What is the Nature of Anxiety-Related Attentional Bias to Threat?

by

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A thesis
presented to the University of Waterloo
in fulfillment of the
thesis requirement for the degree of
Doctor of Philosophy
in
Psychology

Waterloo, Ontario, Canada, 2014

AUTHOR'S DECLARATION

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

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Abstract

Although attentional biases to threat (ABT) are thought to contribute to the development and persistence of anxiety disorders (e.g., Matthews & Mackintosh, 1998; Mogg & Bradley, 1998), it is not clear whether such biases in high trait and clinically anxious individuals are characterized as vigilance in directing attention towards threat (i.e., vigilance hypothesis) and/or a delay in disengaging from threat once it has been detected (i.e., maintenance hypothesis; Weierich, Treat, & Hollingworth, 2008). Furthermore, some researchers have suggested that anxiety disorders are maintained when vigilance for threat is followed by avoidance over time (i.e., vigilance-avoidance hypothesis; Mogg & Bradley, 1998). Thus, further research clarifying the nature of anxiety-related ABT over an extended time course is needed. In the current program of research, I conducted three studies using a free viewing eye movement paradigm where participants were presented with pairs of images, one that was threat-related and one that was neutral, while their viewing behaviour was monitored over time. Study 1 indicated that while all participants showed a general vigilance-avoidance pattern to threat over time, trait-anxiety was not associated with ABT over a 3000 ms time course. However, in Study 2 when state anxiety was elevated, HTA individuals showed a greater proportion of viewing time assigned to threat stimuli than those low in trait anxiety when averaged over the 3000 ms time course, indicating a greater maintenance of attention following threat detection. Vigilance for threat was found in all participants for emotional stimuli in general. In Study 3, the relative contribution of trait and state anxiety on ABT was assessed by manipulating state anxiety levels within-participants and the data indicated that state anxiety, rather than trait anxiety, was associated with an increase in the maintenance of attention on threat over a 5000 ms time course. Overall, the results suggest that early vigilance for threat and the maintenance on threat over time are likely more normative process involved in an effective threat detection system rather than maladaptive processes that predict vulnerability to anxiety and anxiety disorders. Further theoretical and clinical implications, as well as areas for further study, are discussed.

Acknowledgements

I would first like to deeply thank my supervisors Christine Purdon and Daniel Smilek for their continued scientific, financial and moral support with this program of research and for their invaluable passion for the field and mentorship in my research and clinical career more generally. I would also like to sincerely thank my committee member, Jonathan Oakman, as well as Erik Z. Woody for their long-standing assistance with my research, clinical practice and professional development.

Support for this research was received from the Social Sciences and Humanities Research Council (SSHRC) through a Joseph-Armand Bombardier Canadian Graduate Scholarship Doctoral Award.

Moreover, I would like to give a special acknowledgment to my colleagues and collaborators, Jonathan Carriere, Leanne Quigley and Stephanie Waechter who have worked with me in the trenches and become my dear friends. Also, I could not have completed the current program of research without many hard working and dedicated research assistants: Hafeera Abubacker, Amanda Cheung, Jenna Dawson, Maja Djuric, Ira Grover, Phoebe Lo, Brandon Ralph, Dan van der Werf and Trish L. Varao Sousa.

Last, but not least, I would like to thank all my professors and supervisors at the University of British Columbia, University of Victoria and University of Waterloo who have inspired me to think critically about the field of Psychology and that have taught me to develop strong, systematic and creative research in the pursuit of evidence based practices in Clinical Psychology.

Dedication

I would like to dedicate this dissertation to my amazing husband Paul, who has supported me in all endeavours and encouraged me to follow my passions and dreams.

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Chapter 1

The Time Course of Anxiety-Related Attentional Biases to Threat

1.1 Introduction

Leading models of anxiety propose that preferences for attending to threatening relative to neutral information, or *attentional biases towards threat* (ABT), are associated with the development and maintenance of anxiety and anxiety disorders (Beck & Clark, 1997; Eysenck, 1992, 1997; Eysenck, Derakshan, Santos, & Calvo, 2007; Matthews & Mackintosh, 1998; Mogg & Bradley, 1998; Wells & Matthews, 1994; Williams, Watts, MacLeod, & Mathews, 1988, 1997). A large body of research supports these models, demonstrating that high trait-anxious (HTA) individuals and/or those with clinical anxiety are more likely than low trait-anxious (LTA) to selectively attend to visual threat-related relative to non-threatening information (for reviews see Armstrong & Olatunji, 2012; Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007; Mathews & MacLeod, 2005; Yiend & Mathews, 2005). However, the nature of these attentional biases is still being debated. Some argue that attention is facilitated towards threat-related information, such that anxious individuals are faster at detecting threat and have a greater probability of attending to threat-related compared to non-threatening information (e.g., Matthews & Mackintosh, 1998). Additionally, some argue that facilitated attention followed by attentional avoidance of threat is responsible for the maintenance of anxiety (Mogg & Bradley, 1998). However, other researchers contend that highly anxious individuals have greater delay in disengaging their attention from threat (Fox, Russo, Bowles & Dutton, 2001; Koster, Cromzez, Verschuere, & De Houwer, 2004). While these varying hypotheses are not mutually exclusive, and may all contribute to the development and persistence of anxiety disorders, the exact nature of anxiety-related attentional biases is still unclear (Weierich et al., 2008).

In addition to the disputed disposition of anxiety-related attentional biases, research in this domain has yielded findings that are often inconsistent, and indeed the effects are "actually less solid than would be desirable" (p. 448; Calvo & Avero, 2005). There are a number of critical factors that likely contribute to the varying inferences in this debate, and more generally, to the inconsistencies in the literature. The most notable factors requiring further investigation are the attentional *components* and *time course* of attention. Attention can be separated into a number of distinct processes (e.g., Posner, 1980) including initial orienting or shifting of attention, engagement, and disengagement, with the potential for engagement and disengagement to vary over time. Assessment of these components and the time course of attention have been limited by a number of methodological factors (Calvo & Avero, 2005; Koster et al., 2004; Mogg, Holmes, Garner, & Bradley, 2008). However, more recently, eye tracking technology has been used to elucidate these components and has the potential to clarify the complex nature of anxiety-related attentional biases (Armstrong & Olatunji, 2012; Clarke, MacLeod, & Guastella, 2013; Richards, Benson, Donnelly, & Hadwin, 2014; Weierich et al., 2008).

The current program of research extends the previous literature by evaluating the phenomenology of anxiety-related attentional biases to threat-related and emotional images by monitoring eye movements in an attempt to understand the nature of these biases and more generally how people allocate their attention when presented with threat-related information over time. Do all individuals show a bias towards threat-related information or are such biases only found in those high in trait anxiety? Do HTA individuals show greater ABT than low or mid trait anxious? How does attention towards threat shift over time? Are anxiety-related ABT characterized as pre-attentive facilitated orienting to threat, maintenance of attention on threat over time and/or attentional biases away from threat (e.g., avoidance)? These are the primary research questions that initiated my program of research and that are addressed in the three eye movement studies reported in this dissertation.

The purpose of this chapter is to critically evaluate the current literature on anxiety-related ABT, highlighting the factors that may account for the inconsistencies and debate regarding the nature of these biases, and to introduce a program of study that addresses the current lacunae and several limitations in this past research. First the constructs of state anxiety, trait anxiety and anxiety disorders will be introduced to provide the basis for understanding the leading models of anxiety-related ABT. Then, the paradigms used to measure ABT will be reviewed briefly, followed by a critical review of the eye movement literature to date that has attempted to advance the measurement of attentional biases by distinguishing multiple attentional component and processes over time.

1.2 Anxiety and Anxiety Disorders

Anxiety is generally thought to be a mood state involving activation of the autonomic nervous system and subjective feelings of nervousness, tension, apprehension, and worry (Spielberger et al., 1983) that is related to and based on the same defense system as *fear* (Öhman, 1993), but also distinct from the more basic emotional experience (see Craske, 1999). Craske (1999) proposed a continuum based on the perceived imminence of a threat that places anxiety and worry (associated with the potential for threat) at one end and fear and panic (associated with imminent threat) at the other, with anticipatory anxiety (associated with approaching threat) falling in between. As the threat imminence decreases from fear to anxiety, the motivation of the emotional states shifts from an immediate urgency to escape the threat that is relatively automatic and "noncognitive" (Izard, 1992) to more cautious behaviours and complex cognitive processing.

It has long been recognized that anxious states are experiences that occur at a relatively short period in time, but when such states are predictably elicited over the course of time and one's life, this tendency is characterized as a personality trait (Cattell & Scheier, 1961; Spielberger, 1966). Spielberger and colleagues (1983) defined *trait anxiety* as a relatively stable individual difference in "anxiety-proneness, that is, to differences between people in the tendency to perceive stressful situations as dangerous or threatening and to respond to such situations with elevations in the intensity of their state anxiety" (p. 1). They argue that HTA individuals are more likely to experience states of anxiety than those low in trait anxiety because they appraise a broader range of situations as threatening and/or dangerous. More recent conceptualizations of anxiety as a personality trait extend this work and highlight the complex integration of state and trait factors in a multilevel information processing framework that incorporates affective, behavioural, cognitive and motivational factors (Wilt, Oehlber & Revelle, 2011).

Our understanding of anxious states and trait anxiety has, in part, been motivated by our desire to understand how individuals develop pathological anxiety, in order that we may ultimately be able to treat such conditions most effectively (Mobini & Grant, 2007). Anxiety disorders are conceptualized generally by the Diagnostic and Statistical Manual of Mental Disorders (DSM-5, American Psychiatric Association, 2013) as “disorders that share features of excessive fear and anxiety and related behavioral disturbances” (p. 189, APA, 2013) that like other disorders, are associated with significant distress and/or interference in daily life. It was estimated that world-wide, between 1980 and 2004, the lifetime prevalence of any anxiety disorder was 16.6% (95% confidence interval = 12.7 – 21.1%; based on DSM-III and DSM-IV criteria; Somers, Goldner, Waraich, & Hsu, 2006) and more recently, approximately 29% for individuals in the United States (Kessler et al., 2005) based on DSM-IV-TR classification criteria (APA, 2000; see Afifi, Cox, & Sareen, 2010 for Canadian estimates by anxiety disorder).

Moreover, many more individuals develop problems that may not reach diagnostic criteria (i.e., subclinical) or develop disorders where anxiety may be a central experience and maintenance factor (e.g., sexual dysfunction, eating disorders, etc.). Researchers have sought to understand what factors put people at risk for developing an anxiety disorder and have identified trait anxiety (or neuroticism and the tendency to experience negative affect more generally) as highly associated with anxiety disorders (Bieling, Antony & Swinson, 1998) and a vulnerability factor among other biological, psychological and social factors (APA, 2013).

Leading models of anxiety propose that a central factor in the development and persistence of anxiety disorders is the way that individuals process information from their environment. That is, HTA individuals are thought to interpret situations and stimuli as more threatening than others and relatedly show biases in attention towards threat-related information (e.g., Beck & Clark, 1997). The following section will briefly review the prominent models of anxiety-related ABT and the roles that trait anxiety, state anxiety, and the attentional components play in the development and persistence of anxiety and anxiety-related disorders.

1.3 Models of Anxiety-Related Attentional Biases to Threat

Early cognitive models (e.g., Beck, 1976) proposed that clinically anxious individuals are most likely to show biases in information processing towards threat in attention, interpretation and memory, similarly to how those who are clinically depressed would show biases in all three cognitive processes towards depressive stimuli. However, the data began to indicate that anxiety was largely associated with information biases in attention to threat-related information, while depression was associated with biases in memory for mood congruent information. Thus, more specific models of information processing biases in anxiety were needed to account for these results.

1.3.1 Williams, Watts, MacLeod and Mathews, 1988

Williams and colleagues (1988, 1997) proposed one of the first models to account for the information processing biases in emotional disorders (anxiety and depression). This model purported that there is an initial stage of processing during which the valence of stimuli (including threat value) are assessed pre-attentively by an Affective Decision Mechanism (ADM). The term "pre-attentive" was conceptualized similarly to Graf and Mandler's (1984) concept of priming, in which there is evidence of influence by a stimulus in the absence of awareness of the stimulus. Thus, Williams and colleagues proposed that all individuals assess the valence and threat value of stimuli in their environment whether or not there is intent, or perhaps even awareness, of so doing. Once the threat level has been appraised, a Resource Allocation Mechanism (RAM) then either directs attention towards or away from the stimulus. They argue that "high trait anxiety reflects a permanent tendency to react to the affective decision at the pre-attentive stage by orienting resources towards the source of threat" (p. 176, Williams et al., 1988), and thus results in biases best characterized as facilitated orienting of attention in HTA individuals. LTA individuals, on the other hand, are proposed to direct attention away from threat. Moreover, Williams and colleagues proposed that state anxiety acts to increase the output of the ADM, similar to that of increasing the threat value or intensity of a stimulus. They suggest an interaction between trait and state anxiety, such that when state anxiety increases, HTA individuals are more likely to show early, pre-attentive biases towards threat.

1.3.2 Öhman, 1996

Öhman's (1993, 1996) evolutionary model of fear and anxiety views biases in attention to threat as highly adaptive processes that also occur relatively automatically and non-consciously. In this model, stimuli are evaluated in a two-step process, first by *feature detectors* and then by a *significance evaluator.* The feature detector mechanism, if primed by features that have been associated with aversion and/or threat through an evolutionary process (e.g., features of spiders, angry faces), can have a direct effect on the *arousal system*. The arousal system can also impact the significance evaluator, such that elevations in state anxiety would increase the significance level of a stimulus. The processes described thus far are considered "bottom-up" or stimulus driven attentional processes that occur through priming. "Top-down" processing, according to Öhman (1996), can also bias attention towards threat through the *expectancy system*, "which contains memorial representations of past experience with the stimuli involved, as well as of their covariations and associations with threat. This is the route addressing the data on attentional bias in anxiety…" (pp. 280-281). Thus, the expectancy system would be associated with trait anxiety that is thought to directly influence a stimulus' appraised level of significance. The *conscious perception of threat* is then a result of the output from the significance evaluator and the expectancy and arousal systems. In the current model, ABT are primarily describing early facilitated orienting of attention to threat.

1.3.3 Beck and Clark, 1997

Beck and Clark's cognitive model of anxiety (1997) proposes three stages of information processing to account for the cognitive-affective-physiological-behavioral patterns of anxiety. The first stage is termed *initial registration* involving the *orienting mode* which is thought to involve fast, automatic, and involuntary identification of stimuli and to determine the level of priority for processing in an early detection system. The second stage, termed the *immediate preparation* involves activation of the *primal mode* and a range of cognitive (e.g., automatic thoughts and images), affective (fear), physiological (e.g., autonomic arousal), and behavioural (e.g., escape, avoidance) processes that generally serves to aid survival by minimizing threats and maximizing safety. This "goal-directed response pattern" (p. 57) involves both relatively automatic and strategic processing. The third stage, termed *secondary elaboration* involves the *metacognitive mode* and is associated with relatively effortful and slow elaborative semantic processing, including the evaluation of the individual's ability to cope with a potential threat. Beck and Clark (1997) argue that "the central cognitive problem in anxiety is the excessive and/or inappropriate generation of threat meaning assignment in response to stimuli or situations that are innocuous" (p. 56). This appraisal of relatively mild threat stimuli directs attentional resources in the orienting mode towards the threat and then maintains attention onto threat-relevant schema-congruent information over time. Thus, this model hypothesizes trait anxiety-related facilitated orienting towards threat and the maintenance of attention on threat over time, but provides no specific predictions about the role of state anxiety in these processes.

1.3.4 Mogg and Bradley, 1998

Mogg and Bradley (1998) proposed a cognitive-motivational model of emotional disorders that argued for an adaptive and normative function of facilitated orienting of attention towards highly threatening stimuli, drawing from cognitive and neurobiological research (e.g., Ledoux, 1996) and the notion that an effective system for threat detection necessary for survival must assure that attention is directed at imminent threats and dangers in all individuals. In this model, anxiety-related biases in attention are the result of two systems. First, the *valence evaluation system* assesses the threat value of stimuli. This evaluation process is done by assessing stimulus features as well as the contextual factors and previous experience in a relatively pre-attentive and automatic fashion. The output from the valence evaluation system is then processed by the *goal-engagement system* that allocates cognitive resources, including attentional focus, and action plans. Thus, if a stimulus is evaluated as high in threat, a current task/goal will be interrupted and attentional and cognitive resources will be allocated to the stimulus, resulting in facilitated orienting towards threat. In this model, “trait anxiety reflects the reactivity of the Valence Evaluation System to aversive stimuli” (p. 817) such that HTA individuals are more likely to rate ambiguous and trivial stimuli as more threatening than those low in trait anxiety. Furthermore, state anxiety is thought to influence the valence evaluation process by increasing the appraised level of threat of a stimulus. Thus, the cognitive-motivational model proposes that all individuals will show a bias towards highly threatening stimuli, but that only HTA individuals will show a pre-attentive bias towards mild threat stimuli. It is this latter bias that they propose is a sign of vulnerability, but not the cause, of anxiety disorders.

Moreover, while this model primarily proposes that facilitated orienting of attention towards threat is an indicator of vulnerability to clinically anxious states, they also note that the model does not dismiss the possibility that attentional processes are centrally involved in the maintenance of anxious states. That is, pre-attentive biases in orienting towards threat may be followed by attentional avoidance away from threat, a pattern termed “vigilance-avoidance.” Directing attention away from threat may serve to interfere with habituation to the relatively mild threat, and consequently maintain the elevated threat appraisal over time. Despite this proposition, the model does not propose under what conditions a vigilance-avoidance pattern is likely to occur.

1.3.5 Matthews and Mackintosh, 1998

Matthews and Mackintosh’s cognitive model of selective processes in anxiety (1998) proposed two opposing systems that determine whether an ABT will occur. First, the Threat Evaluation System (TES), similar to Williams et al., (1998) ADM and Öhman’s (1996) significance evaluator, assesses the threat value of stimuli in a bottom-up fashion that occurs prior to awareness. They note that biologically prepared (innate) or learned associations between stimuli and past aversive events are stored in the TES, and when activated, will facilitate the orienting of attention towards the perceived threat. In opposition to this stimulus driven process is an Effortful Task Demand (ETD) that involves top-down processing. The ETD accounts for the influence of increased effort and strategic processing to be used to counter the stimulus driven processes when individuals are able to prevent distraction from threat. In this model, state anxiety is argued to lower the threshold of the TES, such that stimuli that previously would not have been assessed as threatening enough to trigger the TES and attentional resources are more likely to when under elevated state anxiety conditions. Furthermore, trait anxiety is thought to be associated with more permanent individual differences in TES thresholds, such that HTA individuals would have lower thresholds than those low in trait anxiety. In addition, they propose that those with greater trait anxiety would also contain a wider range of threat-related representations that would be stored in the TES, making them more likely to demonstrate attentional biases to a range of stimuli. Similar to Mogg and Bradley (1998), they also propose that all individuals will demonstrate attentional biases to highly threatening stimuli, but only relatively weak cues will result in such biases specifically in highly anxious populations.

1.3.6 Wells and Matthews, 1994

Unlike the majority of models that predict pre-attentive anxiety-related ABT, Wells and Matthews (1994) argue that the evidence for automatic, pre-attentive biases in attention is limited and in contrast, emphasize the contributions of top-down processes such as plans and goals in producing ABT in their Self-Regulatory Executive Functions Model of emotional disorders. They propose three levels of cognitive processing that continuously interact: a low-level associated with automatic processing, a level involving controlled conscious appraisal and regulation of actions (i.e., Self Regulation Executive Function or SREF), and a long-term memory store of self-knowledge and strategies for self-regulation. They propose that all stimuli undergo some "low level" processing that may intrude into consciousness and activate the SREF. The SREF appraises the stimuli and then directs an action plan, which could involve directing attention to stimuli if fitting with the individual's goals and self-knowledge. Thus, this model proposes that an ABT results from having a threat monitoring plan that is voluntary and that primes stimuli at a low level of processing. Furthermore, they view trait-anxiety (similar to neuroticism) as being associated with greater access to negative self-knowledge which influences the threat appraisals and strategies used to cope with threat. A threat monitoring plan can also be activated by state anxiety, but Wells and Matthews

(2004) argue that emotional states only weakly influence biases in information processing relative to trait factors that are associated with clinical pathology.

1.3.7 Eysenck, Derakshan, Santos & Calvo, 2007

Eysenck and colleagues' attentional control theory (2007) was developed to account for the effects of trait anxiety on performance on cognitive tasks. This model proposes that anxiety impairs the ability to control attention that consequently reduces the efficiency of information processing on tasks requiring central executive functioning (Baddeley, 1986). The term *control* is described as being "determined in a goal-driven, top-down fashion" relative to "a stimulus-driven, bottom-up fashion" (p. 337, Eysenck et al., 2007) with anxiety decreasing the influence of the goal-driven attentional system and increasing the sensitivity of the stimulus-driven attentional system. Thus, increased sensitivity of bottom-up processing results in facilitated attention towards distracting stimuli, particularly if these stimuli are also threat-related. Furthermore, the attentional control theory hypothesizes that anxiety disrupts the central executive functions of *inhibition*, the ability to inhibit or prevent a dominant and automatic response, and *shifting*, the ability to shift or move attention between tasks, processes or mental sets. Deficits in these functions are thought to result in a difficulty to disengage from stimuli once captured by attention. Of note, the attentional control theory primarily attributes the effects to trait anxiety, but recognizes the difficulty in separating trait and state effects on performance (Eysenck, 2010).

