < .001$, $d = .51$, and left hand, $F(1, 215) = 33.06$, $p < .001$, $d = .79$, copy measures and on right, $F(1, 215) = 7.19$, $p < .01$, $d = .36$, and left hand, $F(1, 215) = 7.11$, $p < .01$, $d = .34$, live measures. However, contrary to expectations, no significant difference in digit ratio was found between LTA and HTA individuals, and no interaction between sex and anxiety group was found.

Correlational Analyses. As reported in previous studies, copy and live measures of digit ratio were significantly and positively correlated ($r = .23$ - $.52$, $p < .05$). Given the secondary aims of this study, within sex bivariate correlations were also conducted to examine the association between digit ratio and anxiety measures. For men, the live left hand digit ratio was negatively associated with scores on the ARD-O subscale of the PAI ($r = -.22$, $p < .05$). Men with lower, more masculine ratios reported greater obsessive-compulsive symptoms than men with higher, less masculine digit ratios. For women,

Table 12
Mean (SD) Digit Ratio Measures for Participant Groups

Measures		Men		Women	
		LTA (n = 48)	HTA (n = 52)	LTA (n = 53)	HTA (n = 66)
Digit Ratio	Copy – Right	.9612 (.03)	.9613 (.02)	.9769 (.03)	.9754 (.03)
	Copy – Left	.9562 (.04)	.9526 (.03)	.9808 (.03)	.9797 (.04)
	Live – Right	.9804 (.04)	.9756 (.03)	.9902 (.03)	.9888 (.03)
	Live – Left	.9770 (.04)	.9725 (.04)	.9975 (.04)	.9822 (.04)

there were no significant correlations between digit ratio and anxiety measures.

Digit Ratio and Eye Tracking Analyses for the 60-Second Presentation

To further explore secondary hypotheses and examine whether hormonal factors may influence attentional biases towards threat, 2 (Sex) x 2 (Digit Ratio) x 4 (Face Type) x 6 (Interval) Mixed Design ANOVAS were conducted for the number of fixations and gaze durations during 1) the 60-second slide presentation and 2) the first 3 seconds of presentation. Right hand copy measures of digit ratio were used for these analyses as right hand digit ratio has been shown to be a more sensitive measure of prenatal androgen action and has been associated with a number of sexually dimorphic behaviors in previous research (Brown, Hines, Fane, & Breedlove, 2002; Manning et al., 1998; McFadden & Shubel, 2002; Williams et al., 2000). High versus low digit ratio groups were created through a median split within each sex. The digit ratio median for men was .9560, and the digit ratio median for women was .9785.

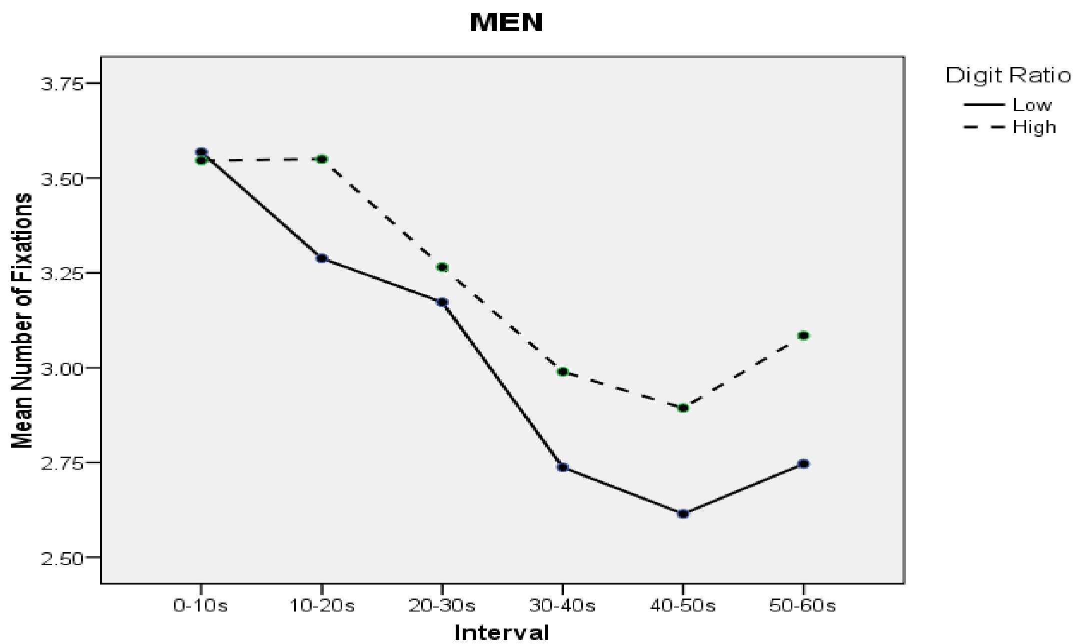
Because main effects of interval, face type, and interactions between face type and interval have been described under the anxiety group analyses in previous sections, they will not be reported here. Only the main effects and interactions with digit ratio will be described.

Number of Fixations Analyses – Combined Angry Face. The analyses for the number of fixations resulted in an interaction between interval and digit ratio group, $F(5, 96) = 2.40$, $p < .05$. To determine whether differences existed between high and low digit ratio groups in number of fixations at each interval, separate ANOVAs were done, with the between-subjects factor of digit ratio group. Results from these analyses did not show any significant difference in number of fixations at each interval level between individuals with low and high digit ratio. To further explore this interaction, Repeated Measures ANOVAS were done for each digit ratio group, with interval as a within-subjects factor. Bonferroni post-hoc comparisons for the low digit ratio group found that number of fixations were significantly higher during the 0-10s interval compared to the 20-30s, 30-40s, 40-50s, and 50-60s intervals (all p's $< .01$). Fixations for the 10-20s interval were significantly higher than the 40-50s interval ($p < .05$), and fixations for the 20-30s interval were significantly higher than the 30-40s and 40-50s intervals (all p's $< .05$). For the high digit ratio group, fixations were also highest during the 0-10s interval as compared to the 20-30s, 30-40s, 40-50s, and 50-60s interval (all p's $< .01$). In addition, fixations for the 10-20s interval were significantly higher than all remaining intervals (all p's $< .01$) and fixations for the 20-30s interval were higher than fixations for the 40-50s interval ($p < .01$). High and low digit ratio groups exhibited a similar number of fixations during the 0-10s interval, but while fixations for the low digit ratio group began decreasing during the 10-20s interval, fixations for the high digit group did not decrease until the 20-30s interval. Nevertheless, the high digit ratio group exhibited a greater decline in number of fixations across the remaining time intervals, although this difference was non-significant.

There was also a marginal interaction of interval by sex by digit ratio, $F(5, 96) = 1.92$, $p < .10$. To further explore this interaction, separate ANOVAs were done for each sex, with the between-subjects factor of digit ratio and the dependent variables of average number of fixations at each time interval. Although men with high digit ratio appeared to have a higher number of fixations during the 10-20s thru the 50-60s intervals, there was no significant difference in number of fixations between the high and low digit ratio groups for any of the time intervals. As illustrated in Figure 10, both high and low digit ratio groups exhibited similar decreasing patterns of fixations from beginning to end of slide presentation. In contrast, for women, number of fixations were significantly higher for the low digit ratio group during the 40-50s, $F(1, 48) = 4.14$, $p < .05$, and the 50-60s, $F(1, 48) = 4.13$, $p < .05$, intervals as compared to the high digit ratio group. No significant differences were found for the 0-10s thru the 30-40s intervals. As portrayed in Figure 10, both women with high and low digit ratio displayed similar number of fixations during the first 10 s of presentation. However, while women with low digit ratio exhibited a fairly stable number of fixations across all time intervals, women with high digit ratio exhibited a significant decline in number of fixations. Results are supportive of early visual attention towards facial stimuli for women with both high and low digit ratio. However, subsequent avoidance of facial stimuli is only seen in women with high digit ratio.

Gaze Duration Analyses – Combined Angry Face. No main effects of digit ratio or interactions with digit ratio were found.

Number of Fixations Analyses – Angry Male and Angry Female Faces. To determine whether sex of angry face influenced attentional patterns of those with high and low digit ratio, 2 (Sex) x 2 (Digit Ratio) x 5 (Face Type) x 6 (Interval) Mixed Design ANOVAS were conducted for the number of fixations and gaze durations for the 60-s presentation and again for the first 3 s of presentation. Results revealed a marginal



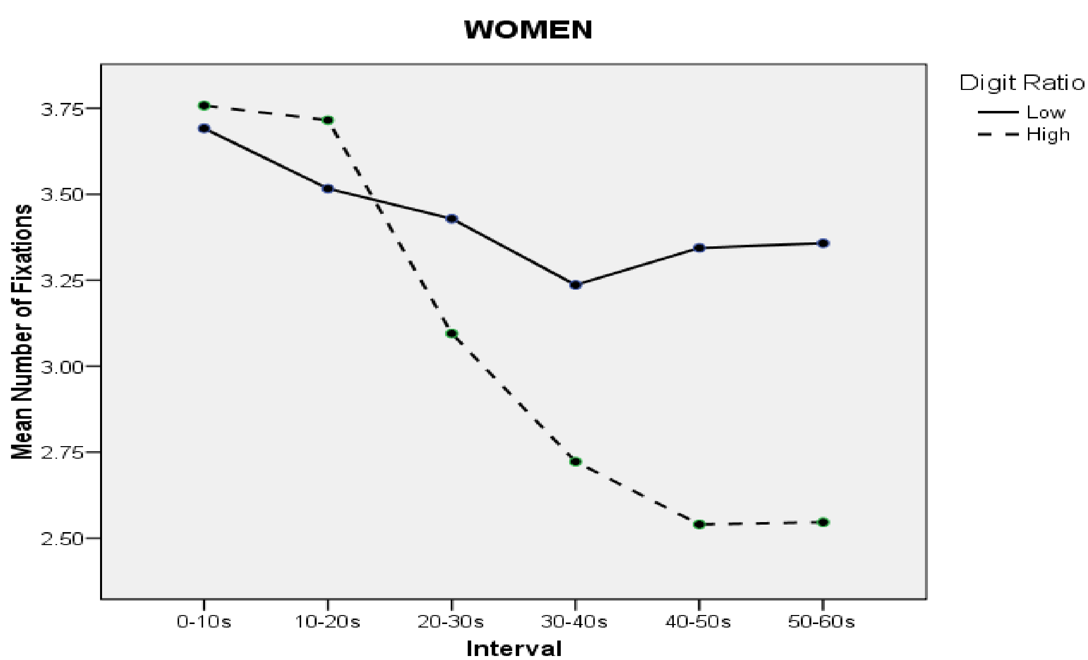


Figure 10. Mean Number of Fixations for Men and Women with Low and High Digit Ratio During the 60-Second Presentation.

interaction of interval by sex by digit ratio, $F(5, 96) = 1.97$, $p < .10$ (see Figure 10). No difference was found between high and low digit ratio men on number of fixations at each interval. In contrast, women with low digit ratio exhibited significantly more fixations during the 40-50s and 50-60s intervals than the high digit ratio women.