1.3.8 Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg & van IJzendoorn, 2007

More recently, Bar-Haim and colleagues (2007) proposed an integrative model based on results from a meta-analysis of response time tasks assessing anxiety-related ABT given that the results were not fully accounted for by the leading models. In their model, they argue that anxious populations could show attentional biases that are not only pre-attentive, but also attentional and post-attentional. More generally, they argue that maladaptive information processing (including attention) can occur at four different stages. The first stage involves the *preattentive threat evaluation system* (PTES) that like previous models (e.g., Williams et al, 1988, Öhman, 1996) involves a system for evaluating the threat value of a stimulus that occurs relatively automatically and does not require awareness. If a stimulus is tagged as having a high threat value, the *resource allocation system* (RAS) activates a state of alert, increases physiological arousal and directs attentional and cognitive resources to process the stimulus. The outcome from the RAS (e.g., direction of attention) is then processed by the *guided threat evaluation system* (GTES) where the current context, access to prior experience and memory, as well as the assessment of coping abilities are evaluated in a more elaborative manner. If the stimulus is still considered to have a high threat value, then an anxious state is likely to result and the *goal engagement system* (GES) will continue to direct attention towards the threat. However, if this evaluation results in a low threat value, a feedback system will override the PTES and reduce the alerted state of the RAS and attention will be redirected away from the minor threat and towards an alternative source associated with their current goal.

Therefore, according to Bar-Haim and colleagues' model (2007), HTA populations may be at risk for developing an anxiety disorder if they show one or more of the following biases: 1) an automatic pre-attentive bias to evaluate benign or mild threat stimuli as highly threatening, 2) a bias to direct resources (e.g., attention) to mildly threatening stimuli, 3) a bias to misinterpret signals of an alert state as highly threatening and 4) deficits in the ability to override the state of alert after elaborative and conscious processing has concluded that the actual threat value is low.

1.3.9 Summary of Models

The models that attempt to account for anxiety-related ABT to date all have focused on early, pre-attentive biases in facilitated orienting to threat (Beck & Clark, 1997; Eysenck, 1992; Matthews & Mackintosh, 1998; Mogg & Bradley, 1998; Wells & Matthews, 1994; Williams et al., 1988, 1997), with only a few models accounting for continued maintenance of attention and/or delays in disengaging from threat (Beck & Clark, 1997; Bar-Haim et al., 2007; Eysenck et al., 2007). In general, the majority of the models are consistent with the *vigilance hypothesis* that contends that high anxious populations will show greater facilitated attention to threat than non-anxious populations. Mogg and Bradley (1998) extend this notion in the *vigilance-avoidance* (VA) *hypothesis* by proposing that following facilitated orienting, high anxious populations later direct attention away from threat in order to avoid the associated distress with continuing to maintain attention on threat. The second central hypothesis made by more recent models is referred to as the *attention maintenance hypothesis* (see Weierich et al., 2008) which proposes that once threat is detected, high anxious populations maintain or delay the disengagement of attention from threat, resulting in greater biases in attention to threat than to neutral stimuli. The maintenance hypothesis incorporates Fox and colleagues (Fox et al., 2001) *delayed disengagement hypothesis* and the proposal that anxious individuals have a delay in disengaging due to a deficit and/or difficulty in shifting attention away from threat. Thus, the delayed disengagement hypothesis assumes motivation or an attempt to disengage from threat but an inability to do so. Rather, the maintenance hypothesis makes no specific claims about *why* anxious individuals maintain their attention on threat, but simply predicts the sustained attentional behaviour. Moreover, the models also primarily focuses on the role of trait anxiety or *between-subject* differences in anxiety in contributing to biases in attention with relatively little attention to state anxiety or *within-subject* differences. Although only some models make predictions about the role of state anxiety (Matthews & Mackintosh, 1998; Mogg & Bradley, 1998; Wells & Matthews, 1994; Williams et al., 1988, 1997), relatively little research has been done to distinguish the two highly related, but distinct constructs (see Quigley, Nelson, Carriere, Smilek, & Purdon, 2012) to test the hypotheses made by the current models.

1.4 Defining Attentional Bias to Threat

Prior to reviewing the attentional bias literature, it is essential to first define the term *attentional bias* and clarify how it is measured given that there have been critical differences in how it has been operationalized that have led to confusion in interpreting the extant literature (Cisler, Bacon & Williams, 2009). Cisler and colleagues (2009) argue that an ABT is best conceptualized as a *within-subjects comparison* between attention toward *threat* relative to *neutral* stimuli. Such biases can be assessed by comparing the magnitude of the attentional bias score to chance levels, thus if a proportion is calculated between attention to threat relative to neutral stimuli, then this value would be compared to a chance probability level of .5 if there are just the two stimuli (e.g., no bias). A score significantly above .5 would indicate a bias *towards* threat, while a score significantly below would suggest a bias *away* from threat. This analysis, thus, determines whether an ABT is present or not and the direction of the bias.

Another way that researchers have conceptualized attentional biases to threat is with *between-subject comparisons* contrasting those who are high and low in anxiety. Some have concluded that if there are significant differences between two anxious groups, then the high anxious group is demonstrating a bias, whether or not the high anxious group exhibits a within subjects bias (e.g., Garner, Mogg & Bradley, 2006). Cisler and colleagues (2009) astutely note that these two types of comparisons address distinct research questions. Within-subject comparisons, as noted, assess the presence and direction of biases and thus, can determine whether biases occur in all individuals or are specific to some anxiety groups. Between-subject comparisons of anxiety groups better illustrate whether observed biases vary as a function of individual differences in anxiety. Using both types of comparisons allows us to examine whether biases in attention to threat-related information occur in all populations, but are exaggerated in high anxious populations (diagnostic extremity), or whether biases in attention to negative information are specific to high anxious populations only (diagnostic specificity; Cisler et al., 2009).

Given the variability in methodology and data analysis in the literature, it is challenging to interpret the results of the extant research in answering these distinct research questions. For instance, in the eye movement literature, many studies have only conducted between-subject analyses (e.g., Armstrong, Bilsky, Zhao & Olatunji, 2013; Armstrong, Olatunji, Sarawgi, & Simmons, 2010; Buckner, Maner & Schmidt, 2010; Mühlberger, Wieser, & Pauli, 2008; Rohner, 2002; Pflugshaupt, Mosimann, von Wartburg, Schmitt, Nyffeler, & Muri, 2005; Wieser, Pauli, Weyers, Alpers & Mühlberger, 2009) while other studies have used both between and within-subject analyses (Calvo & Avero, 2005; Gamble & Rapee, 2010; Garner et al., 2006; Gerdes, Pauli, & Alpers, 2009; Hermans, Vansteenwegen, & Eelen, 1999; Mogg, Garner & Bradley, 2007; Rinck & Becker, 2006; Quigley et al., 2012; Waechter, Nelson, Wright, Hyatt & Oakman, 2014; Miltner, Krieschel, Hecht, Trippe & Weiss, 2004). However, even studies that have used both within and between subject analyses have made conclusions about the presence of attentional biases based on between-group differences. For example, Garner and colleagues (2006) concluded that their high socially anxious group was faster to look at emotional faces relative to neutral faces, thus exhibiting vigilance. Based on the finding that the high socially anxious group spent less time looking at emotional faces relative to the low socially anxious group, they concluded that the high socially anxious group exhibited avoidance. But vigilance was determined through a within subjects comparison whereas avoidance was determined through a between subjects comparison. Garner and colleagues did not actually find a within subjects difference in amount of time the socially anxious group spent looking at emotional vs. neutral faces. This example illustrates that both within-subject and between-subject effects must be considered in order to understand the complex nature and specificity of anxiety-related attentional biases to threat (Cisler et al., 2009).

1.5 Measuring the Components and Time Course of Attentional Biases to Threat

A major limitation of the current attentional bias research is that attention has largely been measured as a unitary and static construct even though cognitive theory and research specifies that there are several components, or stages, in attention, which include initial orientation to a stimulus, engagement, and disengagement from a stimulus (Posner, 1980; Posner & Peterson, 1990). Relatively few studies of attentional deployment to threatening stimuli have actually examined the course of attention over time. Rather, to date, attentional biases have been studied using response time paradigms such as emotional Stroop tasks (see Williams, Mathews, & MacLeod, 1996 for a review), dot-probe detection tasks (e.g., MacLeod, Mathews & Tata, 1986), spatial cueing tasks (e.g., Fox et al., 2001), and visual search tasks (e.g., Rinck, Becker, Kellermann, & Roth, 2003). This body of work has provided some support for the notion that anxiety is characterized by an ABT, such that there may be an early facilitated orientation to threat (e.g., Bar-Haim et al., 2007), a maintenance of attention and/or delay in disengaging from threat (e.g., Fox et al., 2001) and a tendency to avoid threat (e.g., Hermans et al., 1999; see Cisler & Koster, 2010 for a review). But, how can it be true that attention is both oriented towards, but also away from threat? The answer may lie in the limitation of the response time paradigms used to study attentional biases to date, which do not allow for the clear examination of the separate components of attention (e.g., Koster et al., 2004), and that assess attention at one particular point in time only as opposed to over the continuous course of time. The most common response time tasks followed by eye movement tasks will be briefly reviewed below.

1.5.1 Emotional Stroop tasks.

The emotional Stroop task (see Williams, Mathews, & MacLeod, 1996 for a review), a variant of the classic Stroop task (Stroop, 1935), was one of the earliest paradigms used to examine attentional biases towards threat. In this task, participants are shown threatening and non-threatening words printed in one of several colours and asked to identify the colour of each word as quickly as possible. To do well at the task, the semantic content of the word must be ignored, which is said to become more difficult to the extent that the word has salient emotional meaning. Greater latency to colour-name threatening words as compared to the non-threatening words would, then, be said to indicate an attentional bias towards threat. A number of studies have found that individuals high in trait anxiety demonstrated this bias, whereas those low in trait anxiety do not (see Williams, Mathews, & MacLeod, 1996 for a review). However, the results of this task are difficult to interpret given that it is influenced by factors other than attentional capture (e.g., Algom, Chajut, & Lev, 2004; MacLeod & Bors, 2002), such as a general slowing in responding to threat that may be due to requirements to make approach (rather than avoidance) responses (Chajut, Mama, Levy, & Algom, 2010). Moreover, even without such confounds, it is impossible to tell whether the greater latency reflects a bias in initial orientation, a delay in disengaging attention from threatening material once it has been detected, or a combination of the two processes.

1.5.2 Dot-probe detection tasks.

The dot-probe detection task was developed to provide a more direct measure of selective visual attention (MacLeod et al., 1986; Posner, Snyder, & Davidson, 1980). In this paradigm, two stimuli (words or pictures) are presented, one threat-related and the other neutral in valence. The stimuli are presented in two different spatial locations on a computer screen, arranged either horizontally or vertically, and typically presented supraliminally (e.g., for 500 ms) and then are replaced by a neutral probe, such as a dot or an asterisk. Participants are instructed to signal something about the probe, such as its location (e.g., left or right of center) or nature (e.g., one asterisk or two), using response keys. On congruent trials, the probe replaces the threat-relevant stimuli, and in incongruent trials it replaces the neutral stimuli. Response time will be faster if the probe appears in the visual area that is being attended to. Therefore, a faster response time on congruent trials is said to indicate an ABT (e.g., Mogg, McNamara, Powys, Rawlinson, Seiffer, & Bradley, 2000). The degree of attentional bias is measured by subtracting response latency on congruent trials from the incongruent trials.

The dot-probe paradigm overcomes some confounds inherent in the Stroop task. However, as noted by Koster and colleagues (2004) and Fox (2004), once again the task does not determine whether the bias score indicates facilitated attention towards threat or a delay in disengaging from threat. To address this concern, Koster et al., (2004) included baseline trials featuring two concurrent neutral stimuli as a comparison against which to compare response times for the subsequent threat vs. neutral congruent and incongruent trials. Research using this particular variant of the dot-probe has found that high trait- anxious individuals are slower to respond to incongruent trails than baseline trials. Given that the stimuli were presented for 500 ms before the probe appeared, this effect was inferred to reflect a delay or difficulty disengaging from threat (Koster et al., 2004, Koster, Crombez, Verschuere, Van Damme, & Weirsema, 2006; Koster, Verschuere, Crombez, & Van Damme, 2005; Salemink, van den Hout , & Kindt, 2007). Interestingly, there was no evidence of facilitated attention given that there was no significant difference in response time between congruent and baseline trails. A continued limitation of the previous dot-probe paradigm is that it only assesses attention at one point in time, which, in the research described thus far, is at 500 ms following the appearance of the stimulus.

Although researchers have argued that attention at 500 ms reflects initial orienting (see Bar-Haim et al., 2007), it is important to note that this is actually a comparatively long time when studying visual perception and response time. It is possible that attention may have shifted a number of times during the 0 -500 ms interval, with initial orientation being on the threatening stimuli or not. This issue has been addressed recently by varying the Stimulus Onset Asynchrony (SOA), or the length of time the stimuli are presented before the probe is displayed. Thus, research has varied the SOA to assess earlier time point, such as 14 ms (e.g., Mogg & Bradley, 1999) and 100 ms (e.g., Koster et al., 2005; Mogg, Bradley, De Bono & Painter, 1997). The findings from these studies have been mixed. Given that initial orienting of attention is not necessarily occurring at set points in time, the dot-probe detection task is not well suited to assess initial orienting of attention, despite these attempts at shortening the presentation durations (Weierich et al., 2008). Furthermore, the reliability of dot probe tasks is often unacceptably low (e.g., Waechter et al., 2014).

Likewise, to assess later stages of attention with the dot-probe detection task, researchers have used longer SOAs (e.g., 1500 ms). While two studies using this paradigm have found a bias away from threat images in anxious individuals, consistent with attentional avoidance (Koster et al., 2005; Mogg, Bradley, Miles & Dixon, 2004), many studies have failed to find any bias in attention at longer stimulus durations with anxious populations (Mogg et al., 1997, Mogg & Bradley, 2006; Mogg, Philippot, & Bradley, 2004; Mogg, Bradley, Miles, & Dixon, 2004; Bradley, Mogg Falla, & Hamilton, 1998). Interestingly, Mogg, Bradley and colleagues (2004) found a bias away from images involving injury, violence and death presented at 1500 ms in those self-reporting high blood-injury fears, but not in those high in trait-anxiety, suggesting that attentional biases may be more likely to emerge for stimuli that reflect a particular fear. Moreover, the one study that found evidence of a bias away from threat in HTA individuals (Koster et al., 2005) found that they were more likely to attend to the neutral images and *away* from the high and mild threat pictures at 1250 ms. It may be that, as with initial orienting, disengagement and avoidance of threat can occur at different time points, and there may be individual differences in this regard that are driven by motivational factors, such as aversion to the stimuli. Thus, using a response time paradigm such as the dot-probe detection task at set time points may not be most effective in assessing biases away from threat, given that most studies have not found a bias in attention at time points greater than 500 ms.

1.5.3 Spatial cueing tasks.

Another response time task that is thought to assess the components and time course of attention towards threat is the spatial cueing, or Posner task (Posner, 1980). In this paradigm, participants fixate on a center cross that is displayed between two rectangles on a computer screen. A single stimulus, typically threat-related or neutral in valence, is then shown in one of the two rectangles, usually for 500 ms, at which point a neutral probe appears in either the same rectangle as the stimuli (i.e., valid trials), or in the opposite rectangle (i.e., invalid trials). The task is to indicate the location of the probe by pressing one of two response keys. Facilitated attention to threat is determined by faster response times when the stimuli are threatening compared to neutral on valid trials (i.e., when the probe is in the same location as the stimuli), indicating that the threatening stimuli attracted attention more quickly than the neutral cues. Additionally, a delay in disengaging from threat is determined by slower response times when the stimuli are threatening compared to neutral on invalid trials (i.e., when the probe is in the opposite location as the stimuli), indicating that the threatening stimuli held attention away from the probe and delayed the response. Similar to the dot-probe detection task, the SOA can be varied to assess the time course of these attentional components.

The majority of studies using the spatial cueing task suggest that, at least at time points of up to 600 ms, those high in trait-anxiety appear to have a delay in disengaging from threat-related stimuli, rather than showing an initial bias towards threat (Amir, Elias, Klumpp, & Przeworski, 2003; Fox et al., 2001; Fox, Russo & Dutton, 2002; Yiend & Mathews, 2001). One exception is a study in which evidence for both facilitated attention and difficulty disengaging from threatening images at 100 ms was found, as well as a bias away from threat at SOAs of 200 and 500 ms in HTA individuals (Koster et al., 2006). However, Mogg and colleagues (2008) identified a major confound in this paradigm, recently demonstrating that anxious individuals are slower to respond to threatening than to neutral faces in general, regardless of spatial attention, but nonanxious participants show no difference in their response times to centrally located threatening and neutral stimuli. When the general response time for centrally located stimuli is subtracted from the bias scores, the results suggest the opposite of what is typically reported. That is, the results imply that high anxious individuals show facilitated engagement with threat rather than disengagement difficulties. Mogg and colleagues argue that this confound creates problems when determining the components of attention with response time tasks (Koster et al., 2004), and thus they concluded that "the 'delayed disengagement' hypothesis remains untested" (p. 666; Mogg et al., 2008). These methodological complications make it difficult to draw conclusions about the nature of attentional biases towards threat.

1.5.4 Visual search tasks.

Visual search has also been used to assess anxiety-related attentional biases, but to a lesser extent than other paradigms. Nevertheless, it does allow for the distinction between facilitated attention and disengagement (e.g., Rinck et al., 2003). Visual search tasks generally require participants to detect target stimuli that are embedded in an arrangement of distracting stimuli. For example, participants may be asked to identify an image of an angry face (i.e., threat-related target) in a matrix of neutral faces (i.e., neutral distractors), or a butterfly (i.e., neutral target) in an arrangement of spiders (i.e., threat-related distractors). Facilitated attention is indicated by faster response times to detect threat-related targets in an array of neutral distractors compared to identifying neutral targets in an array of neutral distractors (i.e., baseline condition). Conversely, a delay in disengaging from threat is indicated by slower response times to detect neutral targets in an array of threatening distractors compared to detecting neutral targets in an array of neutral distractors. Research using visual search paradigms has found evidence that anxious individuals demonstrate both facilitated attention (e.g., Byrne & Eysenck, 1995) and difficulty disengaging from threat (e.g., Rinck et al., 2003). Other studies that have not used a baseline condition, but assessed for group differences in high and low anxious populations, have found that high anxious individuals are faster at detecting threat-related targets and slower to disengage from threat-related distracters compared to low anxious individuals (e.g., Rinck, Reinecke, Ellwart, Heuer, & Becker, 2005) while others have found no differences between HTA and LTA when stimuli salience are equated (e.g., Notebaert, Crombez, Van Damme, De Houwer, & Theeuwes, 2011). However, one limitation of this approach is that it cannot provide information regarding the time course of these attentional components, and the point in time at which facilitated attention and disengagement take place may be important in understanding the nature of anxiety-related attentional biases. Given this central limitation, in conjunction with the methodological limitations noted above for the emotional Stroop tasks, dot-probe detection tasks and spatial cueing tasks, it is evident that other paradigms are needed to elucidate the specific nature of these biases.

1.5.5 Eye movement tasks.

An alternative method to using response time paradigms to infer visual attention towards threat is the direct observation of visual selective attention through measurement of eye movements (Armstrong & Olatunji, 2012). That is, the direction of visual focus (i.e., foveal vision assessing up to 2° visual angle) is a good indicator where in a visual array attention is being deployed and is thus termed *overt attention* (Findlay & Gilchrist, 2003). In contrast, *covert attention* is the directing of attention to a stimulus without shifting the eyes. While overt and covert attention can be dissociated (i.e., one can attend to a stimulus without moving their eyes), covert attention functions to direct overt attention and the purpose of eye movement is to select visual information for further processing (Findlay & Gilchrist, 2003; Hayhoe & Ballard, 2005; see Weierich et al., 2008). It seems likely that an effective threat detection system would rely on overt attention for detecting potential threat rather than solely on covert attention (Armstrong & Olatunji, 2012; Richards, Benson, Donnelly, & Hadwin, 2014), thus the direction of eye movements may provide a more direct measure of selective visual attention than response time tasks.

Researchers have used eye tracking in a variety of ways to asses for anxiety-related ABT (see Armstong & Olatunji, 2012 for a meta-analysis). Some studies have measured eye movements concurrently with response time paradigms, such as the dot-probe (e.g., Bradley, Mogg & Millar, 2000; Garner et al., 2006; Mogg et al.,2007; Schofield, Johnson, Inhoff, & Coles, 2012) and visual search tasks (e.g., Pflugshaupt et al., 2005; Rinck et al., 2005; Miltner et al.,2004). The majority of studies have used free viewing paradigms that tracked selective visual attention to threat-neutral image pairs (e.g., Calvo & Avero, 2005; Gerdes et al.,2009; Gamble & Rapee, 2010; Quigley et al., 2012), or to 3 neutral images with one threat-related image (Armstrong, Hemminger, & Olatunji, 2013; Armstrong, Sarawgi, & Olantunji, 2012; Becker & Detweiler-Bedell, 2009; Buckner et al.,2010; Rinck & Becker, 2006). Given this range of methodology and the complex nature of eye movements, researchers have made use of multiple indicators for the various attentional components and time course of attentional engagement and disengagement. Each attentional component will be discussed below.

1.5.5.1 Initial orienting and facilitation.

One of the main advantages of measuring eye movements over response time paradigms is that the first shift of visual selective attention can be observed directly. That is, in free viewing paradigms, participants often fixate at a central marked location prior to when the images are displayed and this procedure allows for the observation of the first shift and thus determine whether it is directed towards or away from a threat relative to a control stimulus. In this way, an index can be calculated to assess “pre-attentive” facilitated orienting, or more generally, attending to threat stimuli prior to full awareness of the stimuli content. Another index of facilitated orienting that has been less commonly used in free viewing tasks is the time taken to make the initial fixations on threat relative to neutral stimuli (i.e., latency of facilitation; e.g., Gerdes et al., 2009; Pflugshaupt et al., 2005). Both a greater probability of making initial eye fixations on threat-related stimuli and shorter time to make these fixations towards threat relative to neutral stimuli are thought to indicate facilitated attention.

Although not often assessed, studies that analyze biases (from chance levels) in initial fixation probabilities have found some evidence for an attentional bias in HTA individuals towards images involving threat of injury (i.e., threat; Calvo & Avero, 2005; Quigley et al.,

2012) and past injury (i.e., harm; Calvo & Avero, 2005) and to angry and fearful faces in socially anxious populations (Garner, Mogg, Bradley, 2006; Mogg, Garner & Bradley, 2007). However, one study did not find this bias towards angry or disgust faces in socially anxious individuals (Waechter et al., 2014) and more generally, have not been found for spider stimuli in spider fearful populations (Gerdes, Alpers, Pauli, 2008; Rinck & Becker, 2006). Moreover, some studies have found that low socially anxious individuals also show facilitated attention towards threat-related faces (Garner et al.,2006; Mogg et al.,2007) and that those low in injection fears make more first fixations on images of injection, physical attack and positive images relative to neutral (Armstong et al., 2013), indicating that an attentional bias at the initial fixations to negative (and perhaps positive) information may not always be limited to high anxious populations. Similarly, unselected samples generally show facilitated orienting biases for threat and emotional stimuli when assessed with eye movements (e.g., Calvo & Lang, 2004; Nummenmaa, Hyönä, & Calvo, 2006) suggesting that early facilitated biases to threat may be a normative selective process that is also biologically determined and prewired (LeDoux, 1995; Öhman, 1993).

When comparing anxious groups, between-subjects differences have been found with high anxious individuals showing greater facilitated attention than the low anxious individuals towards potential threat and harm images in HTA populations (Calvo & Avero, 2005), to negative faces in socially anxious individuals (Mogg et al.,2007; Wieser, Pauli, Weyers, Alpers, & Mühlberger, 2009), to fearful faces (but not disgust) in those high in contamination fear (Armstong et al.,2010), to spider stimuli in spider fearful participants (Pflugshaupt et al.,2005; Rinck & Becker, 2006), to injection images in those high in injection fears (Armstrong et al., 2013), and to images of war in Veterans with greater posttraumatic symptoms (Kimble, Fleming, Bandy, Kim, & Zambetti, 2010). However, others have failed to find significant between-subjects differences (Armstrong et al., 2013; Armstrong et al., 2010 for disgust faces; Garner et al., 2006; Schofield et al., 2012; Waechter et al., 2014; Quigley et al., 2012). Moreover, studies assessing facilitation through first fixation latencies in free viewing tasks have found limited support for anxiety group differences (Garner et al., 2006, Study 2), with many studies showing no significant effects (e.g., Armstrong et al., 2010; Garner et al., 2006, Study 1; Waechter et al., 2014). A recent meta-analysis indicated that using the proportion of first fixations as an index of facilitated attention or *vigilance* for threat, differences between anxious and non-anxious samples resulted in a small to moderate effect size (k = 16, g = .58; Armstrong & Olantunji, 2012) despite the discrepancies in the literature.

The current eye movement research provides preliminary support for facilitated orienting of attention to threat-related images in anxious populations as predicted by the prominent models of anxiety-related attentional biases (Beck & Clark, 1997; Eysenck, 1992; Matthews & Mackintosh, 1998; Mogg & Bradley, 1998; Wells & Matthews, 1994; Williams et al., 1988, 1997). However, relatively few studies to date have assessed the presence and nature of ABT using initial fixation data (i.e., comparison to chance levels; Calvo & Avero, 2005; Garner et al., 2006; Gerdes, Alpers, Pauli, 2008; Mogg et al.,2007; Rinck & Becker, 2006; Quigley et al., 2012; Waechter et al., 2014). Given the discrepant results between initial fixation data and some response time results (e.g., dot probe detection task; Gerdes et al., 2008; Rinck & Becker, 2006) further research assessing initial orienting of eye movements is needed to understand the conditions under which facilitated attention to threat is most likely to occur and the extent that this index of ABT is influenced by anxiety.

1.5.5.2 Attentional engagement over time.

Given the focus on biases in facilitated attention towards threat (e.g., Matthews & Mackintosh, 1998; Mogg & Bradley, 1998) there has been less emphasis on assessing the maintenance of attentional biases or engagement with threat over time. Free viewing tasks allow for the presentation of stimuli for extended periods of time and this approach often involves measuring the proportion of fixation durations (e.g., Calvo & Avero, 2005; Quigley et al., 2012) and/or fixation frequencies (e.g., Gamble & Rapee, 2010; Hermans et al.,1999), on threat to overall durations and frequencies, respectively. In other words, a comparison can be made between how long and how often participants look at threat versus neutral information over time. To assess for these attentional factors, studies have frequently assessed eye movements for 3 to 5 seconds and divided this continuous time course into equal intervals (e.g., 500 ms; Calvo & Avero; Wieser et al., 2009). Recent research has demonstrated that both the proportion of fixation frequencies and fixation durations are highly related and, when used over extended time frames (500 and 1000 ms intervals), have the greatest reliability (Waechter et al., 2014).

Research using this approach to assessing attention over time has typically found preliminary evidence for an early attentional bias towards threat in the first 500 ms of viewing in anxious individuals. For instance, Calvo and Avero (2005) found that HTA participants showed a bias for harm-related images (but not threat-related images involving potential threat) in the first 500 ms of viewing. Similar results have been found for participants meeting DSM-IV criteria for social phobia with angry faces (Gamble & Rapee; 2010) and for images of spiders in spider fearful participants (Hermans et al., 1999). This early bias in engagement towards threat in high anxious populations has not typically been found after the first 500 ms (Calvo & Avero, 2005; Gamble & Rapee, 2010; Hermans et al., 1999), however, some studies have failed to find a bias towards threat in HTA samples even prior to 500 ms (e.g., Calvo & Avero, 2005; Quigley et al., 2012; Waechter et al., 2014). Moreover, Rohner (2002) found that HTA individuals demonstrated an early bias in viewing negative versus positive stimuli; however this bias was also found in LTA individuals and without a comparison to neutral stimuli, it is not known the direction of the bias. Similarly, other eye movement studies have found early biases to threat-related stimuli in low anxious individuals (e.g., Hermans et al., 1999; Quigley et al., 2012) indicating that greater attentional engagement with threat is a general phenomenon.

Furthermore, anxiety group differences have been found with high anxious populations showing greater attention to threat than low anxious populations in the first 500 ms of viewing (Gamble & Rapee, 2010: Rinck & Becker, 2006; Wieser et al., 2009), as well as over extended periods of time (Armstrong et al., 2010). However, the results are mixed, for other studies have not found this anxiety group difference (Armstrong et al., 2012; Hermans et al. 1999; Rohner, 2002; Quigley et al., 2012; Waechter et al., 2014). A recent meta-analysis of eye movement studies (Armstrong & Olantunji, 2012) assessed relatively early maintenance of attentional biases in free viewing tasks (using the proportion of viewing time between 1000 and 2000 ms and the duration of the initial fixations), but did not find evidence for differences between high and low anxious individuals. The results did indicate however, that anxiety group differences in maintenance was moderated by type of anxiety, such that spider fearful individuals showed much less maintenance on spider images while those studies assessing posttraumatic stress disorder symptoms (PTSD) found the opposite; that is, those with PTSD showed greater maintenance on threat-related stimuli over time. Therefore, research monitoring eye movements has provided some evidence for an anxiety-related attentional bias in early engagement of threat that appears to occur in the first 500 ms of viewing and does not seem to be consistently maintained over time. Nevertheless, relatively few eye movement studies assessing the time course of attention have been conducted and these studies have yet to be replicated.

1.5.5.3 Attentional disengagement.

Monitoring eye movements can also provide some indication of visual disengagement of attention from threat. Researchers have used a variety of approaches to assess attentional disengagement and there appears to be less consensus regarding how best to use eye movement data to assess this attentional component. Some have monitored eye movements during a visual search task (Rinck et al., 2005; Miltner et al., 2004), while others have used free viewing tasks (Rink & Becker, 2006; Garner et al., 2006; Quigley et al., 2012).

Research monitoring eye movements concurrently with a visual search task generally involves presenting threat-related distractors (e.g., spider) in the search for a non-threatening target (i.e., mushroom). Longer gaze durations on the threat distractors compared to neutral distractors, using the same neutral target, would indicate delay in disengaging from threat. Studies that have used this approach have generally supported an anxiety-related delay in disengagement in spider phobic populations (Rinck et al., 2005; Miltner et al., 2004). Similarly, Schofield and colleagues (2012) monitored eye movements during a dot-probe task and found that social anxiety was positively associated with longer latencies to disengage from angry face stimuli.

Some free viewing tasks have indexed disengagement from threat by comparing the length of visual fixations (e.g., first fixation duration) on threat such that longer fixations on threat relative to neutral stimuli would be consistent with a delay in disengaging. However, Rink and Becker (2006) assessed the length of the initial fixations on spider images and found that individuals with spider phobia had shorter initial fixation durations, indicating faster disengagement than low spider fearful individuals. Statistical comparisons were not done to compare the initial fixation durations on spiders versus neutral stimuli, such as mushrooms, so it is not clear whether a bias in attention was present. While these results are seemingly contrary to the hypothesis that high anxious populations have a greater delay in disengaging attention from threat, it is not known whether the end of the initial fixation indicated a move of attention away from the threat image or to another fixation on the same image. Participants make multiple fixations and if they continue to fixate on the same image, the end of the initial fixation would not necessarily indicate disengagement from the stimuli.

A more representative measure of disengagement using eye movements may be the length of time participants spend looking at the initially fixated threat images compared to neutral images. That is, once participants have made their initial fixation on a threat image, how long do they continue to look at it compared to when they initially fixated on the neutral image? Garner, Mogg and Bradley (2006) used this index, termed *first fixation gaze duration*, and found that under a social stress condition (Study 2), those participants low in fear of negative evaluation looked at emotional faces (angry and happy) longer than neutral faces, but those high in this fear did not show any bias. Of note, these results are also not consistent with the maintenance hypothesis (Weierich et al., 2008). Furthermore, Armstrong and colleagues (2012) found no differences in those high and low in contamination fear in the first fixation gaze durations for contamination or general threat images. Rather, Quigley and colleagues (2012) found more generally that state anxiety delayed the disengagement of eye movements from threat images in all participants (relative to neutral), regardless of trait anxiety. One possible explanation for the discrepancy between free viewing and other attention tasks may be that the former designs are assessing participants' tendencies to engage and disengage from stimuli when viewing threat paired with neutral information, and not necessarily their *ability* to disengage. Testing the delay in disengagement hypothesis (Fox et al., 2001, 2002) likely requires more explicit instructions for shifting of attention (e.g., Gerdes et al., 2009). Nevertheless, understanding both the viewing preferences and attentional control abilities associated with anxiety are important in understanding the specific potential maladaptive attentional processes that may contribute to the development and persistence of anxiety disorders.

1.5.5.4 Attentional Avoidance.

In the same way that engagement has been assessed in eye movement studies, a bias away from threat can also be indicated by a bias score significantly below chance levels (e.g., a proportion below .5). However, it has become common in the literature to describe an attentional bias away from threat as *avoidance* (e.g., Cisler & Koster, 2010; Mogg & Bradley, 1998). That is, in free viewing tasks, when threat and neutral stimuli are paired and participants are significantly more likely to attend to the neutral relative to the threat stimuli, researchers have concluded that participants are *avoiding* the threatening information. An equivalent conclusion using this logic is that when participants show a bias towards threat, they are *avoiding* the neutral stimuli. The term avoidance, as it is used in the anxiety literature, suggest that there is a motivation to shift attention away (or at least the eyes) from threatening information. It is reasonable to expect that when shown two stimuli that participants will look at both images, without any necessary intent to avoid any information. Before such an inference can be made, research will need to assess whether attention away from threat in these studies is indicative of a motivation to avoid. Thus, for the purposes of this research, I will refer to this result as a bias away from threat, rather than making inferences about motivation. Nevertheless, a bias away from threat is most likely to take place later in the time course when an individual seemingly has greater control over their attentional abilities (Cisler & Koster, 2010).

To date, very few studies have assessed attentional biases over an extended period of time against chance levels separately for high and low anxiety groups (Calvo & Avero, 2005; Hermans et al., 1999; Gamble & Rapee, 2010; Waechter et al., 2014). Calvo & Avero (2005) found that HTA participants demonstrated a bias away from images of harm at several time intervals (1500-2000, 2000-2500 and 2500-3000 ms), while Hermans et al., (1999) found that high spider fearful individuals show a bias away from spiders at intervals 2000-2500 ms and 2500-3000 ms after stimuli onset. In contrast, other studies have failed to find any bias away from images of threat in those with high trait-anxiety over 3000 ms (Calvo & Avero, 2005), from angry faces in those meeting DSM-IV criteria for social phobia over 5000 ms (Gamble & Rapee, 2010), and to angry and disgust faces in high socially anxious participants (Waechter et al., 2014).

More commonly, studies have assessed "avoidance" as a between-subjects factor indicated by high anxious groups directing less attention to threat than low anxious groups (refer to section titled *Defining Attentional Bias to Threat* above for problems with this operationalization). Some studies have found that high anxious, compared to low anxious populations, were less likely to view images of harm at 2000-2500 and 2500-3000 ms after stimuli onset (Calvo & Avero, 2005), images of emotional faces (angry and happy) at 1000-1500 ms (Weiser et al., 1999), and spiders from 500 ms to 3000 ms (Hermans et al., 1999). Similarly, Rinck and Becker (2006) found that over six 10-second intervals (60 seconds), high spider fearful individuals were significantly less likely to view spider stimuli than low spider fearful individuals and Armstrong and colleagues (2013) found that over six 3-second intervals (18 seconds) those with high injection fears reduced their viewing of injection images over time while those low in injection fears showed a more stable viewing over time relative to other stimuli. However, no anxiety group differences of this nature were found in other comparable studies (Armstrong et al., 2010; Armstrong et al., 2012; Gamble & Rapee, 2010; Calvo & Avero, 2005; Schofield et al., 2012; Quigley et al., 2012; Waechter et al., 2014) as well as in a meta-analysis of eye movement studies (Armstrong & Olantunji, 2012 2012). Other studies have found evidence consistent with avoidance of threat, but have varied in their methodology such that it is difficult to compare to the extant literature (e.g., Becker & Detweiler-Bedell, 2009; Mühlberger et al., 2008; Rohner, 2002). Nevertheless, research assessing eye movements has provided some support for attentional biases away from threatening information at later stages of attentional engagement, (typically after 2000 ms), while differences between anxiety groups may appear as early as 500 ms. However, this effect is not found consistently across studies, suggesting that a bias away from threat may be more likely to occur to certain types of stimuli (e.g., no imminent threat) and/or in select populations (e.g., phobic fears).

In sum, eye tracking technology can be used to assess the components and time course of attention more directly than through inferences from response time paradigms, thus, this approach may provide a more accurate and sensitive analysis of attention to threat over time. To date, eye movement research evaluating anxiety-related attentional biases has provided some evidence that anxious populations can show early facilitated attention towards threat, maintenance of attention on threat, delays with disengagement and attentional biases away from threat at later points in time (Cisler & Koster, 2010). Nevertheless, the results are largely mixed and relatively few studies have monitored eye movements. Furthermore, the extant literature ranges greatly in many essential factors, such as the type of stimuli, anxious samples, methodology, indices of attentional bias and analyses (e.g., within and between subject comparisons) that make clear interpretations a challenge. For instance, very few studies have assessed ABT to complex scenes over time using eye movements as a function of trait anxiety (Calvo & Avero, 2005; Quigley et al., 2012). Therefore, more systematic research of this nature is required to further our understanding of the factors that influence the components and time course of attention in order to comprehend how and when anxiety is associated with ABT (Weierich et al., 2008) and ultimately, what potential pathological attentional processes may be contributing to the development and persistence of anxiety and anxiety-related disorders.

1.6 Current Program of Research

The current program of research was designed to evaluate a central question: What is the continuous time course of selective visual attention towards threat stimuli as a function of trait anxiety? While the focus of this research was on anxiety as a relatively stable trait (as an indicator of vulnerability to anxiety disorders), the current research also assessed the effects of state anxiety in order to identify normative attentional processes associated with anxious mood states that may be distinct and/or interact with trait anxiety in the selective attention to threat. Threat stimuli involved scenes where there was *potential* danger either in the image or directed at the viewer (e.g., someone holding a knife to a person's throat, a gun pointed at the viewer). Scenes may be more ecologically valid than other commonly used stimuli (e.g., faces and words) in that they more closely approach the complex environments in which threat occurs. To improve on past research, we monitored eye movements to assess several components of attention, including initial orienting as an indication of facilitated attention (i.e., vigilance), as well as visual engagement and disengagement of threat over time. Assessing these multiple components and time course of attention allowed us to evaluate the phenomenological nature of anxiety-related attentional biases and to test the assumptions made by multiple models (e.g., Matthews & Mackintosh, 1998; Mogg & Bradley, 1998; Wells & Matthews, 1994; Williams et al., 1997) regarding the nature of anxiety-related ABT.

Chapter 2

Study 1: Assessing the Time Course of Anxiety-Related Attentional Biases to Threat

2.1 Introduction

The purpose of Study 1 was to evaluate the time course of visual selective attention to complex threat-related images as a function of trait anxiety by monitoring eye movements. Prior to this program of research, only one study to my knowledge had assessed ABT to complex images as function of trait anxiety using a free viewing paradigm with two competing images (Calvo & Avero, 2005). In this study, participants viewed threat, harm and positive images paired with neutral images that were projected on a large screen and eye movement behaviour was captured by video camera and calculated by raters. All emotional images that depicted people were paired with objects. To control for biases in attention towards people over objects (e.g., Garner et al., 2006) they included neutral-neutral pairs with one image involving people and the other an object and then subtracted this bias effect from the emotional image pair to form their bias indices. The reliability of these difference scores were not reported and could be poor due to the use of subtraction (Crocker & Algina, 1986). This approach could account for their null bias results involving threat images over time, contrary to their hypotheses. Such biases may not be additive and thus, a more accurate evaluation of ABT would involve a direct comparison of images that involve similar content, but vary primarily (as much as possible) in emotionality rather than in both regards. Thus, the current program of research first sought to replicate (see Pashler & Harris, 2012 for the importance of direct replication) and extend previous research by improving the methodology of Calvo and Avero (2005) with more advanced eye tracking technology to address the following research questions:

1) Do ABT only occur in HTA individuals or in all individuals?
2) Do ABT vary as a function of trait anxiety, such that HTA individuals show greater attention to threat than mid or LTA individuals?

3) Are anxiety-related attentional biases characterized as facilitated orienting towards threat at the first fixations, maintenance of attention following the detection of threat, and/or attention directed away from threat (e.g., avoidance)?
4) Are ABT moderated by time?
5) Are ABT moderated by the type of negative stimuli, such that images depicting the *potential* for threat would be most related to trait anxiety or do biases occur to negative images more generally, including images where harm has already occurred?

Of interest to our research questions were multiple components of attention, including the relative facilitated orienting of attention on the first fixations (i.e., proportion of first fixations), the length of time participants continued to gaze at images once they were first fixated before they disengaged and shifted attention from the image (i.e., first fixation gaze durations), and the relative time spent viewing the images over time (i.e., proportion of viewing time). Based on previous research and leading models of anxiety discussed above, we expected that HTA individuals would show early facilitated orienting towards threatening images on the initial fixations and during the first 500 ms of viewing relative to neutral images. Furthermore, we expected that these early attentional biases towards threat would be greater in HTA than in the mid and LTA individuals. In accordance with the attention maintenance hypothesis (Weierich et al., 2008), we expected that HTA participants would demonstrate longer gaze duration biases on threat images (relative to neutral) following the first fixations than LTA. Eye movements were recorded for 3000 ms to assess the time course of attention and for the potential for attention to be biased away from threatening images at later time points as predicted by the vigilance-avoidance hypothesis (Mogg & Bradley, 1998). Last, threat (the potential for harm) and harm images (where harm has already occurred) were included in this study to evaluate whether anxiety-related attentional biases were specific to images of *potential* threat of physical harm or to negative images of injury more generally.

2.2 Methods

2.2.1 Participants

Participants were sampled from undergraduate students who completed screening questionnaires for course credit and met the following inclusion criteria: 1) scored high (≥ 47) or low (≤ 36) on the State-Trait Anxiety Inventory Trait version (STAI-Trait; Spielberger, Gorsuch, Lushene, Bagg & Jacobs, 1983); 2) scored less than 19 on the Beck Depression Inventory-II (BDI-II; Beck, Steer, & Brown, 1996), and responded to item 9 on the BDI-II with a 0 response assessing suicidal ideation (to control for moderate to high depressive symptoms, and to protect potentially vulnerable participants who might find the threatening images highly distressing), 3) scored 11 or below on the 20-item version of the Marlowe and Crowne Social Desirability Scale (SDS; Strahan & Gerbasi, 1972) and thereby less likely to underreport anxiety symptoms (e.g., Derakshan, Eysenck & Myers, 2007), and 4) had normal or corrected-to-normal vision.