Gaze Duration Analyses – Angry Male and Angry Female Faces. No main effects of digit ratio or interactions with digit ratio were found.

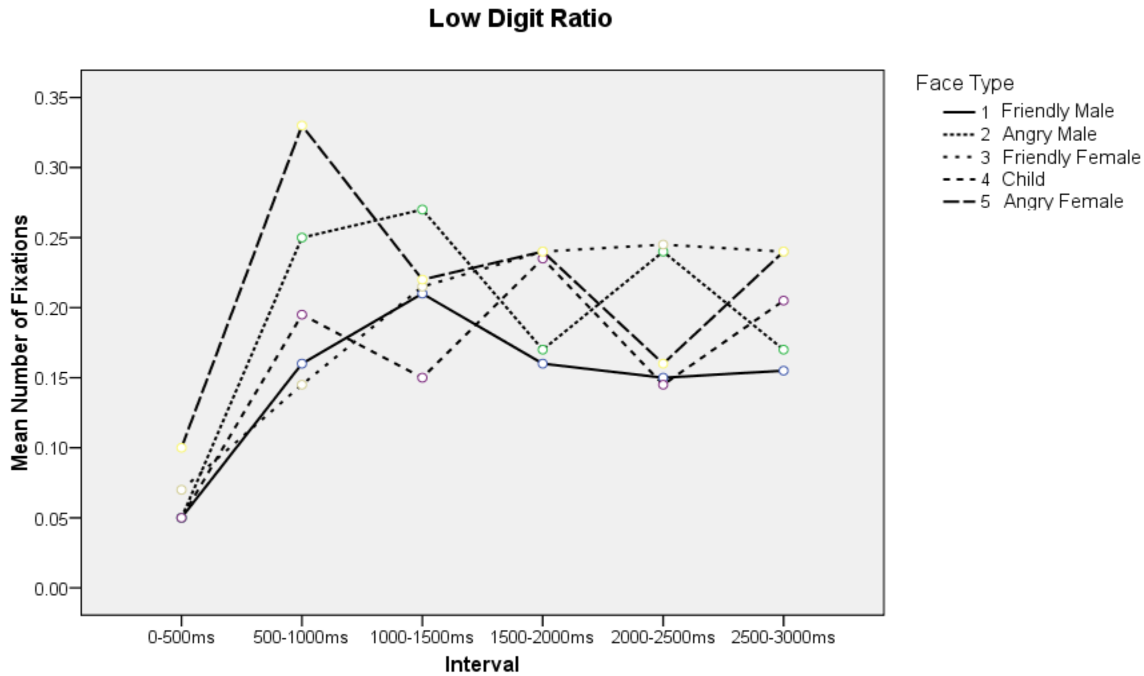
Digit Ratio and Eye Tracking Analyses During First 3 Seconds of Presentation

Number of Fixations Analyses – Combined Angry Face. No significant main effects of digit ratio or interactions with digit ratio were found.

Gaze Duration Analyses – Combined Angry Face. The analyses of the first 3 s of presentation for gaze durations (in ms) resulted in an interaction between interval and digit ratio, $F(5, 96) = 2.32$, $p < .05$. Although low digit ratio individuals displayed longer gaze durations during the 1000-1500ms and 1500-2000ms intervals, and individuals with high digit ratio had longer gaze durations during the 2000-2500ms and 2500-3000ms intervals, these differences did not reach statistical significance in post-hoc analyses.

Number of Fixations Analyses – Angry Male and Angry Female Faces. Analyses for the number of fixations during the first 3 s of presentation yielded a significant four-way interaction between interval, face type, sex, and digit ratio, $F(20, 81) = 1.83$, $p < .05$. To explore this overall interaction, separate Repeated Measures ANOVAs were conducted for each within sex, digit ratio group (e.g., high digit ratio men) using interval and face type as within-subjects factors. Given the small number of participants in each of these groups and violations of sphericity, the univariate within-subjects results are reported with Greenhouse-Geisser Corrections, as these may have greater power with smaller samples than the multivariate approach. For men with low and high digit ratio, no interval by face type interaction was found. In contrast, marginal interval by face type interactions were found for women with low, $F(9.98, 239.56) = 1.65$, $p < .10$, and high digit ratio, $F(9.13, 219.06) = 1.79$, $p < .10$. Bonferroni post-hoc comparisons for number of fixations for each face type were done at each level of time interval. As illustrated in Figure 11, women with low digit ratio displayed significantly more fixations for the angry female ($M = .33$, $SD = .19$) during the 500-1000ms interval as compared to the friendly male ($M = .16$, $SD = .13$, $p < .001$) and female faces ($M = .15$, $SD = .14$, $p < .05$). No difference in number of fixations for each face type was found for the remaining intervals. Also as illustrated in Figure 11, women with high digit ratio showed a non-significant trend for greater fixations for the angry female ($M = .13$, $SD = .16$) during the 0-500ms interval as compared to the friendly male ($M = .04$, $SD = .06$, $p < .10$). They also exhibited significantly greater fixations for the angry female ($M = .26$, $SD = .21$) during the 1000-1500ms interval as compared to the friendly female ($M = .10$, $SD = .13$, $p < .05$). No further differences were found by face type for the remaining intervals.

Gaze Duration Analyses – Angry Male and Angry Female Faces. Similar to results for number of fixations, a marginal four-way interaction of interval by face type by sex by digit ratio, $F(20, 81) = 1.67$, $p < .10$, was found. As with the number of fixations analyses, post-hoc analyses were conducted for digit ratio groups within each



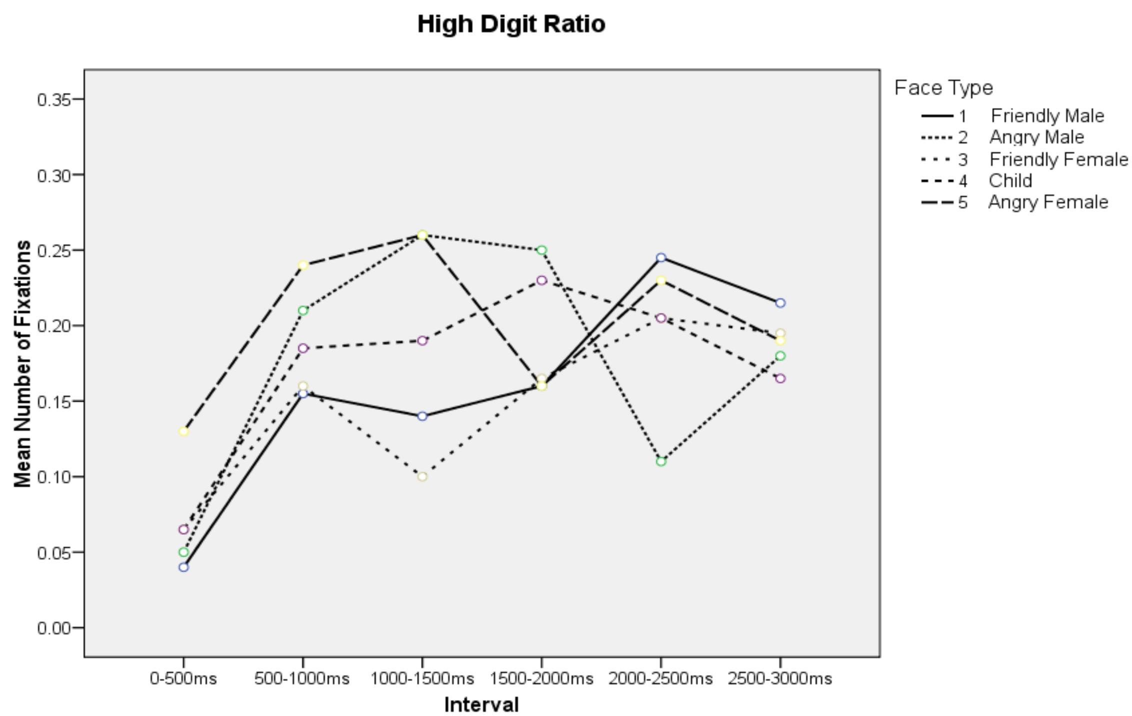


Figure 11. Mean Number of Fixations for Women with Low and High Digit Ratio by Interval and Face Type (Angry Male and Angry Female) for the First 3 Seconds of Presentation.

sex. Once again, univariate within-subjects results with Greenhouse Geisser corrections are reported. For men with low and high digit ratio and women with low digit ratio, no significant interaction was found between interval and face type. However, for women with high digit ratio, the interaction between interval and face type was marginally significant, $F(8.92, 214.13) = 1.70$, $p < .10$. Bonferroni post-hoc comparisons for gaze durations for each face type were then conducted at each time interval. As depicted in Figure 12, women with high digit ratio exhibited a tendency for longer gaze durations for the angry female ($M = 35.20$, $SD = 43.32$) during the 0-500ms interval as compared to the friendly male ($M = 10.40$, $SD = 16.34$, $p < .10$). They also had significantly longer gaze durations for the angry female ($M = 99.80$, $SD = 75.72$) as compared to the friendly female during the 1000-1500ms interval ($M = 36.00$, $SD = 44.44$, $p < .05$). No other differences in gaze durations were found for the remaining intervals.

Summary of Digit Ratio Analyses for First 3 Seconds. Results from the number of fixations and gaze duration analyses suggest that women are more likely than men to show differing patterns of attention for each face type across the 6 time intervals. Women with both high and low digit ratio show an early vigilance towards the angry female relative to other faces, but this vigilance appears to begin earlier (at the 0-500ms interval) and be maintained longer (until the 1000-1500ms interval) in women with high digit ratio than in women with low digit ratio.

Digit Ratio and First Fixation Analyses

To examine the possible influence of hormonal factors on first fixations, separate 2 (Sex) x 2 (Digit Ratio) x 4 (Face Type) Mixed Design ANOVAs were conducted for

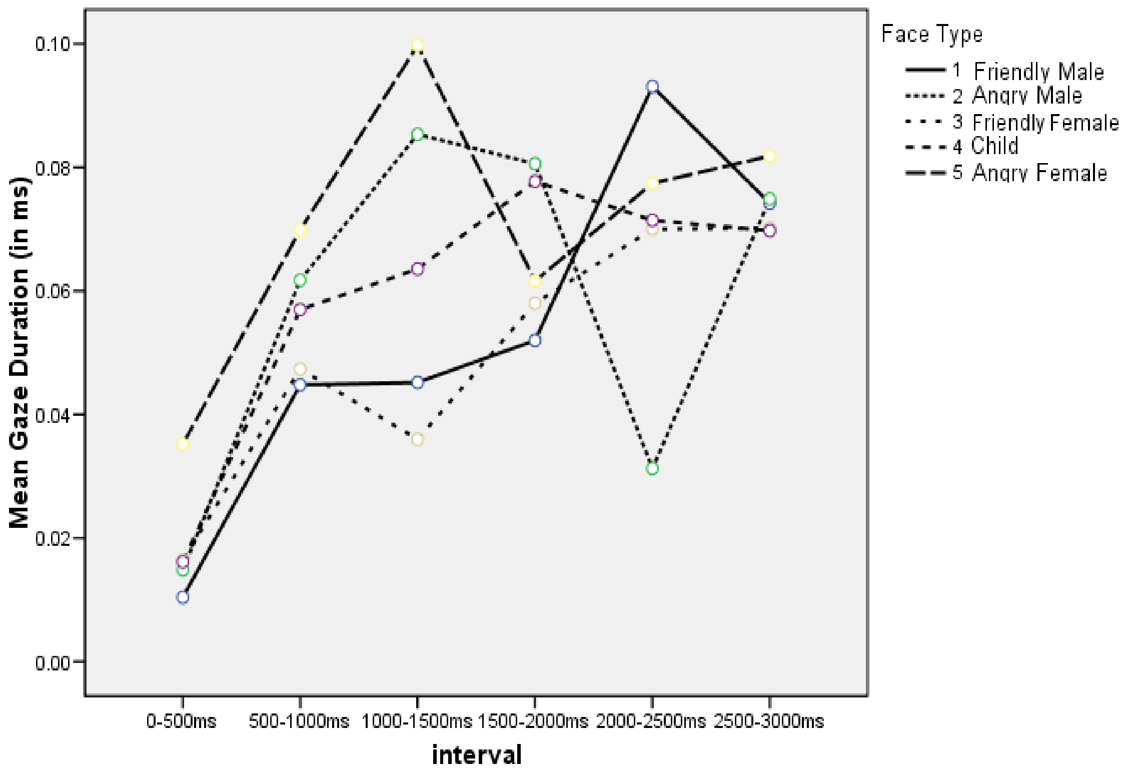


Figure 12. Mean Gaze Durations for Women with High Digit Ratio by Interval and Face Type (Angry Male and Angry Female) for the First 3 Seconds of Presentation.

percentage of first fixations and duration of first fixations. Because main effects of face type were discussed in the anxiety group analyses, they will not be discussed here. Only main effects of digit ratio or interactions with digit ratio will be reported.

First Fixation Analyses – Combined Angry Face. An interaction between sex and digit ratio, $F(1, 100) = 6.35$, $p < .05$, for percentage of first fixations was found. Men with high digit ratio had a higher percentage of first fixations ($M = 17.94$, $SD = 6.35$) for all faces than men with low digit ratio ($M = 13.66$, $SD = 6.44$, $p < .05$) and women with high digit ratio ($M = 13.25$, $SD = 7.51$, $p < .05$), who had the lowest percentage of first fixations.

First Fixation Analyses – Angry Male and Angry Female Faces. To determine whether digit ratio effects on early attentional patterns differed by sex of angry face, separate 2 (Sex) by 2 (Digit Ratio) x 5 (Face Type) Mixed Design ANOVAs were conducted for percentage and duration of first fixations. A sex by digit ratio interaction, $F(1, 100) = 6.87$, $p = .01$, was found for percentage of first fixations, as described in the combined angry face analyses above. No additional information was provided by these analyses.

Exploratory Analyses of Activational Hormonal Effects and Anxiety

Given the preliminary findings of an association between digit ratio and attentional patterns towards threat, particularly in women, follow-up analyses were conducted to examine whether circulating hormones influenced degree of trait anxiety and attentional biases in women. Oral contraceptive use (OC versus non-OC) served as a rough measure of circulating hormones. Of the total sample, 49 women were OC users, 75 women were non-OC users, and 3 did not provide a response. A univariate ANOVA showed no difference between OC and non-OC users in reports of trait anxiety. For the subset of women completing eye tracking measures (25 OC, 24 non-OC), analyses similar to those reported for digit ratio also did not reveal differences between OC and non-OC users on attentional patterns towards threat during the 60-s presentation, the first 3 s of presentation, or on first fixations.

DISCUSSION

The present study had two primary aims: 1) to reexamine the validity of the vigilant-avoidant hypothesis and determine whether results by Rink and Becker (2006) with spider phobia were replicated for high trait anxiety and other ecologically valid stimuli (i.e., faces), and 2) to directly assess whether sex affected attentional patterns towards threat in high anxious individuals, thus contributing to the previous mixed results in the literature. Given the primary aims of this study, two hypotheses were tested. First, consistent with results from Rinck and Becker (2006), it was hypothesized that HTA individuals, compared to LTA individuals, would initially orient and show an early vigilance for angry faces compared to friendly faces, which would then be followed by avoidance of angry faces over the 60-s slide presentation (i.e., a three-way interaction between anxiety group, interval, and face type). Second, because anxiety disorders are two times more prevalent in women than in men (Howell et al., 2006) and because women show enhanced face and emotion processing (Craske, 2003), the vigilant-avoidant pattern was expected to be most evident in HTA women (i.e., a significant four-way interaction between sex, anxiety group, time interval, and face type).

Did HTA Compared to LTA Individuals Show a Vigilant-Avoidant Pattern for Threat?

Results from the very first fixation analyses and time course analyses of the first 3 seconds and 60-s presentation do not support a heightened vigilant-avoidant pattern in HTA versus LTA individuals. HTA individuals were not more likely to initially orient to threat than LTA individuals. Rather, the reverse pattern was found. HTA participants had a similar percentage of first fixations for the combined angry face and the friendly faces, whereas the LTA individuals appeared most likely to fixate first on the combined angry face and least likely to fixate first on the friendly male face. Time course analyses of the first 3 s also did not show an early vigilance for threat in HTA individuals, compared to LTA individuals. That is, a three-way interaction between anxiety group, time interval, and face type did not emerge. Instead, all participants showed an attentional bias for the combined angry face, compared to the friendly male and female faces, from 500 to 1500 ms. After 1500 ms, participants looked more often and spent more time looking at the child face, relative to the friendly male, and no difference in attention for the combined angry face and the other faces was found for the remaining 1500 ms. This similarity in attention for all faces then continued for the majority of the 60-s presentation, with no evidence of avoidance by HTA individuals. Although all participants attended the least to the friendly male, compared to the combined angry face and friendly female face, during the first 10 s of presentation, no differences were found in attention for any of the faces during the remaining 50 s of presentation.

This study's failure to replicate differences in vigilance for threat between HTA and LTA individuals contradicts the findings from studies using the dot-probe task, which have found an early attentional bias towards angry faces compared to neutral faces in individuals with high trait anxiety (Bradley et al., 1998) and high and medium state anxiety (Bradley et al., 2000). The results are also inconsistent with findings from eye tracking studies, which have found an early bias towards intensely angry and fearful faces in high anxious individuals and threatening faces in individuals with Generalized Anxiety Disorder (Mogg et al., 2000; 2007). In contrast, this study's findings are in line with previous eye tracking studies that have not found a difference in anxious versus non-anxious samples in vigilance for threat. For example, both spider-fearful and non-fearful controls showed a bias towards spider pictures relative to flowers at 500ms (Hermans et al, 1999). Similarly, both HTA and LTA individuals viewed angry faces more than happy faces for the first 1000 ms of stimulus presentation (Rohner, 2002), and HTA and LTA individuals did not show a difference in attention towards emotional scenes depicting sadness or loss (Caseras et al., 2007). Significantly, other eye tracking studies which have found a difference in high anxious and low anxious samples have shown that the bias is not specific to threat, but that highly anxious individuals selectively attend to emotional stimuli (negatively and positively valenced) in general (Calvo & Avero, 2005; Garner et al., 2006). Thus, the vigilance for threat in anxiety appears to be highly variable from study to study and may depend on a variety of factors.

First, evolutionary theories suggest that threat is biologically relevant for all individuals, anxious and non-anxious, and that in the interest of self-preservation, everyone is more likely to attend to threat (Öhman, 1993). For example, at 100ms presentation, individuals with both high and low state anxiety showed an attentional bias towards threat (Fox et al., 2001). Non-anxious individuals have also been found to look first at threatening and injury scenes compared to neutral pictures (Calvo & Lang, 2004), and both depressed and non-depressed individuals appear to spend more time initially attending to threat (Kellough, Beevers, Ellis, & Wells, 2008). This suggests that early visual attention to threatening stimuli has a general adaptive function, and this may be particularly true for highly threatening stimuli. Research showing a threat bias in all individuals is also consistent with evidence that emotional stimuli (negatively and positively valenced) in general tend to draw and hold attention from everyone, even normal, non-anxious samples (Alpers, 2008; Murphy & Isaacowitz, 2008; Nummenmaa et al., 2006). Consequently, the lack of an attentional bias for threat that is specific to HTA individuals in this study, may be related to the evolutionary adaptiveness of such a bias for all individuals.