A total of 185 participants attended the lab to participant in the current study. Of these, 11 participants did not have valid eye movement data due to calibration or other technical difficulties. Those participants whose STIA-T scores changed from the screening session to the lab session more than 2.5 *SD*s above the mean change (M = - .55, SD = 6.46) were also removed to ensure stability of measurement (n = 5). [1] The excluded participants did not differ from the remaining sample of 168 on age, gender, STIA-Trait or STIA-State, ps < .05. Trait anxiety groups were formed by a tertile split on the in lab administration of the STAI-Trait (M = 39.63, Mdn = 38, SD = 8.71) resulting in 58 HTA, 52 Mid Trait Anxious (MTA) and 58 LTA. Participants had a mean age of 18.9 years (SD =1.79), 54% were female, and 46% identified as White (30% as Asian, 12% as East Indian & 12% as another category). The LTA, MTA and HTA groups did not differ significantly in terms of age, $F(2, 160) < 1$, or gender, $\chi^2 (4, N = 168) = 5.37$, $p = .07$.[2]

[1] Note that the test-re-test reliability between the screening and in-lab administrations of the STAI-Trait was .77
[2] This marginal effect was due to a lower number of men (n = 17) in the MTA group relative to the women (n = 35) while there were more equivalent ratios in the LTA (men n = 31; women n = 27) and HTA (men & women n = 29) groups.

2.2.2 Materials

2.2.2.1 Self-Report Measures

State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983). The state (STAI-State) and trait (STAI-Trait) scales each list 20 symptoms of anxiety and participants are instructed to rate each according to how they feel *in the present moment*, and how they *generally* feel, respectively, using a 4-point Likert scale ranging from 0 (almost never) to 4 (almost always). The coefficient alphas for the STAI-State and STAI-Trait in the current sample were .92 and .93, respectively.

Beck Depression Inventory – II (BDI-II; Beck et al., 1996). The BDI-II was used to screen out participants high in depressed mood and/or suicidal ideation. Participants rated 21-items on a 4-point scale on the extent that they have experienced specific depressive symptoms in the past 2 weeks. The coefficient alpha in the current sample was .92.

Marlowe–Crowne Social Desirability Scale (SDS; Crowne & Marlowe, 1960; Strahan & Gerbasi, 1972). The 20-item short version of the scale was used to assess the tendency of participants to respond in a socially desirable manner on self-report measures. Participants rated statements about attitudes and traits as to whether each was a true or false description of themselves. The coefficient alpha reliability estimate for the current sample (N = 1850[3]) was .70.

2.2.2.2 Apparatus

Eye movements were tracked using an SR Research Ltd. EyeLink 1000 (Mississauga, Ontario, Canada) desktop mounted eye tracking system that has a single desk-mounted camera and IR Illuminator that tracks the pupil and corneal reflections for a single eye at a rate of once per millisecond (ms; 1000 Hz). Participants were positioned in a chin and forehead rest and situated approximately 63 cm from a 19 inch LCD colour monitor that had

[3] Data for 1850 of the 3788 potential participants was available for these analyses due to a change in when the SDS was administered. In the first term of data collection, participants completed the SDS in the lab session. However, it was then given in the screening questionnaires in subsequent terms to reduce the collection of unusable data.

a 1280 X 1024 resolution. Calibration was achieved using a 9-point location procedure with an average accuracy rating of .25° - .5° visual angle. Data were extracted using Data Viewer Software. The standard settings identifying saccades and fixations were used, such that a saccade was considered an eye movement that travels at least 30° per second or with an acceleration of at least 8000° per second per second; eye movements that were located on screen and did not meet this criteria were classified as fixations.

2.2.2.3 Stimuli

Two categories of threat-related images, selected from the International Affective Picture System (IAPS; Lang, Bradley & Cuthbert, 1999; See Appendix A), were formed based on previous research (Calvo & Avero, 2005) for the current Eye Movement Attention Task (EMAT). The *threat* images were selected as representing physical threat with the *potential* for injury to a person (e.g., a person holding a knife to someone's throat), while the *harm* images involved physical harm that had already occurred to a person (e.g., someone with bruises and a black eye). The neutral control images were selected to match the negative images as best as possible in content, colour, and complexity by the researchers.

The IAPS provides normative ratings for all images on a 9-point scale for affective valence (1 = *unpleasant* and 9 = *pleasant*) and arousal (1 = *low arousal* and 9 = *high arousal*). Average valence ratings were 2.3 (*SD* = .27) for the threat images, 1.9 (*SD* = .44) for the harm images, and 6.0 (*SD* = 1.1) for the neutral images. Average arousal ratings were 6.5 (*SD* = .54) for the threat images, 6.4 (*SD* = .74) for the harm images, and 4.1 (*SD* = .68) for the neutral images. A MANOVA comparing the image categories (threat vs. harm vs. neutral) on valence and arousal ratings yielded a significant effect of image type, $F(4, 106) = 23.16$, $p < .001$, $\eta_p^2 = .47$, that was significant for both valence ratings, $F(2, 53) = 156.43$, $MSE = .67$, $p < .001$, $\eta_p^2 = .86$, and arousal ratings, $F(2, 53) = 82.94$, $MSE = .44$, $p < .001$, $\eta_p^2 = .76$. Post-hoc comparisons revealed that the threat and harm images were both significantly more negative in valence and arousal than the neutral images, *ps* < .001, but the threat and harm images did not differ significantly from one another on valence or arousal, *p*s > .05.

2.2.3 Procedure

Participants meeting initial inclusion criteria completed the STAI-Trait and STAI-State, followed by the EMAT in the lab. In this task, participants were told that they would view image pairs, one involving "injury, violence and death", and they were to look at these images as they wished. In the EMAT, a series of image pairs consisting of one negative image (threat or harm) and one neutral image were presented side- by-side (side was counterbalanced). Each picture was 512 X 384 pixels and was displayed 80 pixels from the center fixation location (2.8° visual angle), on a light-gray background. Each image pair was preceded by a fixation cross and once participants had fixated on the cross, the next pair was presented in order to ensure that participants' gaze was fixated in the same center location before each image pair was shown. Image pairs were displayed for 3 seconds, followed by a 500 ms interval before the next fixation cross appeared. Participants completed two practice trials, two filler trials and 28 test trials (14 threat and 14 harm image pairs). Before leaving the study session, participants were shown a video of babies laughing[4] to improve their affective state and then asked to rate their current state on a 7 point scale (1=*very negative*; 7=*very positive*) to ensure that they were not distressed before leaving.

2.2.4 Eye Movement Indices

2.2.4.1 First Fixation Probability (FFP)

Following the procedures used by Gamble and Rapee (2010) and others (e.g., Calvo & Avero, 2005; Hermans et al. 1999), we calculated the *probability of first fixation* on the negative images compared to all initial fixations made on the image-pairs (e.g., frequency of first fixations on the threat images / [frequency of first fixations on the threat images + frequency of first fixations on the neutral images]). First fixations that were preceded by a blink or shorter than 100 ms were not used.

[4] Youtube video of babies laughing

2.2.4.2 First Fixation Gaze Durations (FFGD)

Similar to Garner et al. (2006), we evaluated the maintenance of attention following the first fixation by calculating the average *first fixation gaze durations* (FFGD), or the average length of time before participants shifted their gaze off the image (i.e., outside the interest area). Time taken to make saccades was not included in this calculation given that visual information is not registered during saccades. If analyses indicate a significant effect between the negative and neutral images (e.g., bias), then the FFGD scores will be converted into *first fixation gaze bias* scores (FFGB) by subtracting the FFGD for the neutral images from each of the FFGD for the threat and harm image types. FFGB scores that are positive would thus indicate greater gaze bias on the negative images than the neutral images.

2.2.4.3 Proportion of Viewing Time (PVT)

We also followed procedures used by Calvo and Avero (2005) and others (e.g., Wieser et al., 2009), by dividing the 3 second exposure duration for the image-pairs into six 500-milisecond intervals, and then calculating the proportion of viewing time on the negative images relative to the matched neutral images for each of the 6 time intervals (e.g., viewing time of threat images / [total viewing time of the threat images + total viewing time of the neutral images]). The proportion of viewing time did not include time spent blinking, nor the length of time taken to make eye movements (saccades), since visual information is not perceived during these occasions. The six 500 ms intervals are labelled as follows: T1 = 0-500 ms, T2 = 501-1000 ms, T3 = 1001-1500 ms, T4 = 1501-2000 ms, T5 = 2000-2500 ms, and T6 = 2501-3000 ms.

For both the first fixation probability and the proportion of viewing time, values significantly above .5 indicate greater visual attention towards the threat-related images relative to the neutral control images (i.e., attentional bias towards threat), while values below .5 indicate greater visual attention towards the neutral control images relative to the threat-related target images (i.e., attentional bias away from threat).

2.3 Results

2.3.1 Participants

Multivariate analysis of variance (MANOVA) results confirmed a significant multivariate effect of the three trait anxiety groups on self-report measures of trait anxiety (STAI-Trait), state anxiety (STAI-State), and depression (BDI-II): F (6, 328) = 39.64, $p < .001$. Means, standard deviations, and results of the independent one-way ANOVAs for the self-report measures by trait anxiety group are shown in Table 1. Post-hoc comparisons (Least Significant Difference) revealed that all groups differed from one another on all three self-report measures, *p*s < .01, in the expected directions.

Table 1. Study 1: Self-Report Measures by Trait Anxiety Group

	LTA (n = 58)		MTA (n = 52)		HTA (n = 58)			
Measure	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*F*	η_p^2
STAI-T	30.69	(3.07)	38.44	(2.75)	49.62	(4.69)	397.87***	.83
STAI-S	28.98	(5.73)	34.79	(6.29)	39.93	(8.52)	35.75***	.30
BDI-II	4.12	(3.76)	6.75	(4.35)	10.34	(4.77)	30.44***	.27

Note. LTA = Low Trait Anxious; MTA = Mid Trait Anxious; HTA = High Trait Anxious; STAI-T = State Trait Anxiety Inventory – Trait; STAI-S = State Trait Anxiety Inventory – State; BDI-II = Beck Depression Inventory – II.

*** $p < .001$

2.3.2 Eye Movement Indices

For the eye movement indices calculated as proportions (i.e., proportion of first fixation, proportion of viewing time), analyses were first conducted to establish whether there were significant attentional biases present separate for each trait anxiety group and image type. Thus, one sample *t*-tests from .5 were used and we refer to these as the *baseline bias analyses*. Then analyses were conducted to assess whether the degree of attention bias varied as a function of trait anxiety group and image type with appropriate follow up analyses to evaluate the potential specificity and extremity of ABT as a vulnerability factor for anxiety (as advised by Cisler et al., 2009). However, for the FFGD scores, biases were first assessed by a within-subjects factor included in an ANOVA given that the scores for the negative and neutral images are independent of one another. If this analysis resulted in a significant effect involving the bias factor, then bias scores were calculated and an ANOVA was used to assess whether the degree of FFGB varied as a function of trait anxiety group and image type, with appropriate follow-up analyses. Lastly, if there were significant biases in the FFGD, each bias score would be evaluated separately by trait anxiety group and image type from 0, similarly to the baseline bias analyses for the proportion indices.

For each ANOVA involving the eye movement indices, trait anxiety group (low vs. mid vs. high) was always a between-subjects factor, image type (threat vs. harm) was a within-subject factor and time was a within-subjects factor (T1 – T6). When the within-subject effects violated the assumptions of sphericity, the effects were adjusted using the Greenhouse-Geisser correction (adj. *df* indicates the adjusted degrees of freedom). Least Significant Difference (LSD) comparisons were used for all between-subject post-hoc analyses and an alpha of p <.05 was used for all analyses.

2.3.2.1 Proportion of First Fixations

The PFF means and standard deviations by trait anxiety group and image type and the baseline bias analyses are listed in Table 2. In sum, there were no significant biases involving threat or harm images in any of the trait anxiety groups.

To determine whether trait anxiety or image type influenced the PFF on the threat-related images, a mixed 3 (trait anxiety group: low vs. mid vs. high) x 2 (image type: threat vs. harm) repeated measures mixed ANOVA was conducted. There was no significant main effect of trait anxiety group, $F(2, 165) < 1$, a marginal difference between threat and harm images, $F(1, 165) = 3.68$, $MSE = .008$, $p = .057$, $\eta_p^2 = .02$, and no significant anxiety group by image type interaction, $F(2, 165) < 1$. Thus, contrary to our hypotheses, trait anxiety had no significant effect on initial orienting.[5]

Next, we followed up these analyses with one-sample *t*-tests comparing the PFF on the threat and harm images against a probability of .5 collapsed across trait anxiety group. These analyses revealed no significant bias towards threat images, $t(167) = .26$, $p = .79$, but a significant (but small) bias *away* from harm images, $t(167) = -2.11$, $p = .04$, that was only found when using the power of the full sample.

[5] When the STAI-Trait is used as a covariate in this analysis rather than a between-subjects factor, the trait anxiety effects still do not reach or near significance.

Table 2. Study 1: First Fixation Indices by Trait Anxiety Group and Image Type

	LTA (n = 58)		MTA (n = 52)		HTA (n = 58)		Full Sample (N = 168)	
Index and Image Type	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*
Proportion of First Fixation								
Threat	.50	(.11)	.50	(.12)	.50	(.11)	.50	(.11)
Harm	.48	(.10)	.48	(.10)	.49	(.11)	.48*	(.10)
First Fixation Gaze Durations (ms)								
Threat	756.43	(327.91)	720.65	(303.68)	726.83	(294.45)	735.13	(307.67)
Neutral w/Threat	877.68	(357.58)	827.14	(312.24)	774.34	(310.72)	826.36	(329.00)
Harm	699.82	(371.22)	683.27	(372.56)	735.90	(387.36)	707.15	(375.66)
Neutral w/Harm	904.31	(377.69)	919.82	(413.83)	712.62	(292.66)	842.94	(373.19)
First Fixation Gaze Bias (ms)								
Threat	-121.25*	(455.29)	-106.50'	(400.50)	-47.51	(328.02)	--	--
Harm	-204.49**	(554.57)	-236.56**	(597.06)	23.28	(455.41)	--	--

Note. LTA = Low Trait Anxious; MTA = Mid Trait Anxious; HTA = High Trait Anxious.

* $p < .05$. ** $p < .01$. ' $p < .09$

2.3.2.2 First Fixation Gaze Durations

Participants with FFGD scores greater than 3 standard deviations (SD) above the mean per image category type (e.g., threat, neutral when shown with threat) were replaced with a value at 3 SD to ensure that means were not unduly influenced by outlying values. Two participants in each of the neutral image type conditions and 3 participants in each of the negative image type conditions were above this cut off and were adjusted accordingly. The resulting average FFGD and FFGB scores by trait anxiety group are listed in Table 2.

To determine whether there were differences between the negative and neutral images (i.e., biases) for the FFGD and whether trait anxiety or image type influenced the FFGD on the negative images, a mixed 3 (trait anxiety: low vs. mid vs. high) x 2 (image type: threat vs. harm) x 2 (negative bias: negative vs. neutral) repeated measures ANOVA was conducted. This analysis resulted in a main effect of negative bias, F (1, 165) = 11.94, MSE = 187211.02, p = .001, η_p^2 = .07, a marginal interaction involving negative bias and trait anxiety group, F (2, 165) = 2.44, MSE = 187211.02, p = .09, η_p^2 = .03, that were subsumed under a 3-way interaction involving negative bias, trait anxiety group and image type, F (2, 165) = 4.30, MSE = 36004.95, p = .015, η_p^2 = .05.

To interpret this interaction, bias scores were calculated for threat and harm images separately and a mixed 3 (trait anxiety: low vs. mid vs. high) x 2 (image type: threat vs. harm) repeated measures mixed ANOVA was conducted on the FFGB scores. This analysis revealed a marginal main effect of trait anxiety group, F (2, 165) = 2.44, MSE = 374422.04, p = .091, η_p^2 = .03 and a trait anxiety group by image type interaction, F (2, 165) = 4.30, MSE = 72009.90, p = .015, η_p^2 = .05. Next, we assessed the effect of trait anxiety group for threat and harm image types separately with one-way ANOVAs. For threat images, there was no significant effect of trait anxiety group, F (2, 165) < 1, but for harm images this effect reached significance, F (2, 165) = 3.94, MSE = 288073.88, p = .02. Post-hoc comparisons revealed that the HTA group had significantly less bias (lower FFGB scores) than the MTA and LTA groups, ps < .05, but that the MTA and LTA groups did not differ from one another, p = .75. Of note, the FFGB bias scores for the MTA and LTA groups were negative, indicating greater FFGD on neutral than harm images. In other words, the MTA and LTA groups showed a bias towards neutral images relative to harm images, while the HTA group showed no biases in gaze duration.

Lastly, to test for attentional biases from chance, one-sample *t*-tests were used from 0 separately by image type and trait anxiety group. The results are listed in Table 2. In sum, the HTA group did not show any significant biases. However, the LTA group showed a bias away from threat and harm relative to neutral, while the MTA group showed a bias away from harm images and a marginal bias away from threat images, $p = .086$.

2.3.2.3 Proportion of Viewing Time

The PVT means and standard deviations by trait anxiety group, image type and time point are listed in Table 3, along with the baseline bias analyses results. In sum, all trait anxiety groups show significant biases towards threat and harm images at T2 and T3 (500-1500 ms) and only the HTA group's bias towards harm images at T1 reached significance.

To assess the attentional biases over time as a function of trait anxiety, we conducted a mixed 3 (trait anxiety: low vs. mid vs. high) x 2 (image type: threat vs. harm) x 6 (time: T1 vs. T2 vs. T3 vs. T4 vs. T5 vs. T6) repeated measures ANOVA on PVT.[6] This analysis revealed a significant main effect of image type, F (1, 164) = 10.48, $MSE = 0.2$, $p < .001$, $\eta_p^2 = .06$, with greater bias on harm images ($M = .54$, $SD = .14$) than threat images ($M = .51$, $SD = .09$), and a significant effect of time, F (2.44, 399.37 adj. *df*) = 35.55, $MSE = .05$, $p < .001$, $\eta_p^2 = .18$. The within-subjects contrasts indicated a significant time function as high as the 4th order, F (1, 164) = 7.79, $MSE = .009$, $p < .01$, $\eta_p^2 = .05$, but the data, as displayed in Table 3, appeared to have two primary bends in the 3 second duration, suggesting a cubic time course, F (1, 164) = 72.60, $MSE = .019$, $p < .001$, $\eta_p^2 = .31$. These effects were both subsumed under an image type by time interaction, F (3.48, 570.47 adj. *df*) = 3.27, $MSE = .015$, $p = .016$, $\eta_p^2 = .02$. No effects of trait anxiety group reached significance, all *F*s > 1.

[6] Note that 1 participant did not have valid time course data due to technical difficulties and thus, are not included in the PVT analyses.

Table 3. Study 1: Proportion of Viewing Time by Trait Anxiety Group and Image Type

	LTA (n = 58)		MTA (n = 52)		HTA (n = 58)		Full Sample (N = 168)	
Proportion of Viewing Time	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*
Threat								
T1 (0-500)	.50	(.13)	.50	(.11)	.51	(.10)	.50	(.11)
T2 (501-1000)	.58***	(.13)	.55*	(.14)	.59***	(.13)	.57***	(.13)
T3 (1001-1500)	.55*	(.16)	.55*	(.16)	.55**	(.13)	.55***	(.15)
T4 (1501-2000)	.51	(.15)	.51	(.18)	.48	(.16)	.50	(.16)
T5 (2001-2500)	.49	(.16)	.46	(.19)	.47	(.18)	.48	(.18)
T6 (2500-3000)	.47	(.15)	.47	(.19)	.47	(.19)	.47*	(.17)
Harm								
T1 (0-500)	.51	(.12)	.52	(.10)	.53*	(.10)	.52**	(.11)
T2 (501-1000)	.63***	(.16)	.61***	(.18)	.64***	(.14)	.63***	(.16)
T3 (1001-1500)	.61***	(.19)	.57*	(.21)	.60***	(.16)	.59***	(.19)
T4 (1501-2000)	.53	(.21)	.50	(.23)	.53	(.20)	.52	(.21)
T5 (2001-2500)	.49	(.21)	.47	(.24)	.49	(.21)	.49	(.22)
T6 (2500-3000)	.47	(.22)	.45	(.23)	.47	(.22)	.47*	(.22)

Note. Note. LTA = Low Trait Anxious; MTA = Mid Trait Anxious; HTA = High Trait Anxious

* $p < .05$. ** $p < .01$. *** $p < .001$. ' $p < .09$.

To interpret this interaction, paired samples t-tests were used to compare the PVT between image types at each of the 6 time points. These analyses revealed greater biases towards harm than threat images at T2 (501-1000 ms), $t(167) = 5.1$, $p < .001$ and T3 (1001 – 1500 ms), $t(167) = 2.98$, $p < .01$, a similar marginal effect at T1, $t(167) = 1.94$, $p = .055$, but no significant differences at T4 through T6, *ts*(167) = -.27 – 1.62, *ps* > .10.

Next, to understand the effect of time, a series of one-sample *t*-tests comparing the proportion of time spent viewing the threat and harm images relative to the neutral images against a probability of .5 in each time interval was conducted collapsed across trait anxiety group. These results are listed in Table 3. In sum, biases towards threat images were shown at T2 and T3 and away from threat at T6. For harm images, biases were shown towards harm at T1 through T3, and a bias away from harm at T6. These general patterns are consistent with a vigilance-avoidance pattern over time.

Lastly, we calculated the correlations between the eye movement indices and trait and state anxiety scores, given our primary interest in the associations between anxiety and viewing behaviour when presented with threat and harm images. The results are listed in Table 4. The STAI-Trait and STAI-State were positively correlated, $r = .64$, $p < .001$. Of note, there was a small positive association between trait anxiety and the FFGB for harm images, consistent with the ANOVA results reported above. There were also some small negative associations between state anxiety and the PVT for threat images at relatively late time points (T4 & T5). Thus, the greater the level of state anxiety, the less participants looked at threat between 1501 and 2500 ms. Overall however, there were no strong associations between anxiety, either trait or state, and ABT.