Additional factors may further account for the absence of a heightened threat bias in HTA individuals. It has been previously suggested that attention towards negative stimuli depends simultaneously on the threat value of the stimulus (e.g., mild versus high threat) and the state anxiety of the individual (Bradley et al., 2000). Several studies have found either heightened or reduced attentional biases towards threat in high anxious individuals, compared to low anxious individuals, as a function of the level of threat. In one study, HTA individuals showed an attentional bias for highly, but not mildly threatening pictures from the IAPS (Liu et al., 2006). Similarly, high anxious individuals were more likely to gaze at intense negative facial expressions, while no difference was found between low anxious and high anxious groups in attention to mild negative expressions (Mogg et al., 2007). Therefore, it may be that angry faces used in this study were perceived by all participants as mildly threatening, perhaps due to the use of constructed images rather than real faces or to the use of black and white versus colored faces. This may have then resulted in no difference between HTA and LTA groups. In contrast, another study found an attentional bias for highly threatening IAPS pictures in both HTA and LTA participants, whereas only HTA individuals selectively attended to mildly threatening pictures (Koster et al., 2005). This suggests that participants in the present study may have judged the angry faces as highly threatening instead. In fact, the angry faces used in this research were constructed to include features associated with high threat, such as direct eye gaze (Wieser, Pauli, Alpers, & Mühlberger, 2009) and a greater percentage of eye whites (Whalen et al., 2004). Because valence and arousal ratings of pictures were not obtained from participants, it is unclear whether the faces used in this study were judged as more or less threatening. Regardless, threat value is a factor that appears to greatly influence attentional patterns towards threat and likely contributed to the results of the present study.

At the same time, partcipants' mood state and stress level during attentional tasks seem to affect the outcome of attentional biases. Socially anxious individuals undergoing a social evaluative stress condition initially oriented more to emotional faces, compared to non-anxious controls. However, this effect was lost in no stress conditions (Garner et al., 2006). Similarly, individuals with increased state anxiety showed greater vigilance for threatening pictures than those with low state anxiety, irrespective of trait anxiety levels (Bradley et al., 2000). Alternatively, individuals induced into positive mood show an associated bias for positively valenced stimuli (Wadliger & Isaacowitz, 2006). If, in fact, attentional biases depend on current mood, then given that no induced stress or mood condition was used in the present study, no differences or a smaller, less discernible difference in LTA and HTA individuals would be expected. It should, however, be mentioned that HTA participants also exhibited greater state anxiety than LTA participants, but the mean score (M = 39.98) for the HTA group was still fairly low and may not have been enough to produce a bias effect. In fact, reports on the Visual Analogue Scale suggested that after the face viewing task participants were more calm and did not experience an increase in their level of fear. This suggests that the task was not stress-inducing, although it did lead to feeling less happy and content and more tired and bored, which may have affected attentional patterns differentially.

In this study, HTA individuals also did not show the selective avoidance of the threatening stimuli, which has been found to occur after approximately 1 second in previous research (Koster et al., 2006; Hermans et al., 1999; Rinck & Becker, 2006; Rohner, 2002; Stirling et al., 2006). Rather, the early bias exhibited by all participants for the combined angry face dissipated after 1500 ms and participants displayed similar attention for the angry face and each of the friendly faces. The lack of an avoidance effect by HTA individuals is likely connected to the fact that they did not engage in heightened vigilance for the angry faces and may be accounted for by the same factors thought to affect vigilance for threatening stimuli described above. Nevertheless, the disappearance of the angry face bias in all participants following 1500ms is consistent with other research showing a reduction in the vigilance for threat over time (Bradley et al., 1998; Liu et al., 2006) and may be considered a milder form of avoidance.

Although HTA individuals did not show a vigilant-avoidant pattern towards angry faces, they did show a marginal, overall tendency to look more often and for a longer period of time at all facial stimuli than LTA individuals across the 60 s of presentation. This tendency provides some evidence that attentional patterns differ between high anxious and low anxious individuals and suggest that high anxious individuals generally have more difficulty disengaging from facial stimuli. It may further reflect a general bias towards both positive and negative facial expressions, which has been found in previous studies (Garner et al., 2006). Perhaps friendly faces were judged as happy rather than neutral, as originally intended, due to the mouth resembling a smile, which may have led HTA individuals to be drawn to them as well. Alternatively, it may be that the friendly face was more ambiguous with regards to affect and in the context of another threatening face, HTA participants spent more time deciphering whether friendly faces also presented a threat. Consistent with this hypothesis, high anxious individuals seem to also maintain attention and have difficulty disengaging from jumbled or ambiguous faces (Fox et al., 2002), which may represent potential threat.

Did Sex of Participants Contribute to Different Attentional Patterns for Threat?

Contrary to expectations, participant's sex did not appear to influence attentional patterns towards the angry versus friendly faces. However, there was some evidence from the time course analyses of the 60-s presentation that attentional patterns for the facial stimuli as a whole differed by sex and anxiety group. HTA men generally looked at the faces more often (i.e., fixations) and for a marginally longer period of time (i.e., gaze durations) than LTA men. In particular, HTA and LTA men differed significantly in how often they fixated on the faces at the midpoint of the presentation (30-40s) due to a significant decrease in fixations by LTA men. In comparison, HTA and LTA women were more similar in their fixations for faces while they were somewhat more divergent in gaze durations. HTA women had marginally longer gaze durations than LTA women during the first 10 s, with no significant differences thereafter, suggesting an early vigilance for faces in HTA women. HTA women then showed a declining pattern of gaze durations, while LTA women exhibited a more variable pattern. In all, these results appear to suggest that anxiety is associated with greater attentional dissimilarities in men. Those with high anxiety show a greater vigilance for facial and emotional stimuli that is maintained for 60 seconds. In contrast, HTA and LTA women appear to have more similar fixations and gaze durations, with the exception that HTA women are more vigilant towards the facial and emotional stimuli early on and then exhibit a gradual decline in attention.

Differences in attention to emotional and facial stimuli in men and women are consistent with research showing that women have enhanced face and emotion processing than men (Craske, 2003). It is also consistent with sex differences in brain activation during facial and emotion processing (Hamann & Canli, 2004; Hofer et al., 2006), as well as sex differences in brain activity when emotion and cognitive processing interact, such as when negative mood is induced during a working memory task (Koch et al., 2007). Overall, women show greater activation in brain areas associated with emotion, such as the amygdala, while men show greater activation in brain areas associated with cognitive control, such as prefrontal and superior parietal activity (Koch et al., 2007). It may, thus, be that HTA men show a more female-typical pattern of emotion and face processing, along with a more female-typical pattern of brain activation, which results in their greater dissimilarity from LTA men.

Although attentional patterns towards threat were not influenced by sex of participants, a novel finding emerging from this study is that the sex of facial stimuli did appear to influence the attentional bias towards threat in the entire sample. Interestingly, all participants were more likely to fixate first on the angry female face, with a slightly greater tendency in LTA participants, and then show a continued bias towards the angry female from 500 to 1500 ms. This was followed by a gradual decrease in attention for the angry female face, such that heightened attention was maintained through the first 10 s of slide presentation, relative to the friendly male and child. In contrast, if participants fixated first on the angry male, they more quickly looked away from it. Although attention increased for the angry male during the 1000-1500ms interval, it did not significantly differ from the friendly faces, suggesting that the early vigilance occurred 500 ms earlier and was stronger for the angry female. Then, in the extended presentation (after the first 3 s), the angry male face was generally avoided, particularly during the 10-20s, 40-50s, and 50-60s intervals. In summary, patterns of attention by participants were best characterized by an early vigilance for the angry female and an overall avoidance of the angry male.

What may account for the stimulus-based sex effects on participants' attentional patterns? Given that angry faces did not differ from the friendly faces of the same sex in several analyses, one potential explanation is that the differential patterns were driven by sex of the face, rather than affect. It is possible that female faces in general draw more attention than male faces. One study supporting this idea found that female participants, regardless of social anxiety level, looked longer at female than male characters, particularly if they portrayed a direct eye gaze (Wieser et al., 2009). The authors concluded that this bias towards the female stimuli was related to female participants being more comfortable in same-sex interactions while they more often averted eye contact in opposite-sex interactions. However, this explanation cannot fully explain why both men and women in the present study showed selective attention for the angry female. Other characteristics of female faces may be involved. For example, infants appear to show a preference for female faces (Quinn, Yahr, Kuhn, Slater, & Pascalis, 2002), which is attributed to infants' greater experience with female caregivers. This may represent an adaptive mechanism to ensure survival, facilitating the mother-child bonding process and leading to nurturing of the infant. Remnants of this early bias may then carry on into adulthood. Alternatively, it is possible that female faces were perceived as more aesthetically pleasing, and research suggests that physically attractive women typically garner greater attention (DeWall & Maner, 2008). Based on these potential reasons, we would expect that the friendly and angry faces within each sex would consistently obtain equal amounts of attention throughout. However, several analyses did show a difference in attention for the angry and friendly female and for the angry and friendly male (e.g., first 3 second analyses), suggesting that sex may not be entirely driving the vigilance for the angry female and the avoidance of the angry male.

A second hypothesis is that the angry female faces were perceived as more novel because anger is more incongruent with the stereotypical female emotions (e.g., sadness, fear, happiness) and the perceived lower dominance of females (Hess, Adams, & Kleck, 2005). In fact, angry faces are most often judged to be male, while happy faces are more likely to be judged as female (Becker, Kenrick, Neuberg, Blackwell, & Smith, 2007). As a result of the mismatch between the expected emotional expression and gender, participants may be more likely to direct attention towards the angry female face.

Attending to the angry female more rapidly than the angry male may also signify an evolutionary advantage in the service of protecting offspring and ensuring reproductive success. This is supported by theories of cooperative breeding (Bergmüller, Johnstone, Russell, & Bshary, 2007), which suggest that animals and humans alike are invested in the care of the young, even if unrelated to one self. Because women's role has generally been one of nurturing for infants, an angry female may be perceived as an immediate danger to the life of a child, and early detection may motivate people to help and prevent harm. Interestingly, this idea is consistent with the increase in attention noted for the child faces during the 1500-2000ms interval, suggesting that after threat is detected, participants may be motivated to protect the child.

Finally, the divergent attentional patterns for the angry male and female may be due to differences in the perceived threat value of the male and female faces. It is possible that angry females were judged as mildly threatening because they are historically smaller and physically weaker than males (Becker et al., 2007), thereby leading to decreased arousal and a more gradual decline in attention to these faces. In contrast, angry males may be perceived as more aversive because they are generally bigger, stronger, and are more likely to become violent (Becker et al., 2007), thereby leading to greater arousal and general avoidance of angry males. If, indeed, angry men and women were perceived to have different levels of threat, then this may have been one reason for the lack of a difference between HTA and LTA individuals in this study. Given that threat value appears to contribute to whether differences are observed in high anxious and low anxious populations (Bradley et al., 2000), the inclusion of both mild and high threatening stimuli may have confounded the effects.

Summary of Digit Ratio Analyses and Discussion of Secondary Hypotheses

This research was also interested in following up on exploratory findings from a previous study demonstrating a positive association between trait anxiety and digit ratio in men (Evardone & Alexander, 2009). As other female-linked psychopathology, such as trait depression and eating disorder symptoms (Bailey & Hurd, 2005a; Klump et al., 2006) has been found to be positively correlated with digit ratio, suggesting that the development of these disorders is influenced by weaker prenatal androgen action, it was expected that scores on anxiety measures, particularly trait anxiety, would also be significantly and positively correlated with digit ratio. In addition, given that attentional biases towards threat are commonly found in anxious individuals and are theorized to contribute to the development and maintenance of anxiety, it was expected that the proxy measure of prenatal androgen action, digit ratio, would also be associated with this cognitive bias.

Contrary to previous findings, no association was found between digit ratio and trait anxiety in either men or women. This is consistent with the idea that trait anxiety may be more influenced by the socialization of gender roles, such that less masculine or instrumental traits are associated with higher trait anxiety (Evardone & Alexander, 2009). Nevertheless, correlations between the various measures of digit ratio in this study and scores on the anxiety scales revealed a small, yet significant association, between the live left hand measure of digit ratio and scores on the Obsessive-Compulsive Subscale of the PAI in men. Men with lower, more masculine digit ratios reported greater obsessive-compulsive symptoms than men with higher, less masculine digit ratios. Given the large number of analyses, this association may prove to be spurious. However, this finding is consistent with the greater prevalence of OCD in boys during childhood (Weiss & Last, 2001) and the relation between OCD and autism spectrum disorder traits (Ivarsson & Melin, 2008). The extreme-male brain theory of autism-spectrum disorders suggests that prenatal androgens may influence the development of autism by producing exaggerated male neuroanatomy and male-typical traits and behaviors (Baron-Cohen, Knickmeyer, & Belmonte, 2005). Significantly, more masculine digit ratios have also been associated with autism-spectrum disorders, (Manning et al., 2001; Voracek, 2008), and other male-linked disorders, such as ADHD (Martel et al., 2008; McFadden, Westhafer, Pasanen, Carlson, & Tucker, 2005; Stevenson et al., 2007). Thus, this new finding of an association between digit ratio and obsessive-compulsive symptoms suggests that the development of OCD may be influenced by an androgen-dependent organization of the brain in prenatal life, similar to other male-linked psychopathology, and should be further investigated in future research.

Interestingly, although attentional patterns towards threat did not appear to differ in LTA and HTA individuals in this study, attentional patterns during the first 3 s and the 60-s presentation did appear to differ between individuals with low and high digit ratio. A significant four-way interaction between digit ratio, sex, interval, and face type was found for the analyses of the first 3 seconds and a marginal interaction between digit ratio, sex, and time interval was found for the 60-s presentation. Overall, the exploratory analyses of the time course of attention towards threat in individuals with high and low digit ratio suggest that men with low and high digit ratio show similar patterns of attention towards angry faces (during first 3 s), relative to other faces, and towards faces in general (during 60-s presentation), while women with low and high digit ratio show a more divergent pattern of attention. In particular, women with high digit ratio seem to exhibit a "vigilant-avoidant" pattern, often seen in individuals with high anxiety. They showed an earlier vigilance (though not statistically significant) for the angry female face, relative to friendly faces, during the first 500 ms of presentation than women with low digit ratio and continued to maintain vigilance for the angry female through the 1000-1500ms interval. Women with high digit ratio then maintained attention for all faces for the first 20 s of presentation and then showed a more avoidant pattern during the remaining time intervals. In contrast, women with low digit ratio showed selective attention for the angry female face only during the 500-1000ms interval and exhibited a more constant pattern of fixations for all faces across the 60-s presentation.

The relation between digit ratio and attentional patterns towards threat observed in this study, may be related to the biological significance of attending to threatening stimuli to promote survival of the organism (Öhman, 1993). As digit ratio is a putative measure of prenatal androgen action, and hence a biological measure, it is not surprising that it would be related to a cognitive pattern with evolutionary significance. Individuals with high digit ratio may perceive threat as even more threatening because they are expected to be less strong (Fink, Thanzami, Seydel, & Manning, 2006), less aggressive (Bailey & Hurd, 2005b; Benderlioglu & Nelson, 2004; Kuepper & Hennig, 2007), and less socially dominant (Fink, Seydel, Manning, & Kappeler, 2007), leading them to be more vulnerable to peril. Thus, it may be that individuals with high digit ratio selectively attend to threat in order to promote self-preservation by preparing for or escaping the current danger. This proposal is consistent with results of a recent study showing that individuals with high digit ratio are more likely to act in a prosocial and less aggressive manner after viewing an aggressive video (Millet & Dewitte, 2009), which is interpreted as an attempt to please the aggressor and avoid harm.

Results from this study further suggest that early selective attention towards threat, compared to non-threatening stimuli, is most sensitive in females with high digit ratio. This may occur because women are even more vulnerable to peril due to their generally smaller size, strength, and level of physical aggression and dominance. In addition, women may have more of an imperative to attend to threat beyond self-preservation, and that is protection of offspring. Another angry woman may present a significant threat to the welfare of the children, so women may selectively attend to them.

The relation between digit ratio and attention towards threat in this study suggests that degree of prenatal androgenization may lead to cognitive biases, primarily an early vigilance towards threat, followed by a general avoidance of all stimuli, which may then influence the development of anxiety. This finding of a hormonal contribution to attentional biases is in line with studies demonstrating a relation between circulating levels of testosterone and attention towards threat, particularly attention towards angry faces (van Honk et al., 1999; Wirth &Schultheiss, 2007). Higher testosterone levels have been associated with greater attention towards threat, while lower testosterone levels have been associated with attention away from threat. As behaviors showing sensitivity to circulating sex hormones are believed to be organized through the sexual differentiation of brain structures in prenatal life (Collaer & Hines, 1995), the relation between circulating testosterone and attention towards threat provides compelling evidence that prenatal androgen action influences attentional biases typically observed in anxious individuals. It should be noted, however, that women taking oral contraceptives in this study did not differ in reports of trait anxiety or attentional patterns towards threat from women not taking oral contraceptives. Although this was a fairly rough measure of circulating hormones in women and more precise measures (e.g., salivary or blood assays) may reveal different results, this suggests that the association between attentional patterns and circulating hormones may be most sensitive for male-typical (i.e., androgens) than female-typical hormones (i.e., estradiol and progestin).

Summary of Face Recognition Task and Discussion

As would be expected by women's enhanced ability to identify and process emotional and facial stimuli (Craske, 2003), women were more accurate and confident in their ratings of old and new faces during the face recognition task. However, LTA and HTA women and men did not differ in their recognition of angry faces. The latter is consistent with previous research showing that anxiety is associated with attentional, but not memory biases, towards threat (Rinck & Becker, 2005).

Limitations and Future Directions

Although it is plausible that no true differences existed in the time course of attention towards threat by HTA and LTA women and men, characteristics of the sample and the study design may have affected this study's ability to detect differences between these groups. First, clinical samples (i.e., those meeting criteria for clinical disorders like GAD and Specific Phobias) may have more clear attentional biases towards threat than non-clinical samples. In support of this idea, post-experiment exploratory analyses of the most and least anxious participants in this study, revealed that those with the highest anxiety levels (i.e., more similar to clinical samples) showed an attentional bias for the angry male during the first 3 seconds of presentation and a bias for the angry female over the entire 60 s. Yet, even within the most anxious participants, no evidence of the vigilant-avoidant pattern was found. Second, the present study used a sample of young adults ranging in age from 18-27, and young adults have been previously shown to have a general bias for negative stimuli, particularly if in a bad mood, while older adults appear to have a positive bias (Isaacowitz, Toner, Goren, & Wilson, 2008; Leclerc

& Kensinger, 2008). Third, the format of the stimulus presentation may have led to a similar bias towards threat in HTA and LTA individuals, which was unforeseen prior to the study. It has been previously found that a discrepant angry face in the context of three friendly faces, similar to the design in the present study, was associated with facilitated detection of the angry face by a non-anxious sample (Calvo et al., 2006). Although the authors conclude that this is related to improved processing efficiency for the angry face and not initially orienting attention towards it, the lone angry face amidst the majority of friendly faces may have drawn attention from everyone. Fourth, although previous researchers have suggested that facial cues are salient stimuli for HTA individuals (Rohner, 2002), it is possible that faces are not sufficiently relevant or specific to the concerns of this population to produce a threat bias. For example, research showing differences between anxious and non-anxious populations has often used stimuli specific to the type of disorder, such as crowds of people for social phobia and spiders for spider phobia. The inclusion of stimuli more consistent with the concerns of HTA individuals (i.e., threat of failure in school or work, illness, threats to relationships) may yield a different pattern of results. Fifth, the relatively long duration of slide presentation (60 s) appears to have produced a tiredness and boredom effect, which may have affected attention to subsequent slides. Sixth, unlike studies using more elaborate cover stories, participants in the present study were informed that the purpose was to examine how certain personality characteristics and mood may influence how people process faces. They were also explicitly told that a camera would be monitoring their eye movements. Although participants were not aware that they were selected for the study due to anxiety level, vague knowledge about the study's purpose may have affected their looking patterns. In addition, a manipulation check was not included in this research, so it is unclear if the threat value and valence of the facial stimuli affected results. Finally, it has been reported that research assessing biases in attentional patterns generally show weaker effects than research examining memory biases for negative and positive information (Murphy & Isaacowitz, 2008), and thus need bigger sample sizes to have sufficient power to detect differences.

Future research should thus examine the "vigilant-avoidant" hypothesis of anxiety in various clinical (e.g., GAD, PTSD, SAD, PD) and non-clinical (state anxiety, trait anxiety, social anxiety) populations to determine the existence and stability of this bias across the developmental stages of anxiety. Research should also incorporate participants of various age groups to determine whether attentional patterns towards threat in anxiety override other age-related biases in emotional information across the life span. In addition, rather than using one angry face in the context of three friendly faces, which may inadvertently lead to attention for the discrepant face, future research might benefit from using multiple facial stimuli with varying facial expressions (e.g., sad, disgusted, surprised, happy), as well as using visual stimuli that has threat specificity for the particular population studied. Finally, due to the potential that angry females and angry males may be perceived as more or less threatening, future research should investigate attentional patterns for angry males and angry females in separate experiments.