Table 4. Study 1: Correlations among Trait and State Anxiety and Eye Movement Indices

	Anxiety	
Index and Image Type	Trait	State
Proportion of First Fixations		
Threat	-.05	-.02
Harm	-.01	-.03
First Fixation Gaze Durations		
Threat	-.02	-.03
Neutral w/Threat	-.09	-.21**
Harm	.04	.00
Neutral w/Harm	-.18*	-.21**
First Fixation Gaze Bias		
Threat	.05	.15'
Harm	.16*	.14'
Proportion of Viewing Time		
Threat		
T1 (0-500)	.08	.04
T2 (501-1000)	.06	.01
T3 (1001-1500)	.03	.00
T4 (1501-2000)	-.14'	-.16*
T5 (2001-2500)	-.09	-.19*
T6 (2500-3000)	-.06	-.14'
Harm		
T1 (0-500)	.02	-.02
T2 (501-1000)	.01	-.05
T3 (1001-1500)	-.04	-.07
T4 (1501-2000)	-.04	-.08
T5 (2001-2500)	-.05	-.10
T6 (2500-3000)	-.03	-.07

Note. Trait = State-Trait Anxiety Inventory – Trait;

State = State-Trait Anxiety Inventory – State.

* $p < .05$. ** $p < .01$. ' $p < .08$

2.4 Discussion

The purpose of Study 1 was to evaluate the time course of visual selective attention to threat-related images as a function of trait anxiety in attempts to reveal the nature of anxiety-related ABT. We assessed both within-subject and between-subject attentional bias effects and each of the research questions and hypotheses will be addressed below.

Based on the models of anxiety-related ABT and extant literature (e.g., Armstrong & Olantunji, 2012; Bar-Haim et al., 207; Mathew & Mackintosh, 1998, Mogg & Bradley, 1998), it was first hypothesized that HTA participants would show early facilitated orienting towards threat-related images on the initial fixations and during the first 500 ms of viewing relative to neutral images. Overall, the current data do not support this hypothesis. On the first fixations, the HTA group was *not* more likely to shift their eye movements towards threat or harm images than to neutral stimuli. For the relative viewing during the first 500 ms, the HTA group showed a small, but significant, bias towards harm images, yet not towards threat images. Of note, the LTA and MTA displayed no early facilitated orienting of attention to the negative stimuli. Thus, in contrast to some previous eye movement research (e.g., Calvo & Avero, 2005; Gamble & Rapee, 2010; Hermans et al., 1999; Quigley et al., 2012; Wieser et al., 2009) little evidence of facilitated attention to threat in HTA participants was found. Similar null results have been found in other published studies for first fixation biases (Gerdes, et al, 2008; Rinck & Becker, 2006; Waechter et al., 2014) and duration biases within the first 500 ms (Calvo & Avero, 2005 for threat images; Quigley et al., 2012; Waechter et al., 2014), with no clear methodological distinction for these mixed results. Of note, when such facilitated attention effects have been found, they have been relatively small in magnitude (e.g., Calvo & Avero, 2005; Quigley et al., 2012).

Furthermore, we hypothesized that early ABT threat would be greater in HTA than in LTA and MTA participants; however the current data also did not support this prediction. There were no significant trait anxiety effects on the tendency to make initial fixations to negative images relative to neutral, or on the relative viewing time in the first 500 ms. Other studies have also failed to find differences in anxious groups on the first fixation biases

(Armstrong et al., 2013; Armstrong et al., 2010 for disgust faces; Garner et al., 2006; Schofield et al., 2012; Waechter et al., 2014; Quigley et al., 2012) and duration biases in the first 500 ms (Armstrong et al., 2012; Armstrong et al., 2013; Hermans et al. 1999; Rohner, 2002; Quigley et al., 2012; Waechter et al., 2014), despite others finding such effects (Armstrong et al., 2010 for fearful faces; Calvo & Avero, 2005; Mogg & Bradley, 2007; Pflugshaupt et al., 2005; Rinck & Becker, 2006; Wieser et al., 2009). Clearly, the eye movement literature, like the response time research, has not revealed consistent results that would fully support the vigilance hypothesis, indicating that such facilitated orienting biases do not likely occur in all conditions and it will be important to identify potential moderators.

In part, methodological factors may account for some mixed results. The current literature has used a range of eye movement tasks (e.g., dot probe, visual search, free viewing), but even within the free viewing studies, there are notable differences in samples (e.g., trait anxiety, social anxiety, contamination fears, spider fears), threat stimuli (e.g., scenes, faces, spiders), control stimuli (e.g., objects versus people), stimulus durations (e.g., 3 – 60 seconds) and there are no replications yet published on which to base firm conclusions. The current study design and stimuli were most similar to Calvo & Avero (2005), however they found first fixation biases towards threat and harm images and biases in viewing time in the first 500 ms for harm images (not for threat). The different results could be due to methodology, such that they displayed the images on a large projection screen that may have made the images appear more threatening than those presented on a computer screen, particularly for high-anxious participants, and could increase the potential to detect observable biases. Nevertheless, other research has found facilitated attention effects using a computer screen and similar images (e.g., Quigley et al., 2012). Theoretically, the current design should result in trait anxiety related early ABT if HTA individuals show a greater preference for viewing threat-related relative to neutral stimuli than LTA.

Another more likely explanation for these discrepant results in facilitated attention is that the reliability of the first fixation indices is poor (Waechter et al., 2014). In the current study, the image pairs were presented side-by-side and participants tended to look at the left image first, regardless of the image content. The probability that the initial fixations were made on the left image was .76, well above chance levels, $p < .001$. Previous research has found a bias towards threat stimuli when presented in the left hemifield (i.e., threat-neutral), but not in the right hemifield (i.e., neutral-threat), suggesting a right hemisphere advantage in processing emotional information (e.g., Alpers, 2008; Calvo & Nummenmaa, 2007). However, in the current study, there were no significant first fixation biases in either the left or right hemifield, suggesting that a laterality effect was not responsible for the large probability of looking left. It may be that presenting stimuli on a computer screen, as opposed to a large projection screen, as in Calvo and Avero (2005), naturally evokes a left to right visual response, thus reducing the likelihood of initial fixations being made to material in the right visual field. A similar bias has been found in vertical stimulus presentations towards images above a central fixation cross over those below, and such biases are problematic for the reliability of early ABT indices (Waechter et al., 2014).

These results are consistent with research demonstrating that movement of attention is more efficient in a top-to-bottom direction and left-to-right direction relative to the opposite directions (e.g., Spalek & Hammad, 2004) and the left-to-right bias in shifting attention seems to be associated with the direction of text reading and writing rather than a hemispheric specialization (Spalek & Hammad, 2005). Thus, free viewing paradigms are based on the assumption that participants are equally likely to look left or right, but that is not the case. In attempts to reduce this initial bias in attention and improve the ability to measure ABT more reliability at the first fixations, future research might benefit from presenting the images in an unpredictable fashion (e.g., randomly vertically and horizontally), although this approach would not likely eliminate the bias given that it occurs for both images on the left and top positions. Rather, ABT to threat may be more reliability measured in a free viewing task by attention at later points in time (Waechter et al., 2014).

Moreover, the hypothesis that HTA participants will demonstrate gaze duration biases on threat (relative to neutral) following the first fixations and that these biases will be greater for HTA than LTA, as predicted by the attention maintenance hypothesis (Weierich et al., 2008), was also not supported. Rather, the current data suggest that HTA show no differences between the length of time they gazed at negative and neutral images when they were fixated first, similar to Garner and colleagues (2006; Study 2 only), but the LTA and HTA spent less time fixating on negative than neutral images. In other words, non-anxious individuals disengaged from negative images sooner than neutral images, whereas anxious individuals did not. This trait anxiety (between-group) effect should not be interpreted as anxious participants maintaining their attention on threat given the lack of difference between threat and neutral stimuli. Rather, examination of the gaze durations (Table 2) suggests that these bias results are largely due to LTA and MTA viewing the neutral images longer (when paired with negative images) than the HTA rather than differences in how they view the negative images. Similarly, the correlational results (Table 4) indicated that state anxiety was negatively associated with the first fixation gaze durations on neutral images (when paired with threat and harm), but not with negative images, such that greater levels of anxiety was associated with less maintenance of attention to neutral images. These results may suggest that state anxiety increases a vigilant search for negative images (hypervigilance; Richards et al., 2014), shifting attention off of the neutral images more quickly or that low anxiety (trait and/or state) delays shifting attention to threat when they first fixate on the neutral stimuli. Nevertheless, the current results are not consistent with Weierich and colleagues' (2008) attention maintenance hypothesis.

Rather, the current data suggest that attention to threat changes over time and the time course is consistent with a general vigilance-avoidance pattern, irrespective of trait anxiety levels. That is, biases towards threat images reached significance at time segments between 501 and 1500 ms after the stimuli onset, and then shifted away from threat over time that then reached a significant bias away at the final time interval (2501-3000 ms). Similarly, significant biases towards harm images were found at the first three time intervals (0-1500 ms) and then away from harm at the final interval (2501-3000 ms). These results are highly consistent with the time course found in a similar studies using threat images (Quigley et al. 2012) and to fear and disgust faces (Waechter et al., 2014) in our lab, although in these studies, the attentional bias away from threat-related stimuli did not reach the required level of significance. Other studies have found somewhat similar (Armstrong et al., 2010; Gamble & Rapee, 2010; Hermans et al., 1999; Rohner, 2002) or different patterns of attention over time (Armstong et al., 2013; Buckner et al., 2010; Calvo & Avero, 2005; Rinck & Becker, 2006; Wieser et al., 2009), however due to multiple methodological differences (e.g., anxious samples, threat stimuli type, control stimuli type, stimuli arrangements, stimuli durations, stimuli interval length) it is difficult to compare across studies. More direct replication and extension studies are needed to clarify the seemingly inconsistent results.

Lastly, a qualitative comparison of threat and harm images did not reveal any clear specificity of ABT to potential threat over negative images in general. Rather, participants showed greater biases towards harm images early in viewing (0 – 1500 ms) than to threat images. This difference was not found in Calvo and Avero (2005) and given that the image types were similar in valence and arousal, it is unclear what might account for this difference in viewing behaviour. Calvo and Avero (2005) suggest that threat and harm images likely elicit different emotional and physiological responses (Lang, Greenwald, Bradley, & Hamm, 1993) with threat corresponding to fear and/or anxiety and harm associated with sadness and/or disgust. Perhaps harm images that elicit sadness are attended to and processed in more detail (e.g., Gasper & Clore, 2002) than those that elicit anxiety (e.g., Jefferies, Smilek, Eich, & Enns, 2008) leading to a greater proportion of viewing relatively early in the time course of viewing novel images. In the current design, we do not know what emotions were elicited by the images, or even whether the images were appraised as negative and/or threatening, which would be important to assess in order to understand the current results. Furthermore, in the current study, HTA participants did not show significant biases away from harm images late in the time course as was found in Calvo and Avero (2005). Rather, there was a very small bias away from harm images at the first fixations and small biases away from threat and harm images between 2500 – 3000 ms (in the full sample only). While these results could indicate some avoidance of threat, the motivation of participants is not known and it could simply be that once participants have detected and viewed the emotional image to their liking, they shift their attention to the next most salient stimulus, the neutral image. Nevertheless, given the discrepant results, further research on the qualitative nature of threat-related and negative stimuli is needed in order to identify maladaptive attentional processes that are specific to threat.

In sum, the current results suggest that when viewing threat-related images in a free viewing task, there is little evidence to support the vigilance, maintenance or vigilance-avoidance hypotheses. That is, there were no consistent anxiety-related effects of facilitated orienting to threat prior to 500 ms, attention maintenance on threat following the first fixations, or avoidance of threat over time (i.e., that varied as a function of trait anxiety). However, in general, attentional biases towards negative images were found relatively early (500 – 1000 ms) and then reduced over time such that attention was more often directed towards the neutral images late in the time course (2501-3000 ms). These results suggest that HTA individuals do not simply have a preference for viewing threat-related images relative to neutral images more or less than others do when assessed in the current unconstrained design. What conditions then are also needed in order for ABT effects to occur? One of the most likely factors noted in some leading models of anxiety-related ABT, but not often assessed empirically, is the level of *state anxiety*.

To date, anxiety-related ABT are generally thought to be associated with trait anxiety with relatively minimal consideration to within-subject differences of the current state of anxiety. Consequently, ABT has been much more frequently studied as a function of trait factors (e.g., trait anxiety, social anxiety) without assessing or manipulating state levels of anxiety (Bar-Haim et al., 2007). However, both trait (see Armstrong & Olatunji, 2012 and Bar-Haim et al., 2007 for reviews) and state anxiety (e.g., Bradley et al., 2000; Fox et al., 2001; Mogg et al., 1997; Quigley et al., 2012) have been associated with greater ABT. Not surprisingly, these two constructs are highly related and thus, it is often difficult to separate their relative effects.

Theoretically, some models hypothesize that state anxiety plays an important role in the biasing of attention towards threat. For instance, Mogg and Bradley (1998) note that "in the absence of stress, there may be little apparent difference between high and LTA individuals in their preattentive and attentional biases for aversive stimuli. However, when state anxiety or stress levels increase, HTA individuals will become vigilant for threat. This implies that the vigilant attentional style is a *latent*, rather than manifest, vulnerability factor for anxiety" (p. 827). Similarly, Matthews & Mackintosh (1998) write that "because attentional bias is supposed to arise from an interaction between existing threat values and current anxiety level, we would therefore predict vigilance effects in HTA individuals, but only when state-anxiety levels are also elevated" (p. 551).

Despite these theoretical claims, relatively few studies have manipulated state anxiety in the assessment of ABT (see Bar-Haim et al., 2007) and even fewer have attempted to manipulate state anxiety when assessing eye movement indices of ABT (Garner et al., 2006; Mühlberger et al., 2008; Quigley et al., 2012). Garner and colleagues (2006) measured eye movement in two studies, first without any manipulation where they did not find evidence of anxiety-related ABT. When they added a social-evaluative stress condition, they then found some evidence of facilitated orienting towards emotional faces in socially anxious participants that differed from those low in social anxiety. As previously noted, these results could be due to an interaction between trait (social anxiety) and state (stress) factors or simply to state factors alone since the anxiety groups differed in both. Quigley et al. (2012) attempted to separate the effects of trait and state anxiety and found that experimental induction of state anxiety, relative to a baseline state condition, increased the maintenance of attention on threat-related images (relative to neutral images) following the first fixation over a 3000 ms time course. Contrary to expectations, these biases were not moderated by trait anxiety, suggesting that greater maintenance of attention on threat stimuli may be largely a function of state anxiety. However, it is possible that this study did not have sufficient power to detect the between-subject differences of trait anxiety given that there were relatively few trials (10 threat-neutral images per image set) and some of the trials provided variable results (i.e., image set effect, as discussed in Quigley et al., 2012), thus further research is needed to clarify the relative contribution of trait and state anxiety. Lastly, Mühlberger and colleagues (2008) were not successful in significantly manipulating state anxiety in socially anxious participants leaving their results difficult to interpret in this respect. With so few studies assessing the influence of state anxiety on the multiple components of attention, it is important to assess whether ABT are more likely to be found when trait-anxious participants are also in a state of anxiety as indicated by theoretical models (Matthew & Mackintosh, 1998; Mogg & Bradley, 1998). Such data could help explain, at least in part, some inconsistencies in the literature and help clarify the nature of anxiety-related ABT.

Chapter 3

Study 2: State Anxiety and the Time Course of Attentional Biases to Threat

3.1 Introduction

The purpose of Study 2 was to evaluate the research questions outlined in Study 1 when participants were in an elevated state of anxiety. That is, we expected that when participants increased their level of state anxiety, HTA individuals would show early facilitated orienting towards threatening images on the initial fixations and during the first 500 ms of viewing relative to neutral images. Furthermore, when in a state of anxiety, these early attentional biases towards threat would be greater in HTA than in the mid and LTA individuals, as predicted by the vigilance hypothesis. Consistent with the maintenance hypothesis (Weierich et al., 2008), we expected that HTA participants would demonstrate longer gaze duration biases on threat images (relative to neutral) following the first fixations on threat images, and that such a bias in the maintenance in attention would be greater in HTA than LTA participants.

To assess whether biases in attention are specific to negative information or emotional images more generally, we included positive images for comparison to the threat and harm images. In general, models of anxiety-related ABT (e.g., Mogg & Bradley, 1998) predict that because anxiety functions to assist in the detection of threat, attentional biases should result specifically for threat-related stimuli rather than emotional stimuli in general (see Calvo & Avero, 2005). That is, models suggest the *negativity hypothesis* over the *emotionality hypothesis*, respectively. While the research often supports this specificity of attention to threat (e.g., Bradley et al., 1998, 2000; Fox et al., 2001, 2002; Mogg & Bradley, 1999), other studies suggest similar attentional bias effects for positive stimuli as well, consistent with the emotionality hypothesis (Calvo & Avero, 2005; Fox et al., 2001, experiment 3; Fox et al., 2002, experiment 1; Quigley et al., 2012). Given that this research has largely measured facilitated orienting (i.e., vigilance), further research is needed to assess the specificity of ABT on multiple components of attention over time in order to identify the potential maladaptive attentional processes that are particular to threat.

Lastly, an additional purpose was to assess participants' appraisals or ratings of the stimuli valance (i.e., negativity) and arousal in order to evaluate whether trait anxiety is associated with the extent that participants rate threat-related stimuli as negative and arousing. Models of ABT propose that HTA individuals will rate negative images as more negative and arousing than LTA and it is this bias in appraisal of stimuli that results in greater ABT (e.g., Mogg & Bradley, 1998).

3.2 Method

3.2.1 Participants

One hundred and fifty-four undergraduate students enrolled in psychology courses who met the initial inclusion criteria described in Study 1 attended the lab for the current study. Of these, 11 participants could not be calibrated on the eye tracker and/or had incomplete eye movement data and were removed from the analyses. Participants whose STAI-Trait scores changed from the screening session to the lab session more than 2.5 *SD*s above the mean change (*M* = - 0.59, *SD* = 5.88) were also removed (n = 5) to ensure stable measurement. The excluded participants did not differ from the remaining sample of 138 on age, gender, STAI-Trait or STAI-State scores, ps > .05. Trait anxiety groups were formed with a tertile split on the STAI-Trait (*M* = 41.3, *Mdn* = 40.50, *SD* = 88.30) resulting in 41 HTA, 53 MTA and 44 LTA participants. The sample had a mean age of 19.83 years (*SD* = 2.18) and 65% were female.[7] The LTA, MTA and HTA groups did not differ significantly in terms of age, *F*(2, 132) = 1.39, *p* = .25 or gender, χ^2 (4, *N* = 138) = 2.15, *p* = .71.

3.2.2 Materials

3.2.2.1 Additional Self-Report Measures

The *Positive and Negative Affect Schedule* (PANAS; Watson, Clark, & Tellegen, 1988) was used to assess state affect. This measure contains two scales that assess negative affect (NA) and positive affect (PA), each with 10 associated emotion words. Participants rated the extent

[7] The ethnicity profile of the sample was very similar to Study 1.

to which they felt each emotion word in that moment on a 5-point scale (1 = *very slightly or not at all*; 5 = *extremely*). The measure was administered at baseline prior to the anxious state induction (pre-induction), after the state induction (post-induction), and following the attention task (post-EMAT) (Cronbach's α for NA: .81, .87, and .90, respectively; PA: .87, .89, and .96, respectively).

3.2.2.2 Stimuli

As in Study 1, two categories of negative images (threat and harm) were used from the IAPS; Lang, Bradley & Cuthbert, 1999; See Appendix B), Fourteen positive images were also selected based on the valence ratings. The neutral control images were selected to match the negative and positive images as best as possible in content, colour, and complexity.

Average valence ratings were 2.3 (*SD* = .27) for the threat images, 2.0 (*SD* = .47) for the harm images, 5.4 (*SD* = .82) for the neutral images, and 7.6 (*SD* = .38) for the positive images. Average arousal ratings were 6.5 (*SD* = .54) for the threat images, 6.2 (*SD* = .76) for the harm images, 4.0 (*SD* = .86) for the neutral images, and 4.6 (*SD* = .95) for the positive images. A MANOVA comparing the image categories (threat vs. harm vs. neutral vs. positive) on valence and arousal ratings yielded a significant multivariate effect of image type, $F(6, 160) = 44.96$, $p < .001$, $\eta_p^2 = .63$, that was significant for both valence ratings, $F(3, 83) = 258.83$, $MSE = .41$, $p < .001$, $\eta_p^2 = .91$, and arousal ratings, $F(3, 83) = 49.10$, $MSE = .67$, $p < .001$, $\eta_p^2 = .65$. Post-hoc comparisons revealed that all the images differed significantly from one another, $p < .05$, except that threat and harm images did not differ significantly from one another on valence, $p = .32$, or arousal, $p = .39$.

3.2.3 Procedure

Participants completed the STAI-Trait, the BDI-II, and the SDS as screening measures. In the lab, they completed the STAI-Trait and STAI-State in randomized order and then were administered the PANAS. Participants then underwent an anxiety induction using a standardized procedure developed by Eich and colleagues (Eich, Ng, Macaulay, Percy, & Grebneva, 2007; also see Jefferies et al., 2008). Participants were instructed to think of personally-relevant anxious thoughts in detail with the goal of feeling as anxious as possible for a short period of time (5 minutes; See Appendix C for instructions). During this time, emotionally arousing music was played.[8]

Next, participants completed the EMAT as described in Study 1 where they viewed 2 practice trials, 2 filler trials, and 42 test trials involving one emotional image (threat, harm, or positive) paired with a neutral image side-by-side. In order to sustain anxious arousal during the EMAT, arousing classical music[9] was presented through speakers for its duration and the PANAS was administered for a third time.

Participants were then asked to rate 62 images that appeared in the EMAT in terms of how each image made them feel while viewing it. The procedures and instructions for rating the images were taken from those procedures used to rate the IAPS (Lang et al., 1999). Two 9-point scales were used to assess the valence (1 = *unhappy;* 9 = *happy*) and arousal (1 = *low arousal*; 9 = *high arousal)* associated with each image. Participants were shown all 14 threat, 14 harm, and 14 positive images and a random selection of 20 control images used in the EMAT. Images were selected and displayed at random for 3 seconds. Following each image, each rating scale (valence and arousal) appeared in random order and participants were instructed to make ratings using the number pad on a keyboard.

Lastly, as in Study 1, before leaving the study session, participants were shown a video of babies laughing and then asked to rate their current state on a 7 point scale (1=*very negative*; 7=*very positive*) to ensure that they were not distressed before leaving.

3.3 Results

3.3.1 Participants

As expected, MANOVA results confirmed a significant multivariate effect of the three trait anxiety groups on self-report measures of trait anxiety (STAI-Trait), state anxiety (STAI-State), and depression (BDI-II), F (6, 264) = 39.89, $p < .001$, $\eta_p^2 = .48$. Means, standard deviations, and results of the independent one-way ANOVAS for the self-report measures by

[8] Symphony No. 8 in C Minor: 4. Finale: Feierlich, Nicht Schnell by Bruckner, and Mars, The Bringer of War by Holst

[9] Grosse Fuge in B flat Major, Op. 133 by Beethoven

Table 5. Study 2: Self-Report Measures by Trait Anxiety Group

	LTA (n = 44)		MTA (n = 53)		HTA (n = 41)			
Measure	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*F*	η_p^2
STAI-T	32.14	(3.24)	40.92	(2.73)	51.70	(3.75)	387.07***	.85
STAI-S	31.57	(7.38)	38.46	(8.83)	42.95	(9.74)	18.48***	.22
BDI-II	3.75	(2.90)	8.96	(4.48)	9.80	(4.31)	29.66***	.31

Note. LTA = Low Trait Anxious; MTA = Mid Trait Anxious; HTA = High Trait Anxious; STAI-T = State Trait Anxiety Inventory – Trait; STAI-S = State Trait Anxiety Inventory – State; BDI-II = Beck Depression Inventory – II.

*** $p < .001$

trait anxiety group are shown in Table 5. Post-hoc comparisons revealed that all groups differed from one another on all three self-report measures, *p*s < .01, in the expected directions, except that the MTA and HTA did not differ on their depression scores, $p = .32$.

3.3.2 State Induction Manipulation Check

The means and standard deviations for NA and PA across trait anxiety groups and time are shown in Table 6. Four participants had complete missing PANAS data and another four had 1-2 time points missing due to researcher administration errors and were not included in the analyses. Another six participants had 1-2 data points missing that were corrected with mean substitution. Analyses were conducted to assess whether NA had increased and PA had decreased with the state induction and that the negative affect remained stable across the EMAT.

A 3 (trait anxiety: low vs. mid vs. high) × 3 (time: pre-induction vs. post-induction vs. post EMAT) mixed repeated measures mixed ANOVA on the PANAS NA scale revealed a main effect of trait anxiety group, $F(2, 127) = 3.22$, $MSE = 71.35$, $p = .04$, $\eta_p^2 = .05$, and of time, $F(1.7, 214.0 \text{ adj. } df) = 81.26$, $MSE = 15.40$, $p < .001$, $\eta_p^2 = .39$. The time by trait anxiety group interaction did not reach significance, $F(3.4, 214.0 \text{ adj. } df) = 2.05$, $MSE = 15.40$, $p = .10$. Post-hoc analyses indicted that the NA scores for the HTA group ($M = 18.33$, $SE = .81$) were significantly higher than the LTA ($M = 15.54$, $SE = .74$), $p = .01$, but the MTA group did not differ from the HTA or LTA groups, *p*s >.10. Planned comparisons between the adjacent time points revealed that NA increased from pre-induction to post-induction, $t(131) = 11.44$, $p < .001$, and did not change significantly from post-induction to post-EMAT, $t(129) = .45$, $p = .66$.

A 3 (trait anxiety: low vs. mid vs. high) × 3 (time: pre-induction vs. post-induction vs. post EMAT) mixed repeated measures mixed ANOVA on the PANAS PA revealed a main effect of trait anxiety group, $F(2, 127) = 3.25$, $MSE = 92.80$, $p = .04$, $\eta_p^2 = .05$, and of time, $F(1.74, 221.36 \text{ adj. } df) = 43.47$, $MSE = 14.00$, $p < .001$, $\eta_p^2 = .26$. The time by trait anxiety group interaction did not reach significance, $F(3.5, 221.36 \text{ adj. } df) < 1$. Post-hoc analyses indicted that the PA scores for HTA group ($M = 20.77$, $SE = .93$) were lower than for the

LTA (*M* = 23.92, *SE* = .85), $p = .01$, and marginally lower than the MTA group (*M* = 22.97, *SE* = .78), $p = .072$. Planned comparisons between the adjacent time points revealed that PA decreased from pre-induction to post-induction, $t(131) = 7.09$, $p < .001$, and further decreased following the post-EMAT, $t(129) = 2.30$, $p = .02$.

In sum, the anxious state induction had its intended effect on increasing negative affect and reducing positive affect, as would be expected with the increase of an anxious mood state. Moreover, the mood ratings were stable over the course of the EMAT.

Table 6. Study 2: Positive and Negative Affect Scores

	LTA (n = 43)		MTA (n = 51)		HTA (n = 36)		Full Sample (N = 130)	
Affect Scale and Time Point	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*
Negative Affect								
Pre-Induction	12.95	(2.67)	13.65	(4.30)	14.28	(4.53)	13.59	(3.92)
Post-Induction	16.33	(4.91)	18.47	(6.48)	20.89	(6.41)	18.43	(6.20)
Post-EMAT	17.35	(5.79)	18.78	(7.89)	19.73	(6.20)	18.60	(6.81)
Positive Affect								
Pre-Induction	26.79	(7.18)	24.96	(5.39)	22.83	(6.23)	24.98	(6.40)
Post-Induction	22.98	(8.05)	22.31	(5.91)	20.08	(5.06)	21.92	(6.55)
Post-EMAT	21.98	(6.78)	21.62	(5.82)	19.39	(5.14)	21.12	(6.03)

Note. LTA = Low Trait Anxious; MTA = Mid Trait Anxious; HTA = High Trait Anxious.

3.3.3 Eye Movement Indices

The data analysis plan was identical to Study 1. For each ANOVA involving the eye movement indices, trait anxiety group (low vs. mid vs. high) was always a between-subjects factor, image type (threat vs. harm vs. positive) was a within-subject factor and time was a within-subjects factor (T1 – T6). When the within-subject effects violated the assumptions of sphericity, the effects were adjusted using the Greenhouse-Geisser correction (adj. *df* indicates the adjusted degrees of freedom). LSD comparisons were used for all between-subject post-hoc analyses and an alpha of $p < .05$ was used for all analyses.

3.3.3.1 Proportion of First Fixation

The PFF means and standard deviations by trait anxiety group and image type and the baseline bias analyses are listed in Table 7. In sum, LTA and MTA showed significant biases towards threat, harm and positive images, while the HTA showed biases towards harm and positive images, but the bias towards threat was only marginal, $p = .076$.

A 3 (trait anxiety group: low vs. mid vs. high) x 3 (image type: threat vs. harm vs. positive) mixed ANOVA revealed no significant main effects of trait anxiety group, F (2, 270) < 1, or image type, F (2, 156) < 1, nor a significant interaction F (4, 270) < 1.[10] Therefore, the probability of making the initial fixations to emotional images did not change as a function of trait anxiety or image type.

[10] When the STAI-Trait is used as a continuous covariate in this analysis rather than a between-subjects factor, the trait anxiety effects still do not approach significance.

Table 7. Study 2: First Fixation Indices by Trait Anxiety Group and Image Type

	LTA (n = 44)		MTA (n = 53)		HTA (n = 41)		Full Sample (N = 138)	
Index and Image Type	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*
Proportion of First Fixation								
Threat	.53**	(.08)	.54**	(.11)	.53'	(.12)	.54***	(.10)
Harm	.55**	(.11)	.55***	(.09)	.54*	(.13)	.55***	(.11)
Positive	.55**	(.11)	.55***	(.09)	.54*	(.13)	.55***	(.11)
First Fixation Gaze Durations								
Threat	887.80	(324.62)	931.22	(287.28)	838.67	(329.43)	889.88	(312.30)
Neutral w/Threat	649.22	(305.21)	540.02	(202.48)	541.19	(209.97)	575.18	(245.47)
Harm	964.27	(431.06)	1055.46	(371.61)	967.33	(435.46)	1000.20	(409.90)
Neutral w/Harm	578.47	(331.99)	528.11	(287.01)	477.18	(314.70)	529.04	(310.43)
Positive	779.26	(310.97)	700.64	(237.89)	669.96	(208.06)	716.59	(257.84)
Neutral w/Positive	565.57	(208.80)	545.72	(140.46)	472.17	(142.53)	530.20	(169.14)
First Fixation Gaze Bias								
Threat	238.60***	(404.10)	391.51***	(269.76)	297.49***	(352.69)	314.70***	(345.54)
Harm	385.80***	(515.00)	527.35***	(460.04)	490.15***	(558.51)	471.16***	(508.25)
Positive	213.69***	(218.95)	154.93***	(225.53)	197.79***	(198.58)	186.40***	(215.70)

Note. LTA = Low Trait Anxious group; MTA = Mid Trait Anxious group; HTA = High Trait Anxious group. Fixation Gaze variables in milliseconds.

* $p < .05$. ** $p < .01$. *** $p < .001$. ' $p < .09$

3.3.3.2 First Fixation Gaze Durations

The average FFGD and FFGB scores by trait anxiety group are listed in Table 7. Participants with FFGD scores greater than 3 *SD* above the mean per image category type were replaced with a value at 3 *SD* to ensure that means were not unduly influenced by outlying values. Eleven values (maximum 4 in one image type) met this criterion and were adjusted accordingly (1% of the data).

To determine whether there were differences between the emotional and neutral images for the FFGD and whether trait anxiety or image type influenced the FFGD on the images, a mixed 3 (trait anxiety group: low vs. mid vs. high) x 3 (image type: threat vs. harm vs. positive) x 2 (emotion bias: negative vs. neutral) repeated measures mixed ANOVA was conducted. This analysis resulted in a main effect of emotion bias, $F(1, 135 \text{ adj. } df) = 222.00$, $MSE = 95484.64$, $p < .001$, $\eta_p^2 = .62$, a main effect of image type, $F(1.8, 238.45 \text{ adj. } df) = 36.26$, $MSE = 45883.93$, $p < .001$, $\eta_p^2 = .21$, that were subsumed under an emotion bias by image type interaction, $F(1.67, 225.18 \text{ adj. } df) = 23.13$, $MSE = 69209.91$, $p < .001$, $\eta_p^2 = .15$. No effects involving trait anxiety group reached significance, including the main effect, $F(2, 135) = 1.79$, $MSE = 221740.17$ $p = .17$.[11]

To interpret this interaction, bias scores were calculated (FFGB) for threat, harm and positive images separately and a mixed 3 (trait anxiety group: low vs. mid vs. high) x 3 (image type: threat vs. harm vs. positive) repeated measures mixed ANOVA was conducted on the FFGB scores. This analysis revealed a main effect of image type only, $F(1.7, 225.18 \text{ adj. } df) = 23.13$, $MSE = 138419.81$, $p < .001$, $\eta_p^2 = .15$. The main effect of trait anxiety group did not reach significance, $F(2, 135) = 1.17$, $MSE = 190969.28$, $p = .31$,[12] nor did the image type by trait anxiety group interaction, $F(3.3, 225.18 \text{ adj. } df) = 1.57$, $MSE = 138419.81$, $p = .19$. The FFGB means and standard deviations for the full sample are listed in Table 7. Paired

[11] When STAI-Trait scores were entered as a continuous covariate, there was a significant main effect of trait anxiety on the FFGD, $F(1, 136) = 4.20$, $MSE = 219176.75$ $p = .042$, $\eta_p^2 = .03$. We averaged the FFGD across all image types, but the correlation with trait anxiety was not significant, $r = -.05$, $p = .53$. Correlations between trait anxiety and the FFGD separated by image type are listed in Table 9.

[12] When STAI-Trait scores were entered as a continuous covariate, the main or interactive effects involving trait anxiety still did not approach significance.

Samples *t*-test indicated that the FFGB was significantly greater for harm images than for threat and positive images, and greater for threat images than for positive images, *p*s < .001.

Lastly, to test for attentional biases from baseline, one-sample *t*-tests were used from 0 separately by image type and trait anxiety group. The results are listed in Table 7. In sum, all trait anxiety groups maintained their viewing on emotional images longer than neutral images when first fixated.

3.3.3.3 Proportion of Viewing Time

The PVT means and standard deviations and the baseline bias analyses are presented in Table 8. In sum, all trait anxiety groups showed early biases towards threat and harm images. Furthermore, the LTA also showed biases away from threat images at T5 (2001 – 2500 ms) and T6 (2501 – 3000 ms). For positive stimuli, the LTA group maintained biases towards positive images at all time points (0 – 3000 ms), while the biases for the MTA and HTA groups only reached significance at relatively early and late time points.

A 3 (trait anxiety group: low vs. mid vs. high) x 3 (image type: threat vs. harm. vs. positive) x 6 (time: T1 vs. T2 vs. T3 vs. T4 vs. T5 vs. T6) mixed repeated measures ANOVA on PVT revealed a main effect of image type, $F(1.4, 184.1 \text{ adj. } df) = 4.82$, $MSE = .09$, $p < .001$, $\eta_p^2 = .03$, main effect of time, $F(3.1, 423.03 \text{ adj. } df) = 50.55$, $MSE = .03$, $p < .001$, $\eta_p^2 = .27$, a marginal image type by trait anxiety group interaction, $F(2.7, 184.1 \text{ adj. } df) = 2.42$, $MSE = .09$, $p = .073$, $\eta_p^2 = .27$[13], and an image type by time interaction, $F(5.1, 693.0 \text{ adj. } df) = 11.70$, $MSE = .03$, $p < .001$, $\eta_p^2 = .08$. The main effect of trait anxiety group, $F(2, 135) = 2.29$, $MSE = .10$, $p = .10$[14], and the 3 way interaction, $F(10.27, 693.0 \text{ adj. } df) < 1$, both did not reach significance.

Of particular interest to our hypotheses was the marginal trait anxiety group by image type interaction. To follow-up, we ran three separate one-way ANOVAs for each of the image types comparing the three trait anxiety groups. These analyses revealed a significant effect of trait anxiety group on the PVT for threat images only, $F(2, 135) = 3.76$, $MSE = .01$, $p = .03$,

[13] When STAI-Trait scores were entered as a continuous covariate, the image type by trait anxiety group interaction reached significance, $F(1.4, 185.9 \text{ adj. } df) = 3.74$, $MSE = .09$, $p = .041$, $\eta_p^2 = .03$.

[14] When STAI-Trait scores were entered as a continuous covariate, the main effect of trait anxiety group reached significance, $F(1, 136) = 4.15$, $MSE = .10$, $p = .044$, $\eta_p^2 = .03$.

but not for harm, $F(2, 135) = 1.94$, $MSE = .02$, $p = .15$, or positive images, $F(2, 135) = 1.32$, $MSE = .004$, $p = .27$. Post-hoc analyses indicated that the LTA ($M = .50$, $SD = .12$) demonstrated significantly less PVT on threat images than both the MTA ($M = .55$, $SD = .08$) and the HTA ($M = .55$, $SD = .11$), while the MTA and HTA did not differ from one another, $p = .87$.

Table 8. Study 2: Proportion of Viewing Time by Trait Anxiety Group and Image Type

	LTA (n = 44)		MTA (n = 53)		HTA (n = 41)		Full Sample (N = 138)	
Proportion of Viewing Time	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*
Threat								
T1 (0-500)	.55**	(.10)	.56**	(.10)	.55*	(.13)	.55***	(.11)
T2 (501-1000)	.61***	(.14)	.65***	(.09)	.62***	(.13)	.63***	(.12)
T3 (1001-1500)	.54	(.17)	.62***	(.12)	.59**	(.20)	.58***	(.17)
T4 (1501-2000)	.44'	(.21)	.51	(.14)	.55	(.18)	.50	(.18)
T5 (2001-2500)	.40***	(.19)	.46'	(.15)	.50	(.19)	.45**	(.18)
T6 (2500-3000)	.44*	(.20)	.47	(.15)	.49	(.19)	.47*	(.18)
Harm								
T1 (0-500)	.56**	(.13)	.56**	(.12)	.56**	(.13)	.56***	(.12)
T2 (501-1000)	.65***	(.18)	.71***	(.14)	.71***	(.17)	.69***	(.16)
T3 (1001-1500)	.57*	(.21)	.65***	(.19)	.64***	(.22)	.62***	(.21)
T4 (1501-2000)	.49	(.23)	.57*	(.20)	.53	(.24)	.53	(.22)
T5 (2001-2500)	.47	(.25)	.53	(.21)	.53	(.23)	.51	(.23)
T6 (2500-3000)	.45	(.27)	.53	(.22)	.52	(.26)	.50	(.25)
Positive								
T1 (0-500)	.56**	(.11)	.55***	(.09)	.55**	(.11)	.55***	(.10)
T2 (501-1000)	.60***	(.10)	.58***	(.11)	.61***	(.12)	.59***	(.11)
T3 (1001-1500)	.56**	(.13)	.54*	(.12)	.52	(.13)	.54***	(.13)
T4 (1501-2000)	.55*	(.13)	.53'	(.11)	.53	(.15)	.54**	(.13)
T5 (2001-2500)	.56*	(.17)	.53'	(.14)	.55*	(.14)	.55***	(.15)
T6 (2500-3000)	.58***	(.14)	.55*	(.15)	.56**	(.14)	.56***	(.14)

Note. LTA = Low Trait Anxious; MTA = Mid Trait Anxious; HTA = High Trait Anxious.

* $p < .05$. ** $p < .01$. *** $p < .001$. ' $p < .09$

Lastly, we calculated the correlations between trait and state anxiety and the eye movement indices. The results for the first fixation indices are listed in Table 9 and for the PVT in Table 10. The Pearson's correlation between the STAI-Trait and STAI-State completed at baseline was $r = .49$, $p < .001$.

Table 9. Study 2: Correlations among Trait and State Anxiety and First Fixation Indices

	Anxiety	
Index and Image Type	Trait	State
Proportion of First Fixations		
Threat	.00	.07
Harm	-.03	-.08
Positive	-.03	-.08
First Fixation Gaze Durations		
Threat	-.10	-.05
Neutral w/Threat	-.17*	-.20*
Harm	.03	-.04
Neutral w/Harm	-.17*	-.11
Positive	-.19*	-.20*
Neutral w/Positive	-.24**	-.18*
First Fixation Gaze Bias		
Threat	.03	.10
Harm	.13	.03
Positive	-.04	-.10

Note. Trait = State-Trait Anxiety Inventory – Trait; State = State-Trait Anxiety Inventory – State.

* $p < .05$. ** $p < .01$. ' $p < .08$

Table 10. Study 2: Correlations among Trait and State Anxiety and Proportion of Viewing Time

	Anxiety	
Proportion of Viewing Time	Trait	State
Threat		
T1 (0-500)	.02	.15'
T2 (501-1000)	.02	.10
T3 (1001-1500)	.06	-.03
T4 (1501-2000)	.21*	.16'
T5 (2001-2500)	.21*	.12
T6 (2500-3000)	.14	.10
Harm		
T1 (0-500)	.01	-.03
T2 (501-1000)	.19*	.09
T3 (1001-1500)	.19*	.08
T4 (1501-2000)	.09	.00
T5 (2001-2500)	.12	.03
T6 (2500-3000)	.15	.03
Positive		
T1 (0-500)	-.06	-.11
T2 (501-1000)	.00	-.01
T3 (1001-1500)	-.07	-.14
T4 (1501-2000)	-.06	-.02
T5 (2001-2500)	-.04	-.10
T6 (2500-3000)	-.05	-.06

Note. Trait = State-Trait Anxiety Inventory – Trait; State = State-Trait Anxiety Inventory – State.

* $p < .05$. ** $p < .01$. ' $p < .08$

3.3.4 Image Ratings

The image valence and arousal rating means and standard deviations by trait anxiety group and image type are listed in Table 11. Two participants did not have any image ratings due to early termination of the study. A 3 (trait anxiety: low vs. mid vs. high) x 4 (image type: threat vs. harm vs. positive vs. neutral) mixed repeated measures ANOVA on valence ratings resulted in a main effect of image type only, $F(1.5, 201.7 \text{ adj. } df) = 847.10$, $MSE = 1.53$, $p < .001$, $\eta_p^2 = .86$. The main effect of trait anxiety group, $F(2, 133) < 1$, and trait anxiety by image type interaction were not significant, $F(3.0, 201.7 \text{ adj. } df) < 1$. Similarly, a 3 (trait anxiety: low vs. mid vs. high) x 4 (image type: threat vs. harm vs. positive vs. neutral) mixed repeated measures ANOVA on arousal ratings resulted in a main effect of image type only, $F(1.6, 210.8 \text{ adj. } df) = 221.25$, $MSE = 2.02$, $p < .001$, $\eta_p^2 = .63$. The main effect of trait anxiety group, $F(2, 133) < 1$, and trait anxiety by image type interaction were not significant, $F(3.2, 210.8 \text{ adj. } df) = 1.27$, $p = .28$.[15] Planned comparisons revealed that for valence and arousal ratings, all image types differed significantly from one another, *p*s < .001, except that the mean arousal rating for positive images was not different than for neutral images, $p = .24$. In sum, participants, regardless of their trait anxiety level, rated harm images more negatively than threat, and both threat and harm images more negatively than neutral. Positive images were rated as more pleasant than neutral images as expected. Likewise, harm images were rated as more arousing than threat images and both harm and threat were more arousing than neutral images.