SUMMARY AND CONCLUSIONS

Results from the present study do not support the presence of a heightened vigilant-avoidant pattern of attention towards threat in HTA versus LTA individuals reported for other high anxious versus low anxious populations (Calvo & Avero, 2005, Garner et al., 2006; Rinck & Becker, 2006). Rather, all individuals displayed a greater likelihood of initially orienting to the angry face and continued selective attention towards angry faces during the first 1500ms of presentation. This was followed by increased attention to the child face between 1500-2000ms, and no differences in attention by face type during the last 1000ms. An unexpected, yet novel, finding of this study was that this early attentional bias towards threat was influenced by the sex of the facial stimuli, such that participants initially oriented and engaged attention towards the angry female. Yet over the extended 60-s presentation, it was the angry male face that was generally avoided, particularly during the last 20s of presentation. To the author's knowledge, no previous studies have examined the effects of facial cues' sex on attentional patterns. Though the early bias towards angry females may have various explanations, such as a lower threat value than angry males, results are believed to shed light on the biological preparedness leading humans to automatically detect female threat in the environment and ensure the survival of infants.

The role of evolutionary mechanisms in threat detection is further elucidated by the second novel finding of this study, that of an association between a biologically-relevant measure, digit ratio, and attentional patterns towards angry faces, relative to friendly faces. In particular, although men with low and high digit ratios did not seem to attend differently to the angry faces as compared to the other faces, women with low digit ratio and women with high digit ratio showed an early vigilance for the angry female face. Nonetheless, women with high digit ratio showed trends of this vigilance starting at the 0-500ms whereas women with low digit ratio did not selectively engage on the angry female until the 500-1000ms interval. After 1000 ms, women with low digit ratio showed fairly equal attention for all the faces, which remained mostly stable throughout the 60 s. After 1500ms, women with high digit ratio showed no differences in attention for each face type, but showed a significant decline in attention towards all faces beyond the first 20s of slide presentation. Results appear to suggest an enhanced presentation of a partial “vigilant-avoidant” model in women with more feminine digit ratios, and thus weaker prenatal androgen action. Hormonal influences on the development of cognitive biases may then serve as a precursor for the development of trait anxiety and anxiety disorders.

REFERENCES

Alexander, G. M., & Peterson, B.S. (2001). Sex steroids and human behavior: Implications for developmental psychopathology, *CNS Spectrums, 6,* 75-88.

Alpers, G. W. (2008). Eye catching: Right hemisphere attentional bias for emotional pictures. *Laterality: Assymetries of Body, Brain and Cognition, 13*, 158-178.

Armstrong, K.A. & Khawaja, N.G. (2002). Gender differences in anxiety: An investigation of the symptoms, cognitions, and sensitivity towards anxiety in a nonclinical population. *Behavioural and Cognitive Psychotherapy, 30*, 227-231.

Bailey, A. A., & Hurd, P. L. (2005a). Depression in men is associated with more feminine finger length ratios. *Personality and Individual Differences, 39*, 829-836.

Bailey, A. A. & Hurd, P. L. (2005b). Finger length ratio (2D:4D) correlates with physical aggression in men but not in women. *Biological Psychology,* 68, 215-222.

Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M. J., & van Ijzendoorn, M. H. (2007). Threat-related attentional bias in anxious and nonanxious individuals: A meta-analytic study. *Psychological Bulletin, 133*, 1-24.

Baron-Cohen, S., Knickmeyer, R. C., &Belmonte, M. K. (2005). Sex differences in the brain: Implications for explaining autism. *Science, 310*, 819-823.

Beck, A. T., & Clark, D. A. (1997). An information processing model of anxiety: Automatic and strategic processes. *Behaviour Research and Therapy, 35*, 49-58.

Beck, A.T., Steer, R. A., & Brown, G. K. (1996). *Manual for the Beck Depression Inventory-II*. San Antonio, TX: Psychological Corporation.

Becker, D. V., Kenrick, D. T., Neuberg, S. L., Blackwell, K. C., & Smith, D. M. (2007). The confounded nature of angry men and happy women. Journal of Personality and Social Psychology, 92, 179-190.

Bem., S. L. (1974). The measurement of psychological androgyny. *Journal of Consulting and Clinical Psychology, 42*, 155-162.

Bem, S. L. (1981). *Bem Sex Role Inventory professional manual*. Palo Alto, CA:

Consulting Psychologists Press.

Benderlioglu, Z., & Nelson, R. J. (2004). Digit-length ratios predict reactive aggression in women, but not in men. *Hormones and Behavior, 46*, 558-564.

Bergmüller, R., Johnstone, R. A., Russell, A. F., & Bshary, R. (2007). Integrating cooperative breeding into theoretical concepts of cooperation. *Behavioural Processes,76*, 61-72.

Bradley, B. P., Mogg, K., Falla, S. J., & Hamilton, L. R. (1998). Attentional bias for threatening facial expressions in anxiety: Manipulation of stimulus duration. *Cognition and Emotion, 12*, 737-753.

Bradley, B. P., Mogg, K., & Millar, N. H. (2000). Covert and overt orienting of attention to emotional faces in anxiety. *Cognition and Emotion, 14,* 789-808.

Breedlove, S. M. (1994). Sexual differentiation of the human nervous system. *Annual Review of Psychology, 45*, 389-418.

Brown, W., Hines, M., Fane, B. A., & Breedlove, S. M. (2002). Masculinized finger length patterns in human males and females with congenital adrenal hyperplasia. *Hormones and Behavior, 42*, 380-386.

Calvo, M. G., & Avero, P. (2005). Time course of attentional bias to emotional scenes in anxiety: Gaze direction and duration. *Cognition and Emotion, 19*, 433-451.

Calvo, M. G., Avero, P., & Lundqvist, D. (2006). Facilitated detection of angry faces: Initial orienting and processing efficiency. *Cognition and Emotion, 20*, 785-811.

Calvo, M. G., & Lang, P. J. (2004). Gaze patterns when looking at emotional pictures: Motivationally biased attention. *Motivation and Emotion, 28*, 221-243.

Caseras, X., Garner, M., Bradley, B. P., & Mogg, K. (2007). Bias in visual orienting to negative and positive scenes in dysphoria: An eye movement study. *Journal of Abnormal Psychology, 116*, 491-497.

Cohen-Bendahan, C. C. C, van de Beek, C., & Berenbaum, S. A. (2005). Prenatal sex hormone effects on childhood and adult sex-typed behavior: methods and findings. *Neuroscience and Biobehavioral Reviews, 29*, 353-384.

Collaer, M. L. & Hines, M. (1995). Human behavioral sex differences: A role for gonadal hormones during early development. *Psychological Bulletin,* 118, 55-107.

Craske, M. G. (2003). *Origins of phobias and anxiety disorders: Why more women than men?* Oxford, UK: Elsevier.

Crowne, D. P., & Marlowe, D. (1960). A new scale of social desirability independent of psychopathology. *Journal of Consulting Psychology, 24*, 349-354.

de Bruin, E. I., Verheij, F., Wiegman, T., & Ferdinand, R. F. (2006). Differences in finger length ratio between males with autism, pervasive developmental disorder-not otherwise specified, ADHD, and anxiety disorders. *Developmental Medicine and Child Neurology, 48*, 962-965.

Dewall, C. N., & Maner, J. K. (2008). High status men (but not women) capture the eye of the beholder. *Evolutionary Psychology, 6*, 328-341.

Ellenbogen, M. A., & Schwartzman, A. E. (2009). Selective attention and avoidance on a pictorial cueing task during stress in clinically anxious and depressed participants. *Behaviour Research and Therapy, 47*, 128-138.

Evardone, M., & Alexander, G. M. (2009). Anxiety, sex-linked behaviors, and digit ratios (2D:4D). *Archives of Sexual Behavior, 38,* 442-455.

Fink, B., Manning, J. T., & Neave, N. (2004). Second to fourth digit ratio and the ‘big five’ personality factors. *Personality and Individual Differences, 37*, 495-503.

Fink, B., Seydel, H., Manning, J. T., & Kappeler, P. M. (2007). A preliminary investigation of the associations between digit ratio and women’s perception of men’s dance. *Personality and Individual Differences, 42*, 381-390.

Fink, B., Thanzami, V., Seydel, H., & Manning, J. T. (2006). Digit ratio and hand-grip strength in German and Mizos men: Cross-cultural evidence for an organizing effect of prenatal testosterone on strength. *American Journal of Human Biology, 18*, 776-782.

Fox, E., Russo, R., Bowles, R., & Dutton, K. (2001). Do threatening stimuli draw or hold visual attention in subclinical anxiety? *Journal of Experimental Psychology: General, 130*, 681-700.

Fox, E., Russo, R., & Dutton, K. (2002). Attentional bias for threat: Evidence for delayed disengagement from emotional faces. *Cognition and Emotion, 16*, 355-379.

Freeman, D., Garety, P. A., & Phillips, M. L. (2000). An examination of hypervigilance for external threat in individuals with generalized anxiety disorder and individuals with persecutory delusions using visual scan paths. *The Quarterly*

Journal of Experimental Psychology, 53A, 549-567.

Frewen, P. A., Dozois, D. J. A., Joanisse, M. F., & Neufeld, R. W. J. (2008). Selective attention to threat versus reward: Meta-analysis and neural-network modeling of the dot-probe task. *Clinical Psychology Review, 28*, 307-337.

Garner, M., Mogg, K., & Bradley, B. P. (2006). Orienting and maintenance of gaze to facial expressions in social anxiety. *Journal of Abnormal Psychology, 115*, 760-770.

Gerdes, A. B. M., Alpers, G. W., & Pauli, P. (2008). When spiders appear suddenly: Spider-phobic patients are distracted by task-irrelevant spiders. *Behaviour Research and Therapy, 46*, 174-187.

Hall, G. B. C., Witelson, S. F., Szechtman, H., & Nahmias, C. (2004). Sex differences in functional activation patterns revealed by increased emotion processing demands. *NeuroReport, 15*, 219-223.

Hamann, S., & Canli, T. (2004). Individual differences in emotion processing. *Current Opinion in Neurobiology, 14*, 233-238.

Hermans, D., Vansteenwegen, D., & Eelen, P. (1999). Eye movement registration as a continuous index of attention deployment: Data from a group of spider anxious students. *Cognition & Emotion, 13*, 419-434.