[15] When STAI-Trait scores were entered as a continuous covariate, the main or interactive effects involving trait anxiety did not approach significance.

Table 11. Study 2: Valence and Arousal Image Ratings

	LTA (n = 44)		MTA (n = 53)		HTA (n = 39)		Full Sample (N = 136)	
Rating and Image Type	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*
Valence								
Threat	2.82	(1.06)	2.79	(0.93)	2.87	(0.86)	2.82	(0.95)
Harm	2.16	(0.89)	2.06	(0.86)	2.21	(0.83)	2.13	(0.86)
Positive	6.93	(0.95)	7.11	(0.87)	6.87	(1.10)	6.99	(0.97)
Neutral	5.23	(0.57)	5.06	(0.57)	5.08	(0.70)	5.12	(0.61)
Arousal								
Threat	6.52	(1.19)	6.55	(1.12)	6.21	(1.40)	6.44	(1.23)
Harm	6.82	(1.15)	6.85	(1.20)	6.59	(1.46)	6.76	(1.26)
Positive	4.14	(1.17)	4.38	(1.10)	4.54	(1.35)	4.35	(1.20)
Neutral	4.20	(0.85)	4.21	(0.91)	4.36	(1.09)	4.25	(0.94)

Note. LTA = Low Trait Anxious; MTA = Mid Trait Anxious; HTA = High Trait Anxious.

3.4 Discussion

The purpose of Study 2 was to evaluate the time course of visual selective attention to threat-related images as a function of trait anxiety while participants were in an elevated state of anxiety. Relative to Study 1, increasing state anxiety levels resulted in greater ABT for some eye movement indices and confirmed some, but not all, of our hypotheses. Each will be addressed in detail below.

First, the results from Study 2 suggest that when in a state of anxiety, all participants show a bias in making their first fixations on emotional (threat, harm and positive) relative to neutral stimuli, regardless of trait anxiety. Similarly, all participants were more likely to view the emotional images than the neutral during the first 500 ms of viewing. These results support the hypothesis that HTA individuals show early biases in facilitated orienting to threat, but also indicate that such biases are not specific to this population and are part of a more general adaptive defense system that orients initial attention to images that depict emotionality over relatively neutral stimuli. These results are consistent with some past research (e.g., Nummenmaa et al., 2006; Quigley et al., 2012), but not other data (e.g., Calvo & Avero, 2005), including the results of Study 1. Thus, differences in state anxiety may account for some inconsistencies in the literature, particularly in regards to indices of facilitated attention to threat.

Furthermore, similar to Study 1, HTA participants did not demonstrate greater facilitated attention to threat than LTA and MTA participants as hypothesized. Thus, state anxiety may not account for the between-subject mixed results, suggesting that further research is needed to assess other factors, such as possible methodological and reliability factors noted in the previous discussion. Moreover, the HTA group did not rate the threat images as more negative or arousing than the LTA group and thus, a lack of distinctions in the evaluation of threat may have contributed to a lack of early ABT specificity in HTA participants, given that models infer that biases in attention are fundamentally a result of individual differences in threat appraisals (e.g., Bar-Haim et al., 2007; Mogg & Bradley, 1998). Another possible explanation for the null trait anxiety effects on initial orienting is that the current threat images were intense enough that all participants appraise them as substantially negative and arousing (as suggested by their equal ratings) and thus, deem them to be worth attending to equally. Some models suggest that all participants will attend to highly threatening stimuli, as would be essential for an effective defense system, but that HTA individuals overly attend to relatively mild threat stimuli, while LTA do not (Matthews & Mackintosh, 1998; Mogg & Bradley, 1998). Thus, a distinction between HTA and LTA individuals is more likely to occur with relatively mildly threatening stimuli (Mogg et al., 2004; Wilson & MacLeod, 2003). Some studies have varied threat intensity but have generally not found evidence to support this notion using response time tasks (e.g., Mogg et al, 2000; Yiend & Mathews 2001) with only one study using an eye movement task (Calvo & Avero, 2005). Nevertheless, Calvo and Avero (2005) varied threat intensity by manipulating the colour of the same images (colour versus black-and-white) rather than novel images that varied in negativity. Thus, further research is needed to assess the moderating effect of stimuli intensity in attempts to explain what factors differentiate HTA from LTA individual on early orienting biases.

Regarding the maintenance of attention, the current data supported the hypothesis that HTA participants demonstrate gaze duration biases on threat (relative to neutral) following the first fixations when in a state of anxiety, but these biases were not greater for HTA than LTA, as predicted by the attention maintenance hypothesis (Weierich et al., 2008). Similarly, other research using this index has also not found between group anxiety effects (e.g., Armstrong et al., 2012; Garner et al., 2006, Study 1; Quigley et al., 2012) or found anxiety group effects that were not consistent with this hypothesis (Garner et al., 2006, Study 2). Rather, all participants showed greater maintenance of attention on threat than neutral images when state anxious, indicating that such biases, like facilitated orienting, are not specific to trait anxious samples. Furthermore, maintenance of attention was also found for harm and positive images, suggesting that such biases occur with emotional stimuli in general and are not necessarily specific to threat. Nevertheless, while biases to maintain attention on emotional stimuli may occur generally, it is not known in the current study whether state anxiety is associated with an increase in maintenance to threat specifically (as found in

Quigley et al., 2012) or to emotional stimuli more generally given that there was no comparison state condition. Moreover, in the current study, participants showed the greatest bias in maintenance to harm images, followed by threat and then positive images. These differences in viewing behaviour correspond with the valence ratings, such that participants rated the harm images as more negative than the threat images and both as more negative than the positive images. Thus, appraisals of negativity may account for the extent that participants dwell on emotional images.

Trait anxiety effects were found, however, when assessing ABT over a 3000 ms time course. That is, LTA participants showed less bias to view threat images (relative to neutral) than MTA and HTA, while such differences were not found for harm or positive images. This difference in ABT between LTA and HTA individuals is consistent with models of ABT (e.g., Matthews & Mackintosh, 1998; Mogg & Bradley, 1998) and when considering the null results in Study 1, suggest that differences between trait anxious groups are more likely to result when participants are in a state of anxiety (Matthews & Mackintosh, 1998; Mogg & Bradley, 1998) as is suggested by other research (e.g., Garner et al., 2006; Quigley et al., 2012) and may account for some of the mixed results in the literature.

Of note, the trait anxiety effect was *not* moderated by time, however the baseline bias analyses suggest that while all participants showed significant early biases towards threat in the first 1500 ms, only LTA participants showed a significant bias away from threat between 2000 and 3000 ms (that was not significant in the MTA or HTA groups, but reached significance in the full sample). Thus, this shift in attention away from threat in the LTA likely resulted in the significant differences between LTA and HTA over time. That said it seems that there is a large variance in viewing behaviour over time and likely important individual differences that are not captured by trait anxiety that could account for the orientation of attention to threat. For instance, it has been suggested that LTA individuals are likely to direct their attention away from mild threat (e.g. Williams et al., 1997) in order to regulate their affective state and maintain their low level of anxiety (Cisler & Koster, 2010) while others suggest that HTA are likely to avoid threat stimuli over time (e.g., Mogg & Bradley, 1998). However, research has not clarified the motivation (e.g., approach and/or avoidance) or emotion regulation strategies used by anxious and non-anxious samples when they are presented with threat-neutral image pairs in this context. Recent research has found that short-term approach-related goals bias early indices of attention (thought to be relatively automatic), even when competing for attention with threat stimuli (Vogt, De Houwer, Crombez, & Van Damme, 2013), thus trait and/or state anxiety group differences in facilitated attention may be the result of distinctions in seemingly strategic processing (Wells & Matthews, 1994). Moreover, it seems highly likely that individuals have a variety of strategies for responding to negative stimuli (e.g., Doron, Thomas-Ollivier, Vachon, & Fortes-Bourbousson, 2013) and that these goals/strategies may also influence later stages of attentional processing (Cisler & Koster, 2010) that can both be assessed more accurately with eye movement paradigms. It will therefore be important to evaluate strategic processing in addition to pre-attentive processes using eye movement paradigms in order to more fully understand controlled as well as more relative automatic (respectively) attentional processes.

Despite these promising trait anxiety-related bias results over time, it is essential to note that the HTA group also reported significantly higher state anxiety than did the LTA group, thus the state and trait effects were highly confounded, as is commonly the case in the literature (Bar-Haim et al., 2007). Research that has attempted to distinguish the effects of trait and state anxiety on ABT has yielded mixed results (Bar-Haim et al., 2007; Chen, Lewin, & Craske, 1996; Edwards, Burt, & Lipp, 2006; Egloff & Hock, 2001; MacLeod & Mathews, 1988; MacLeod & Rutherford, 1992; Mathews & MacLeod, 1985, Mogg, Mathews, & Weinman, 1989; Mogg, Mathews, Bird & Macgregor-Morris, 1990; Mogg, Bradley & Hallowell, 1994; Quigley et al., 2012) and have typically used response time tasks to assess ABT and thus, are limited in their ability to assess the nature and components of ABT over time. It may be that trait and state anxiety have different influences on each of the attentional components. For instance, a recent study found that manipulating state anxiety increased alerting and orienting of attention to neutral stimuli, whereas trait anxiety was associated with deficits in controlling (i.e., disengaging) attention (Pacheco-Unguetti, Acosta, Callejas, & Lupianex, 2010) yet to our knowledge only two published studies monitoring eye movements have successfully manipulated state anxiety (Garner et al., 2006; Quigley et al.,

2012) and only Quigley and colleagues compared trait and state anxiety *within* participants, which is necessary to separate the two distinct constructs (e.g., Ree, French, MacLeod, & Locke, 2008).

Garner and colleagues (2006) found some evidence of facilitated orienting towards emotional faces in socially anxious participants compared to those low in social anxiety, but only when under a social-evaluative stress condition (Study 2). These results could be due to an interaction between trait (social anxiety) and state (stress) factors, or simply to state factors alone given that the anxiety groups differed in both. Quigley and colleagues (2012) found that experimental induction of state anxiety increased the maintenance of attention on threat-related images (relative to neutral images) following the first fixation over a 3000 ms time course. Contrary to expectations, these biases were not moderated by trait anxiety, which suggest that greater maintenance of attention on threat stimuli is largely a function of state anxiety. Nonetheless, it is conceivable that the design in Quigley et al., (2012) did not have sufficient power to detect the between-subject differences of trait anxiety since there were relatively few trials (10 threat-neutral images per image set) and some of the trials provided variable results (i.e., image set effect, as discussed in Quigley et al., 2012). Also, ABT in the state anxiety condition was compared to an uncontrolled baseline mood state, which could vary greatly. A calm mood state comparison would be preferable. Such methodological factors could account for the null trait anxiety results and further research is needed to clarify the roles of trait and state anxiety on ABT.

Determining the relative, and potentially interactive, effects of trait and state anxiety on the components of ABT is important for the refinement of theoretical models of anxiety-related ABT. Early theories proposed various roles of trait and state anxiety in ABT (Broadbent & Broadbent, 1988; Matthews & Mackintosh, 1998; Mogg & Bradley, 1998; Williams et al., 1988, 1997). For instance, Williams and colleagues (1988, 1997) posited an interaction between trait and state anxiety, such that state anxiety increases the extent to which a situation or stimuli will be appraised as threatening, whereas trait anxiety determines the allocation of attention towards or away from the source of threat. They argued that under conditions of high state anxiety, HTA individuals will attend to threat whereas LTA individuals will avoid threat (Egloff & Hock, 2001; Williams et al., 1988, 1997), although it was later contended that this pattern may only be true for relatively mild threat, as all individuals, regardless of trait anxiety levels, are likely to attend to severe threat (Matthews & Mackintosh, 1998; Mogg & Bradley, 1998; Wilson & MacLeod, 2003). Nevertheless, researchers have theorized that both trait and state anxiety contribute to more threatening appraisals of stimuli in general, and therefore individuals high in both trait and state anxiety are most likely to show an ABT (Matthews & Mackintosh, 1998; Mogg & Bradley, 1998) as was found in the current study when assessed over a 3000 ms time course.

More recent theories of ABT have focused on the mechanisms and components of ABT (e.g., Bar-Haim et al., 2007; Cisler & Koster, 2010), but have not given consideration to the relative influences of trait and state anxiety on these different components. This omission reflects the lack of extant studies that have been designed to systematically compare the effects of both trait and state anxiety on the components of ABT over time (Bar-Haim et al., 2007). More research is thus needed to increase our knowledge of how trait and state anxiety influence attention to threat and elucidate which components of ABT are observed in all individuals in a state of anxiety and which are characteristic of HTA individuals that may indicate possible vulnerability factors in the development and persistence of anxiety disorders.

The distinction between trait and state anxiety-related ABT also holds significant treatment implications. There has been a proliferation of studies of attention bias modification (ABM) for the treatment of anxiety disorders over the past decade (Hakamata et al., 2010; Hallion & Ruscio, 2011). Despite this enthusiasm, these studies have produced conflicting findings and a recent meta-analysis concluded that ABM procedures have only a small effect on the actual modification of attention ($g = 0.29$) and on reduction of anxiety symptoms ($g = 0.13$ for posttest and $g = 0.26$ for symptoms following a stressor; Hallion & Ruscio, 2011). These results suggest that there is a need for improvement of ABM treatments in order to produce larger and more robust effects on ABT and anxiety symptoms. Refinement and improvement of ABM treatments will require greater knowledge of the components, mechanisms, and moderators of ABT. One possibility is that ABM procedures could be altered to better target the components of ABT that are linked to trait anxiety, which are more likely to be the processes that contribute *causally* to anxiety disorders rather than targeting state anxiety-linked components of ABT, that are more likely to be a product of anxiety.

In sum, the current data indicate that elevating state anxiety in participants results in significant biases in initial orienting and greater maintenance of attention on emotional images in general and in all participants, irrespective of their trait anxiety level. HTA participants showed greater ABT than LTA on the relative overall viewing time specific to threat images (not harm or positive) when averaged across the 3000 ms and only when in a state of anxiety (i.e., in Study 2, but not Study 1). However, the current design does not allow for the separation of trait and state anxiety effects and their relative influence on ABT over time which may have important theoretical and clinical implications for the understanding and treatment of anxiety. Moreover, identifying the attentional processes associated with trait anxiety or a vulnerability to anxiety disorders is of central importance, thus further evaluation of factors that may distinguish HTA from LTA individuals, is needed. A study that manipulates anxious states and that varies threat intensity in the assessment of ABT over time is therefore warranted.

Chapter 4

Study 3: Distinguishing the Roles of Trait and State Anxiety on Attentional Biases

3.5 Introduction

Study 3 was designed to differentiate and examine the unique and interactive effects of trait and state anxiety on attention to emotional images in a free viewing eye movement paradigm. More specifically, we were interested in evaluating the following research questions:

1. What are the relative contributions of trait and state anxiety on the components and time course of ABT?
2. Are anxiety-related ABT moderated by threat intensity, such that all participants show attentional biases to highly threatening stimuli, but HTA individuals (relative to LTA) will show greater biases to mild threat stimuli?
3. Are the contributions of trait and state anxiety on the time course of attentional biases specific to threat-related stimuli or to emotional information (i.e., positive stimuli) more generally?
4. Does participants' motivation to direct attention towards or away from threat predict ABT over time?

Thus, in part, the current study is a replication and extension of Quigley et al. (2012), with a number of methodological refinements to improve the power of the study to detect effects of trait anxiety on ABT, including: 1) the separation of mild and highly threatening stimuli; 2) an increase in trials from 10 to 20 per condition; 3) an increase in the number of participants; 4) an increase in trial duration from 3000 to 5000 ms to allow for the assessment of attention components over a greater period of time; and, 5) the inclusion of a calm mood state induction to contrast with the state anxiety induction.

We hypothesized that all participants will show early attentional biases in facilitated orienting (on the first fixations and in first 500 ms) towards emotional information in general (e.g., Nummenmaa et al., 2006) and that elevated state anxiety would increase the maintenance of attention on threat stimuli specifically over time, consistent with a mood congruent effect (Bower, 1981). In accordance with Mogg and Bradley (1998) and others (e.g., Bar-Haim et al., 2007), we expected that trait anxiety would interact with threat stimulus type (mild vs. high threat), such that high anxious participants would show a greater early ABT to mild threat images than LTA participants, where no such trait effects would be found for high threat images. Given the inconsistencies in the literature, no further hypotheses regarding the role of trait and state anxiety were made. However, there are several possible general outcomes to note. A main effect of trait anxiety on ABT would be consistent with general cognitive models of anxiety (e.g., Beck & Clark, 1997) as would additive and interactive effects between trait and state anxiety on ABT (e.g., Matthews & Mackintosh, 1998, Mogg & Bradley, 1998; Williams et al., 1988, 1997). Furthermore, trait and/or state anxiety may interact with time, such that they differentially influence how participants allocate their attention to threat as they have more time to engage strategic processing (e.g., avoidance).

Another purpose of the study was to explore whether motivation to look towards and away from threatening stimuli is associated with trait and/or state anxiety and ABT. We expected a positive association between motivation to look towards negative images and ABT, while motivation to avoid negative images would be negatively associated with ABT.

3.6 Method

3.6.1 Participants

Participants were undergraduates who completed screening questionnaires for course credit and who met criteria similar to the previous two studies, but with some minor changes to the self-report measures: 1) scored high (≥48) or low (≤26) on the State- Trait Inventory of Cognitive and Somatic Anxiety (STICSA-Trait; Ree et al., 2008), 2) scored less than 9 (85^{th} percentile) on the Depression subscale of the Depression Anxiety Stress Scales (DASS-21: Lovibond & Lovibond, 1995), 3) scored 11 or below on the Marlowe and Crowne Social Desirability Scale (SDS; Strahan & Gerbasi, 1972), and 4) had normal or corrected-to-normal vision. Similar to the previous studies, participants were excluded if they showed high symptoms of depression for ethical reasons and high social desirability given the associations with underreporting anxiety symptoms (e.g., Derakshan et al., 2007).

A total of 184 undergraduates participated. Sixteen participants could not be calibrated on the eye tracker (n = 7) or had technical difficulties (n = 9). Four participants were excluded due to a change in their STICSA-Trait score greater than 2.5 *SD*s above the mean change (*M* = 9.28, *SD* = 6.79) between the screening and lab sessions. The excluded participants did not differ in age, gender, or trait anxiety (STICSA-T) from the remaining sample of 164 participants, *p*s > .05.

3.6.2 Materials

3.6.2.1 Self-Report Measures

The *State-Trait Inventory of Cognitive and Somatic Anxiety* (*STICSA*; Ree et al., 2008) STICSA-Trait was used to determine trait anxiety groups and the STICSA-State was used to assess state anxiety at 5 time points: 1) at baseline, 2) block 1 post-state induction, 3) block 2 pre-state induction, 4) block 2 post-state induction, and 5) at the end of block 2. The STICSA-Trait and State versions each contain 21-items that assess the cognitive and somatic symptoms of anxiety as a personality trait ("*in general*") and as a affective state ("*how you feel right now…"*), respectively. The Cronbach's alpha for the STICSA-Trait was .94 and the STICSA-State ranged from .92 to .94 across time points. The *State-Trait Anxiety Inventory (STAI;* Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) *Trait version* was included to provide comparisons with Study 1 and 2 and previous literature (Cronbach's α = .93). However, the STICSA-Trait was chosen as the primary measure of trait anxiety in the current study given that is it less confounded with depression (Grös, Antony, Simms, & McCabe, 2007). Depressive symptoms were assessed by the 7-item subscale of the *Depression Anxiety and Stress Scale* (*DASS*-21; Lovibond & Lovibond, 1995; current Cronbach's α = .88)[16] and social desirable responding was assessed by the 20-item version of the *Marlowe–Crowne Social Desirability Scale (SDS;* Crowne & Marlowe, 1960; Strahan & Gerbasi, 1972; current

[16] We changed from the BDI-II to the DASS in the current study to reduce the items needed in the screening measures.

Cronbach's α = .71) during the screening session. Finally, participants were asked to rate the extent that they were *motivated to look* "towards" and "away from" each image category (negative, positive, neutral); ratings were made on a 7-point scale (1 = *not at all*, 7 = *a lot*).[17]

3.6.2.2 Stimuli.

As in the previous two studies, the images for the eye movement tasks were selected from the IAPS (Lang et al., 1999; see Appendix D). However, in the current study, 80 *threat* images were selected that involved the *potential* for injury to a person (e.g., a person holding a knife to someone's throat). No harm images were used. The threat images were categorized as either *mild* or *high threat* based on the normative valence ratings and were both divided into two image sets that were counterbalanced across two blocks. For comparison, 40 positive images were selected with 20 in each set. All emotion images were paired with neutral images and matched as best as possible in content, colour, and complexity.

Average valence ratings were 2.40 (SD = .31) for the high threat images, 3.51 (SD = .30) for the mild threat images, 7.54 (SD = .40) for positive images and 5.30 (SD = .71) for neutral images. Average arousal ratings were 6.34 (SD = .50) for high threat, 5.32 (SD = .47) for the mild threat images, 5.25 (SD=.89) for positive and 3.46 (SD = .73) for neutral images. A MANOVA comparing the image categories (high threat vs. mild threat vs. positive vs. neutral) on valence and arousal ratings yielded a significant effect of image category for both valence, $F(3, 236) = 669.14$, $MSE = .31$, $p < .001$, $\eta_p^2 = .90$, and arousal ratings, $F(3, 236) = 220.27$, $MSE = .48$, $p < .001$, $\eta_p^2 = .74$. Post-hoc comparisons indicated that all image types differed significantly from one another on valence and arousal, all ps <.001, except that the mild threat images did not significantly differ from the positive images on the mean arousal ratings, $p = .64$.[18]

[17] The 20-item *Attentional Control Scale (ACS;* Derryberry & Reed, 2002*)* was administered, but was not associated with any of our eye movement indices and thus, removed from the dissertation.
[18] When stimulus set was included in the MANOVA, there were no main or interactive effects of stimulus set, $p > .95$.