Hess, U., Adams, R. B. J., & Kleck, R. E. (2005). Who may frown and who should smile? Dominance, affiliation, and the display of happiness and anger. *Cognition and Emotion, 19*, 515-536.

Heuer, K., Rinck, M., & Becker, E. S. (2007). Avoidance of emotional facial expressions in social anxiety: The approach-avoidance task. *Behaviour Research and Therapy, 45*, 2990-3001.

Hofer, A., Siedentopf, C. M., Ischebeck, A., Rettenbacher, M. A., Verius, M., Felber, S., et al. (2006). Gender differences in regional cerebral activity during the perception of emotion: A functional MRI study. *NeuroImage, 32*, 854-862.

Holt, C. L., & Ellis, J. B. (1998). Assessing the current validity of the Bem Sex-Role Inventory, *Sex Roles, 39*, 929-941.

Howell, H. B., Castle, D. J., & Yonkers, K. A. (2006). Anxiety disorders in women. In D. J. Castle, J. Kulkarni, & K. M. Abel (Eds.), *Mood and anxiety disorders in women* (pp. 59-74). New York, NY: Cambridge University Press.

Ioannou, M. C., Mogg, K., & Bradley, B. P. (2004). Vigilance for threat: Effects of anxiety and defensiveness. *Personality and Individual Differences, 36*, 1879-1891.

Isaacowitz, D. M., Toner, K., Goren, D. & Wilson, H. (2008). Looking while unhappy: Mood-congruent gaze in young adults, positive gaze in older adults. *Psychological Science, 19*, 848-853.

Ivarsson, T., & Melin, K. (2008). Autism spectrum traits in children and adolescents with obsessive-compulsive disorder (OCD). *Journal of Anxiety Disorders, 22*, 969-978.

Juth, P., Lundqvist, D., Karlsson, A., & Öhman, A. (2005). Looking for foes and friends: Perceptual and emotional factors when finding a face in a crowd. *Emotion, 5*, 379-395.

Kellough, J. L., Beevers, C. G., Ellis, A. J., & Wells, T. T. (2008). Time course of selective attention in clinically depressed young adults: An eye tracking study. *Behaviour Research and Therapy, 46*, 1238-1243.

Klump, K. L., Gobrogge, K. L., Perkins, P. S., Thorne, D., Sisk, C. L., & Breedlove, S. M. (2006). Preliminary evidence that gonadal hormones organize and activate disordered eating. *Psychological Medicine, 36*, 539-546.

Koch, K., Pauly, K., Kellermann, T., Seiferth, N. Y., Reske, M., Backes, V. et al. (2007). Gender differences in the cognitive control of emotion: An fMRI study. *Neuropsychologia, 45*, 2744-2754.

Koster, E. H. W., Crombez, G., Verschuere, B., & De Houwer, J. (2004). Selective attention to threat in the dot probe paradigm: Differentiating vigilance and difficulty to disengage. *Behaviour Research and Therapy, 42*, 1183-1192.

Koster, E. H. W., Crombez, G., Verschuere, B., Van Damme, S., & Wiersema, J.R. (2006). Components of attentional bias to threat in high trait anxiety: Facilitated engagement, impaired disengagement, and attentional avoidance. *Behaviour Research and Therapy, 44*, 1757-1771.

Koster, E. H. W., Verschuere, B., Crombez, G., & Van Damme, S. (2005). Time-course of attention for threatening pictures in high and low trait anxiety. *Behaviour Research and Therapy, 43*, 1087-1098.

Kuepper, Y., & Hennig, J. (2007). Behavioral aggression is associated with the 2D:4D ratio in men but not in women. *Journal of Individual Differences, 28*, 64-72.

Lange, W., Keijsers, G., Becker, E. S., & Rinck, M. (2008). Social anxiety and evaluation of social crowds: Explicit and implicit measures. *Behaviour Research and Therapy, 46*, 932-943.

Leclerc, C. M., & Kensinger, E. A. (2008). Age-related differences in medial prefrontal activation in response to emotional images. *Cognitive, Affective, & Behavioral Neuroscience, 8*, 153-164.

Lippa, R. (1991). Some psychometric characteristics of gender diagnosticity measures: Reliability, validity, consistency across domains, and relationship to the Big Five. *Journal of Personality and Social Psychology, 61*, 1000-1011.

Liu, X., Qian, M., Zhou, X., & Wang, A. (2006). Repeating the stimulus exposure to investigate what happens after initial selective attention to threatening pictures. *Personality and Individual Differences, 40*, 1007-1016.

Lundqvist, D., Esteves, F., Öhman, A. (1999). The face of wrath: Critical features for conveying facial threat. *Cognition and Emotion, 13*, 691-711.

MacLeod, C., Mathews, A., & Tata, P. (1986). Attentional bias in emotional disorders. *Journal of Abnormal Psychology, 95*, 15-20.

Manning, J. T., Baron-Cohen, S., Wheelwright, S., & Sanders, G. (2001). The 2nd to 4th digit ratio and autism. *Developmental Medicine & Child Neurology, 43*, 160-164.

Manning, J. T., Scutt, D., Wilson, J., & Lewis-Jones, D. I. (1998). The ratio of the 2nd and 4th digit length: A predictor of sperm numbers and concentrations of testosterone, luteinizing hormone, and oestrogen. *Human Reproduction, 13*, 3000-3004.

Martel, M. M., Gobrogge, K. L., Breedlove, S. M., & Nigg, J. T. (2008). Masculinized finger-length ratios of boys, but not girls, are associated with attention-deficit/hyperactivity disorder. *Behavioral Neuroscience, 122*, 273-281.

McFadden, D., & Shubel, E. (2002). Relative lengths of fingers and toes in human males and females. *Hormones and Behavior, 42*, 492-500.

McFadden, D., Westhafer, J. G., Pasanen, E. G., Carlson, C. L. & Tucker, D. M. (2005). Physiological evidence of hypermasculinization in boys with the inattentive type of attention-deficit hyperactivity disorder (ADHD). *Clinical Neuroscience Research,* 5, 233-245.

McIntyre, M. H. (2006). The use of digit ratios as markers for perinatal androgen action. *Reproductive Biology and Endocrinology, 4*, 10-18.

Millet, K., & Dewitte, S. (2009). The presence of aggression cues inverts the relation between digit ratio (2D:4D) and prosocial behaviour in a dictator game. *British Journal of Psychology, 100*, 151-162.

Mogg, K., & Bradley, B. P. (2004). A cognitive-motivational perspective on the processing of threat information and anxiety. In J. Yiend (Ed.), *Cognition, emotion, and psychopathology: Theoretical, empirical and clinical directions* (pp. 68-85). New York: Cambridge University Press.

Mogg, K., Garner, M., & Bradley, B. P. (2007). Anxiety and orienting of gaze to angry and fearful faces. *Biological Psychology, 76*, 163-169.

Mogg, K., Millar, N., & Bradley, B. P. (2000). Biases in eye movements to threatening facial expressions in generalized anxiety disorder and depressive disorder. *Journal of Abnormal Psychology, 109*, 695-704.

Morey, L. C. (1991). *The Personality Assessment Inventory professional manual (PAI)*. Odessa, FL: Psychological Assessment Resources.

Mühlberger, A., Wieser, M. J., & Pauli, P. (2008). Visual attention during virtual social situations depends on social anxiety. *Cyberpsychology & Behavior, 11*, 425-430.

Murphy, N. A., & Isaacowitz, D. M. (2008). Preferences for emotional information in older and younger adults: A meta-analysis of memory and attention tasks. *Psychology and Aging, 23*, 263-286.

Murphy, P. L. (1994). Social interest and psychological androgyny: Conceptualized and tested. *Individual Psychology: Journal of Adlerian Theory, Research & Practice, 50*, 18-30.

Nummenmaa, L., Hyönä, & Calvo, M. G. (2006). Eye movement assessment of selective attentional capture by emotional pictures. *Emotion, 6,* 257-268.

O'Grady, K. E. (1988). The Marlowe-Crowne and Edwards Social Desirability Scales: A psychometric perspective. *Multivariate Behavioral Research, 23*, 87-101.

Öhman, A. (1993). Fear and anxiety as emotional phenomena: Clinical phenomenology, evolutionary perspectives, and information-processing mechanisms. In M. Lewis & J. M. Haviland (Eds.), *Handbook of emotions* (pp.511-536). New York: Guilford Press.

Öhman, A., Flykt, A., & Esteves, F. (2001). Emotion drives attention: Detecting the snake in the grass. *Journal of Experimental Psychology: General, 130*, 466-478.

Palermo, R., & Rhodes, G. (2007). Are you always on my mind? A review of how face perception and attention interact. *Neuropsychologia, 45*, 75-92.

Pigott, T. A. (2003). Anxiety disorders in women. *Psychiatric Clinics of North America, 26*, 621-672.

Quinn, P. C., Yahr, J., Kuhn, A., Slater, A. M., & Pascalis, O. (2002). Representation of the gender of human faces by infants: A preference for female. *Perception, 31*, 1109-1121.

Rammsayer, T. H., & Troche, S. J. (2007). Sexual dimorphism in second-to-fourth digit ratio and its relation to gender-role orientation in males and females. *Personality and Individual Differences, 42*, 911-920.

Rayner, K. (1998). Eye movements in reading and information-processing: 20 years of research. *Psychological Bulletin, 124*, 372-422.

Rinck, M., & Becker, E. S. (2005). A comparison of attentional biases and memory biases in women with social phobia and major depression. *Journal of Abnormal Psychology, 114*, 62-74.

Rinck, M., & Becker, E. S. (2006). Spider fearful individuals attend to threat, then quickly avoid it: Evidence from eye movements. *Journal of Abnormal Psychology, 115*, 231-238.

Rinck, M., Reinecke, A., Ellwart, T., Heuer, K., & Becker, E. S. (2005). Speeded detection and increased distraction in fear of spiders: Evidence from eye movements. *Journal of Abnormal Psychology, 114*, 235-248.

Rohner, J.-C. (2002). The time-course of visual threat processing: High trait anxious individuals eventually avert their gaze from angry faces. *Cognition and Emotion, 16*, 837-844.

Rohner, J.-C. (2004). Memory-based attentional biases: Anxiety is linked to threat avoidance. *Cognition and Emotion, 18*, 1027-1054.

Spielberger, C. D. (1983). *Manual for the State-Trait Anxiety Inventory (Form Y).* Palo Alto, CA: Consulting Psychologists Press.

Stevenson, J. C., Everson, P. M., Williams, D. C., Hipskind, G., Grimes, M. & Mahoney, E. R. (2007). Attention deficit/hyperactivity disorder (ADHD) symptoms and digit ratios in a college sample. *American Journal of Human Biology, 19*, 41-50.

Stirling, L. J., Eley, T. C., & Clark, D. M. (2006). Preliminary evidence for an association between social anxiety symptoms and avoidance of negative faces in school-age children. *Journal of Clinical Child and Adolescent Psychology, 35*, 440-445.

van Honk, J., Tuiten, A., Verbaten, R., van de Hout, M., Koppeschaar, H., Thijssen, J. et al. (1999). Correlations among salivary testosterone, mood, and selective attention to threat in humans. Hormones and Behaviors, 36, 17-24.

Verkuil, B., Brosschot, J. F., Putman, P., & Thayer, J. F. (2009). Interacting effects of worry and anxiety on attentional disengagement from threat. *Behaviour Research and Therapy, 47*, 146-152.

Voracek, M. (2008). Digit ratio (2D:4D) as a marker for mental disorders: Low (masculinized) 2D:4D in autism-spectrum disorders, high (feminized) 2D:4D in schizophrenic-spectrum disorders. *Behavioral and Brain Sciences, 31*, 283-284.

Wadlinger, H. A., & Isaacowitz, D. M. (2006). Positive mood broadens visual attention to positive stimuli. *Motivation and Emotion, 30*, 89-101.

Weiss, D. D. & Last, C. G. (2001). Developmental variations in the prevalence and manifestation of anxiety disorders. In M.W. Vasey, & M. R. Dadds (Eds.), *The Developmental Psychopathology of Anxiety* (pp. 27-42). London: Oxford University Press.

Whalen, P. J., Kagan, J., Cook, R. G., Davis, F. C., Kim, H., Polis, S. et al. (2004). Human amygdala responsivity to masked fearful eye whites. *Science, 306*, 2061.

Wiebe, J. S., & Penley, J. A. (2005). A psychometric comparison of the Beck Depression Inventory-II in English and Spanish. *Psychological Assessment, 17*, 481-485.

Wieser, M. J., Pauli, P., Alpers, G. W., & Mühlberger, A. (2009). Is eye to eye contact really threatening and avoided in social anxiety? – An eye-tracking and psychophysiology study. *Journal of Anxiety Disorders, 23*, 93-103.

Williams, J. H. G., Greenhalgh, K. D., & Manning, J. T. (2003). Second to fourth finger ratio and the possible precursors of developmental psychopathology in preschool children. *Early Human Development, 72*, 57-65.

Williams, J. M. G., Mathews, A., & MacLeod, C. (1996). The emotional stroop task and psychopathology. *Psychological Bulletin, 120*, 3-24.

Williams, J. M. G., Watts, F. N., MacLeod, C., & Mathews, A. (1997). *Cognitive psychology and emotional disorders* (2nd ed.). Chichester, England: Wiley.

Williams, T. J., Pepitone, M. E., Christensen, M. E., Cooke, B. M., Huberman, A. D., Breedlove, N. J., et al. (2000). *Finger-lengths ratios and sexual orientation. Nature, 404*, 455-456.

Wirth, M. M., & Schultheiss, O. C. (2007). Basal testosterone moderates responses to anger faces in humans. *Physiology & Behavior, 90*, 496-505.

Yiend, J., & Mathews, A. (2001). Anxiety and attention to threatening pictures. *The Quarterly Journal of Experimental Psychology, 54A*, 665-681.

APPENDIX A

EXAMPLES OF ATTENTIONAL PARADIGMS

Spider

Dog

Cat

Tarantula

Bear

Dolphin

Horse

Figure A-1. Sample Emotional Stroop Task.

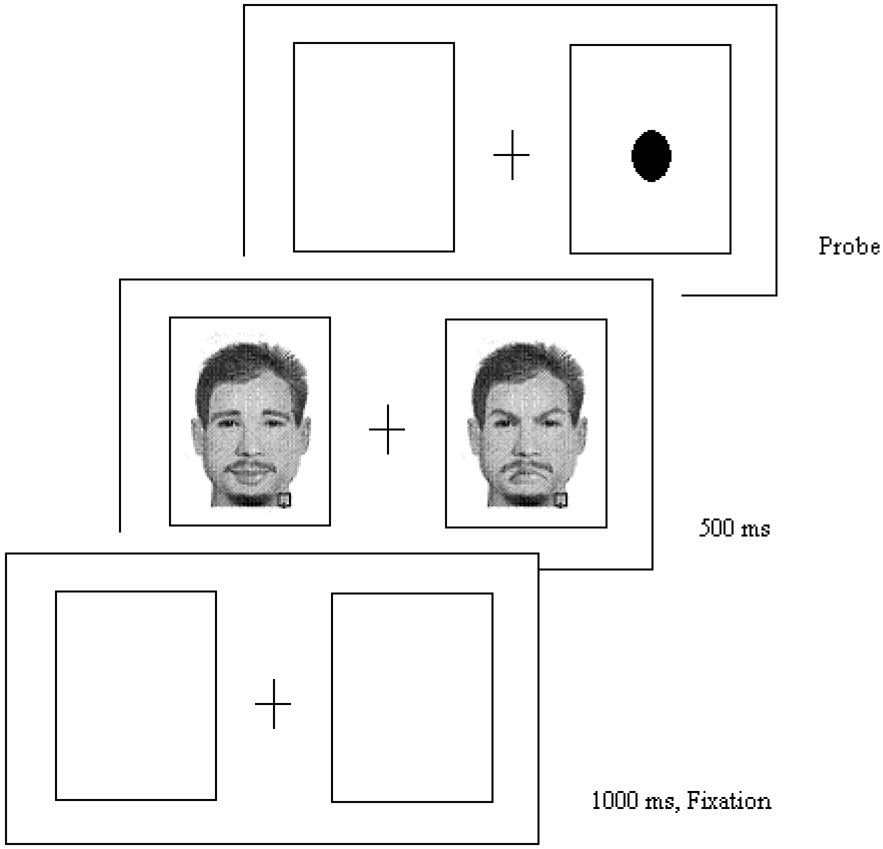


Figure A-2. Sample Dot-probe Task.

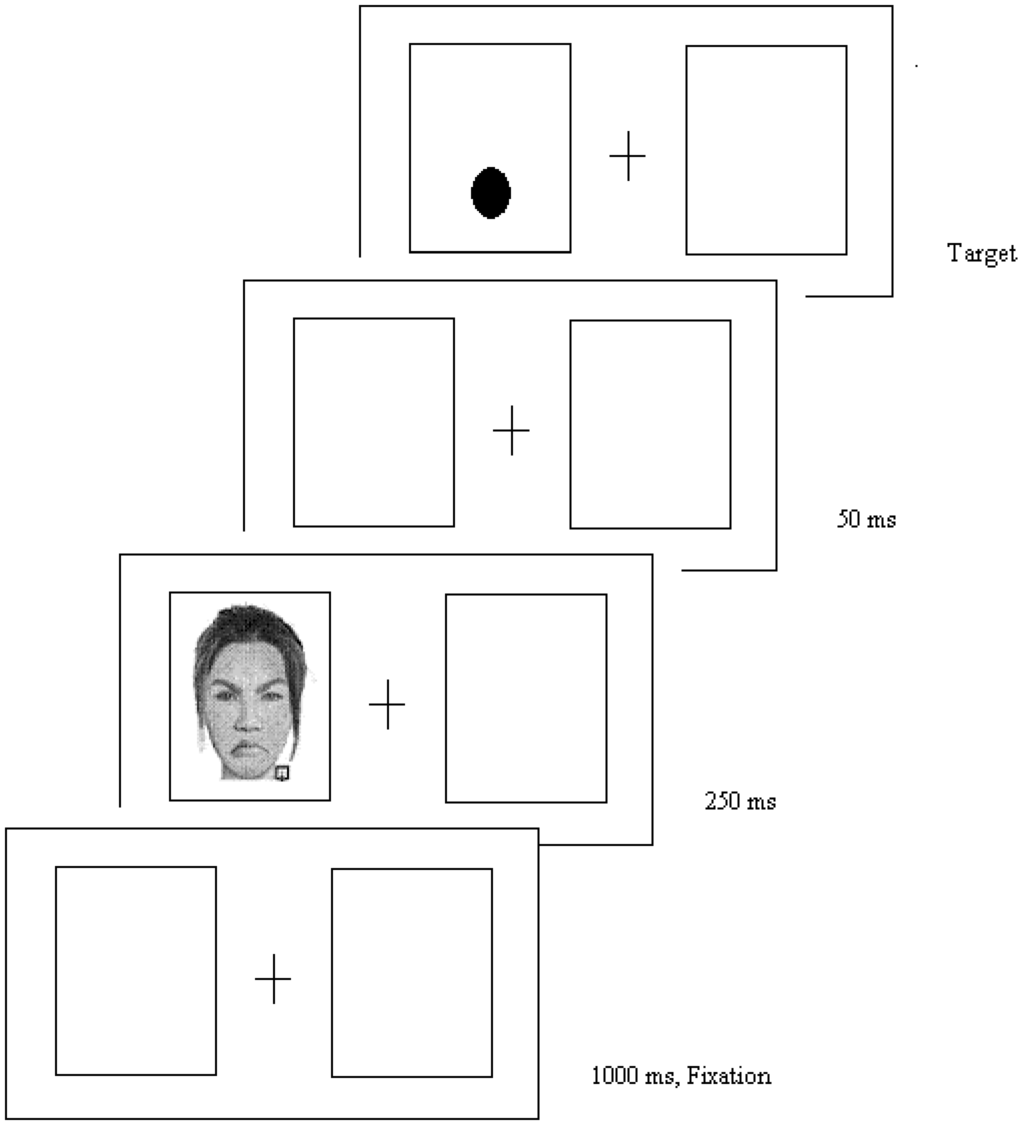


Figure A-3. Sample Cueing Task.

VITA

Name:	Milagros Evardone
Address:	Department of Psychology 4235 TAMU College Station, Texas 77843
Email Address:	mevardon7@tamu.edu

Education:	B.S., Psychology, University of Florida, 2002 M.S., Psychology, Texas A&M University, 2006