3.6.3 Procedure

In the lab, participants completed the STICSA-Trait, STAI-Trait in random order on a computer followed by the STICSA-State on paper. The study was separated into two blocks that were counterbalanced across participants (n = 82 in each), each involving a state induction (calm or anxious) followed by an EMAT. The state induction was the same standardized procedure used in Study 2 (Eich et al., 2007) with the addition of a calm state induction for comparison with the anxious state (see Appendix C). Participants were instructed to think of personally-relevant calm or anxious thoughts in detail for 5 minutes with the goal of feeling as calm or anxious as possible while calm or emotionally arousing music was played.[19]

Following both state inductions, participants completed the STICSA-State before beginning the EMAT. Participants were told that they would view image pairs, some involving “violence, threat, and weapons,” and they were to look at these images as they wished. In each block, participants viewed two practice trials and 60 test trials consisting of one emotional and one neutral image presented simultaneously (20 high threat-neutral, 20 mild threat-neutral and 20 positive-neutral). Half of the image pairs were presented side-by-side and the other half were presented one above the other, in a semi-random fashion.[20] This presentation style was used to reduce the predictability of the image locations, such that participants may be less likely to initiate fixations towards the left and top images first (e.g., Waechter et al., 2014). Each picture was 512 X 384 pixels and was displayed 80 pixels from the center fixation location (2.7° visual angle for the horizontal positioning and 2.5° visual angle for the vertical positioning), on a light-gray background. Before the image pair was presented, participants were required to fixate on a centrally located cross. Image pairs were displayed for 5 seconds, followed by a 500 ms interval before the next fixation cross

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[19] Calm induction music was Venus, The Bringer of Peace by Holst; anxious induction music included the Symphony No. 8 in C Minor: 4. Finale: Feierlich, Nicht Schnell by Bruckner and Mars and The Bringer of War by Holst.
[20] No more than 3 trials were allowed to have the same presentation arrangement consecutively.

appeared. Throughout the EMAT, calm or anxious music was played in order to assist with maintaining the assigned affective state.[21]

Following the EMAT, participants completed the STICSA-State. They then followed the same state induction procedures for the alternative state (calm or anxious), completed a post STICSA-State measure, and then viewed another *novel* 60 image-pairs in a second EMAT. When done, participants completed the final STICSA-State measure.

Before leaving the session, participants were asked about their level of motivation for looking towards and away from each image type (e.g., negative, positive, neutral). They were then shown the same video of babies laughing as in Study 2 and asked to rate their current affective state on a 7 point scale (1=*very negative*; 7=*very positive*) to ensure that they were not distressed.

3.7 Results

3.7.1 Participants

Participants had a mean age of 20.22 years (SD = 3.7) and 68.9% were female.[22] The participants were divided into trait anxiety groups based on a tertial split on the in-lab STICSA-Trait score (M = 41.95, Mdn = 42.00, SD = 10.70), resulting in 55 participants in the LTA group, 55 in the MTA group and 54 in the HTA group. As expected, a MANOVA revealed a significant multivariate effect of the three trait anxiety groups on self-report measures of trait anxiety (STICSA-Trait and STAI-Trait), state anxiety (STICSA-State) and depression (DASS-depression subscale), $F(8, 314) = 33.16$, $p < .001$. Mean scores, standard deviations, and results of the independent one-way ANOVAs for the self-report measures by trait anxiety group are shown in Table 12. Post-hoc comparisons indicated that the three trait anxiety groups differed on all measures in the expected directions.[23]

[21] Calm music included Ave Maria by Bach and Peer Gynt Op.23, No. 13, Act 4 Prelude, Morning by Grieg; anxious music was Grosse Fuge in B flat Major, Op. 133 by Beethoven.
[22] The ethnicity profile of the sample was very similar to Study 1 and 2.
[23] Two participants in the HTA did not have complete self-report data and were excluded in the current analyses.

Table 12. Study 3: Self-Report Measures by Trait Anxiety Groups.

	LTA (n = 55)		MTA (n = 55)		HTA (n = 52)			
Measure	*M*	*(SD)*	*M*	*(SD)*	*M*	*(SD)*	*F*	η_p^2
STICSA-T	30.20	(3.58)	41.51	(3.27)	54.48	(5.330	461.26***	.85
STAI-T	28.05	(4.79)	35.93	(8.440	51.00	(8.23)	134.66***	.63
STICSA-S	25.47	(4.780	31.04	(7.870	41.11	(9.60)	58.25***	.42
DASS - Depression	1.47	(1.550	3.78	(2.950	5.45	(2.36)	38.10***	.32

Note. LTA = Low Trait Anxious; MTA = Mid Trait Anxious; HTA = High Trait Anxious; STICSA-T = State Trait Inventory of Cognitive and Somatic Anxiety - Trait; STAI-T = State Trait Anxiety Inventory – Trait; STICSA-S = State Trait Inventory of Cognitive and Somatic Anxiety – State; DASS-Depression = Depression Anxiety Stress Scales - Depression subscale.

3.7.2 State Induction Manipulation Check

In the current study, the STICSA-State was used to assess the effectiveness of the state anxiety induction in order to assess anxiety more specifically than general negative affect (as in Study 2).[24] Mean substitution was used for 6 participants who were missing 1-2 data points. A 3 (trait anxiety: low vs. mid vs. high) x 2 (state anxiety order: calm/anxious vs. anxious/calm) x 5 (time: block 1 pre-induction vs. block 1 post-induction vs. block 2 pre-induction vs. block 2 post-induction vs. post EMAT) repeated measures mixed ANOVA revealed a 3-way interaction relevant to our purpose, $F(5.86, 460.140 \text{ adj. } df) = 10.64$, $MSE = 25.72$, $p < .001$, $\eta_p^2 = .12$. The means and standard errors are displayed in Figure 1.

[24] One participant had no STICSA-State data and was not included in the current analyses.

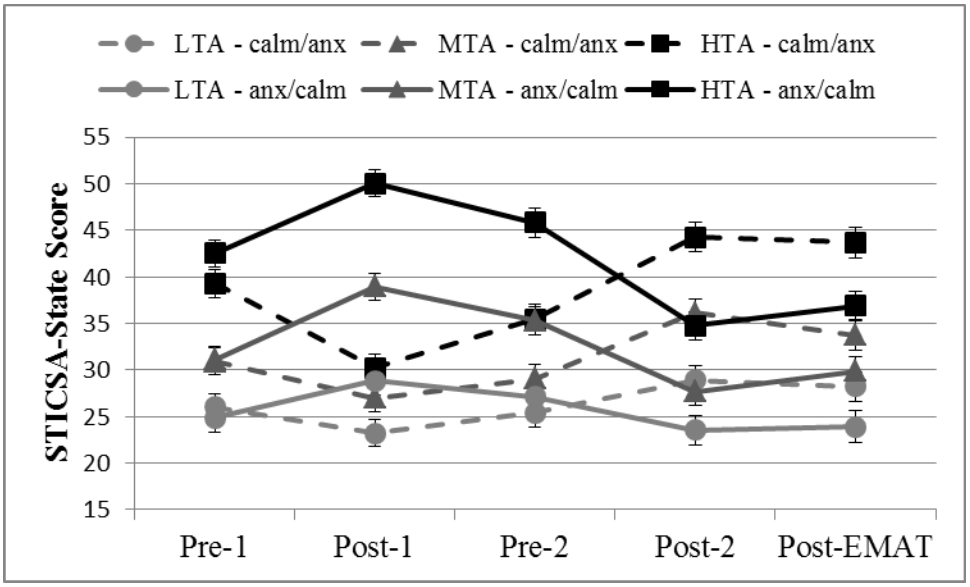

Figure 1. Study 3: STICSA-State Scores over Time

STICSA-State scores over time by state induction condition and trait anxiety group. Error bars are +/- 1 standard error. Pre-1 = baseline before 1st state induction (calm or anxious); Post-1 = after 1st state induction; Pre-2 = before 2nd state induction; Post-2 = after 2nd state induction; Post-EMAT = after the 2nd eye movement attention task. Conditions calm/anxious indicate participants who had the calm state induction in block 1 and the anxious state induction in block 2, while anxious/calm indicates the reversed arrangement.

To interpret this interaction, we ran five 3 (trait anxiety: high vs. mid vs. low) by 2 (state anxiety condition order: calm/anxious vs. anxious/calm) univariate ANOVAs on each of the 5 time points (block 1 pre-induction, block 1 post-induction, block 2 pre-induction, block 2 post-induction, post EMAT). These analyses revealed a significant main effect of trait anxiety group at all time points, *p*s <.001. Post-hoc comparisons revealed that state anxiety scores were significantly greater for the HTA compared to the MTA and LTA and for the MTA relative to the LTA at all time points. There was also a significant main effect of state anxiety condition order at all time points *p*s <.001, except at baseline as expected, $p = .53$. Lastly, the trait anxiety group by state anxiety condition order only reached significance at block 1 post-induction, $F(2, 157) = 11.57$, $MSE = 58.56$, $p < .001$, $\eta_p^2 = .13$, and block 2 pre-induction, $F(2, 157) = 3.63$, $MSE = 68.77$, $p < .05$, $\eta_p^2 = .04$. These interactions are the result of greater differences between the state anxiety conditions as trait anxiety increases (see Figure 1) that have little relevance to our manipulation check.

Most importantly, to assess whether state anxiety levels changed significantly from the pre-induction to post-induction, we conducted paired-samples *t*-tests separately for state anxiety condition and trait anxiety group given their interactive effects. All comparisons revealed changes in state anxiety in the expected directions, *p*s <.001. That is, HTA, MTA and LTA participants all showed an increase in state anxiety in the anxious state condition and a reduction in state anxiety in the calm state condition. Thus, the state induction procedures resulted in their desired effects.

3.7.3 Eye Movement Indices

The data analysis plan was similar to Study 1 and 2 with the addition of the within-subjects effect of state anxiety induction (calm vs. anxious). However, baseline bias analyses would not be conducted for the eye movement indices separately for trait anxiety group and state anxiety condition (as well as for all 10 time points for the PVT) given the excessive number of analyses involved that are not of primary interest to our hypotheses. Rather, the repeated measures mixed ANOVAs would be sufficient to answer the research questions in the current design. Follow-up analyses will be conducted to assess for the presence of biases from a baseline separated by only the factors that are shown to have a significant influence on the attention bias indices.

3.7.3.1 Proportion of First Fixations (PFF).

A mixed 3 (trait anxiety group: low vs. mid. vs. high;) x 2 (state anxiety: calm vs. anxious) x 3 (image type: high threat vs. mild threat vs. positive) repeated measures ANOVA on PFF revealed a main effect of image type, $F(2, 322) = 11.04$, $MSE = .007$, $p < .001$, $\eta_p^2 = .06$, such that the PFF was greater towards positive images ($M = .55$, $SD = .06$) than high threat images ($M = .53$, *SD* .06) and mild threat images ($M = .52$, $SD = .06$), *p*s < .05, and high threat images was greater than mild threat, $p = .01$. No other effects reached significance.
Given that there was only a main effect of image type, the PFF were collapsed across trait anxiety groups and state anxiety conditions and were assess for the presence of attentional biases against .5. The analyses revealed significant biases towards high threat, $t(163) = 6.87$, $p < .001$, mild threat, $t(163) = 3.64$, $p < .001$, and positive images, $t(163) = 9.18$, $p < .001$. The results are illustrated in Figure 2.

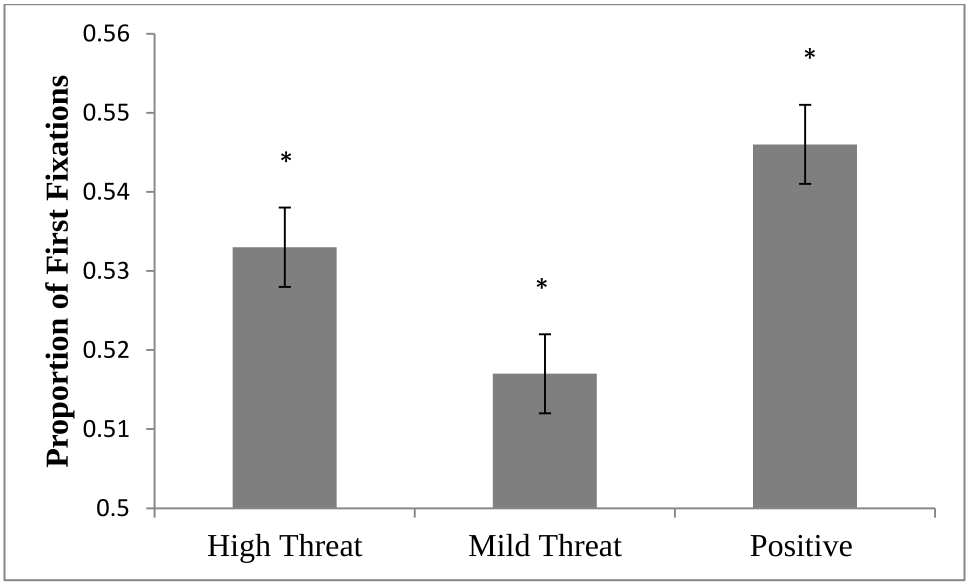

Figure 2. Study 3: Proportion of First Fixation Scores

Proportion of first fixation scores collapsed across trait and state anxiety by image type. Error bars are +/- 1 standard error.* $p < .05$ for one-sample t-test from .5.

3.7.3.2 First Fixation Gaze Bias (FFGB)

FFGD scores greater than 3 standard deviations (SD) above the mean per image category type were replaced with a value at 3 SD to ensure that means were not overly influenced by outlying values. Twenty-two values (maximum 3 in one image type) met this criterion and were adjusted accordingly (1% of the data).

To determine whether there were significant biases and whether trait anxiety, state anxiety and image type influenced the FFGD, a mixed 3 (trait anxiety group: low vs. mid vs. high) x 2 (state anxiety: calm vs. anxious) x 3 (image type: threat vs. harm vs. positive) x 2 (emotion bias: negative vs. neutral) repeated measures ANOVA was conducted. This analysis resulted in a main effect of image type, $F(1.9, 305.0 \text{ adj. } df) = 7.83$, $MSE = 481947.20$, $p < .001$, $\eta_p^2 = .05$, a main effect of emotion bias, $F(1, 161) = 279.45$, $MSE = 39195156.17$, $p < .001$, $\eta_p^2 = .63$, a state anxiety by emotion bias interaction, $F(1, 161) = 3.67$, $MSE = 79463.27$, $p < .001$, $\eta_p^2 = .02$, and an image type by emotion bias interaction, $F(1.9, 307.1 \text{ adj. } df) = 25.37$, $MSE = 80499.66$, $p <.001$, $\eta_p^2 = .14$, that was all subsumed under a 3 way interaction involving state anxiety, image type and emotional bias, $F(2, 322) = 4.25$, $MSE = 65110.49.71$, $p = .015$, $\eta_p^2 =.03$. No effects of trait anxiety group approached significance.

In order to interpret this interaction, FFGB scores were calculated and a 2 (state anxiety: calm vs. anxious) x 3 (image type: high threat. vs. mild threat vs. positive) repeated measures ANOVA on FFGB scores revealed a main effect of image type, $F(1.9, 310.9 \text{ adj. } df) = 25.19$, $MSE = 127645.33$, $p <.001$, $\eta_p^2 = .13$ and a marginal main effect of state anxiety, $F(1, 161) = 3.66$, $MSE = 159293.47$, $p = .058$, $\eta_p^2 = .02$, that were subsumed under a significant image type by state anxiety interaction, $F(2, 326) = 4.26$, $MSE = 129579.27$, $p =.02$, $\eta_p^2 = .03$.

To assist in interpreting the image type by state anxiety interaction, paired-samples *t*-tests to assess the FFGB scores between the state anxiety conditions for each image type revealed that the FFGB was significantly greater in the anxious state than in the calm state only for the high threat images, $t(163) = 3.02$, $SE = 44.91$, $p <.01$, and not for mild threat, $t(163) = .84$, $SE = 45.03$, $p =.41$ or positive images, $t(163) = .84$, $SE = 32.53$, $p =.40$ (see Figure 3). Thus, state anxiety increased the maintenance of attention specifically on high threat stimuli relative to neutral images.

In order to assess whether this greater bias towards high threat images when in a state of anxiety relative to a calm state is a result of longer durations on high threat images once first fixated and/or shorter durations on neutral images, paired samples *t*-tests were used to compare the FFGD for the high threat images and the matched neutral images separately between state anxiety conditions. These results indicated a marginal increase of the duration of gaze on high threat images, $t(163) = 1.82$, $SE = 39.11$, $p = .07$ (calm: $M = 1040.13$, $SD = 524.50$; anxious: $M = 1111.38$, $SD = 575.04$), and a significant reduction in gaze durations on the matched neutral images, $t(163) = - 2.54$, $SE = 25.40$, $p = .01$ (calm: $M = 714.38$, $SD = 397.17$; anxious: $M = 649.97$, $SD = 353.16$), between the calm and anxious states. Thus, state anxiety appears to both, in part, extend the time that participants dwell on high threat images if they fixated on them first and reduce the time one spends viewing neutral images when they are paired with high threat, likely facilitating a shift of attention to threat images when the neutral images are fixated first.

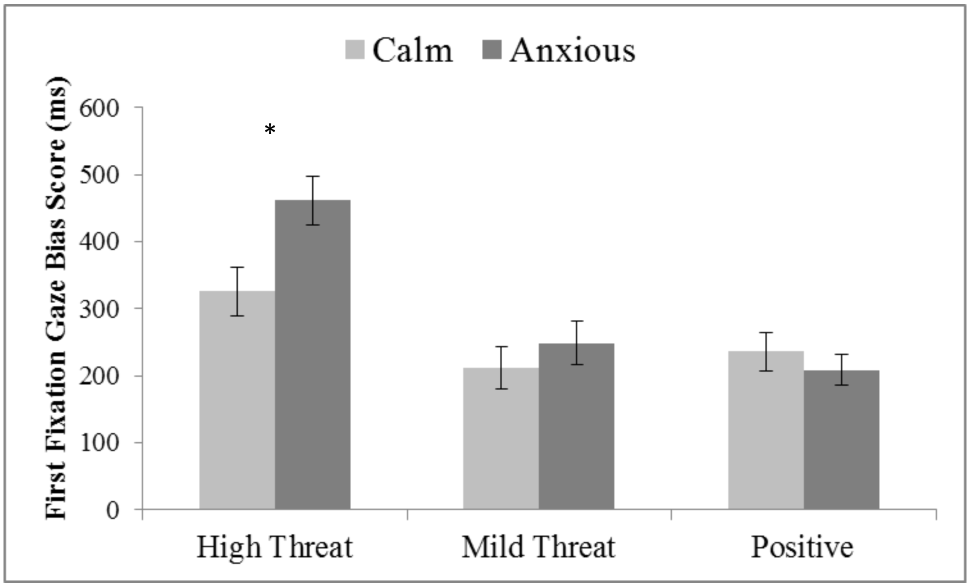

Figure 3. Study 3: First Fixation Gaze Bias

First fixation gaze bias scores by image type and state anxiety condition. Error bars are +/- 1 standard error. * indicates significant difference between state anxiety conditions, $p < .05$.

To assess for attentional biases in the FFGB, one-sample *t*-tests were conducted for each image type separated by state anxiety condition relative to 0 (no bias). The results indicated greater FFGB for emotional images compared to neutral images in both the calm and anxious state conditions, *ts*(163) = 6.81 to 12.42, *ps* <.001. Thus, participants showed greater maintenance of attention following the first fixations on high threat, mild threat, and positive emotional images relative to neutral images, independent of state anxiety levels.

3.7.3.3 Proportion of Viewing Time (PVT)

A mixed 3 (trait anxiety group: low vs. mid vs. high) x 2 (state anxiety: calm vs. anxious) x 3 (image type: high threat vs. mild threat vs. positive) x 10 (time: T1 vs. T2 vs. T3 vs. T4 vs. T5 vs. T6 vs. T7 vs. T8 vs. T9 vs. T10) repeated measures mixed ANOVA revealed a main effect of state anxiety, *F*(1, 162) =18.01, *MSE* = .08, *p* <.001, η_p^2 =.10, main effect of image type, *F*(1.25, 20071 adj. *df*) = 33.18, *MSE* = .19, *p* <.001, η_p^2 = .17, a main effect of time, *F*(3.53, 568.69 adj. *df*) = 40.27, *MSE* = .04, *p* <.001, η_p^2 = .20, a state anxiety by image type interaction, *F*(1.82, 293.73 adj. *df*) = 17.44, *MSE* = .06, *p* <.001, η_p^2 = .10, state anxiety by time interaction, *F*(4.35, 700.47 adj. *df*) = 4.92, *MSE* = .02, *p* <.001, η_p^2 = .03, and an image type by time interaction, *F*(4.70, 757.11 adj. *df*) = 29.96, *MSE* = .05, *p* <.001, η_p^2 = .16, that were all subsumed under a state anxiety by image type by time interaction, *F*(8.995, 1448.14 adj. *df*) = 3.02, *MSE* = .02, *p* = .001, η_p^2 = .02. There were no significant effects involving trait anxiety.[25] The means and standard errors for the PVT by state anxiety and time for high and mild threat images are depicted in Figure 4 and for positive images in Figure 5.

[25] The same results for trait-anxiety were found when using STICSA-Trait scores as a covariate rather than a between-subjects factor for all analyses (PFF, FFGB and PVT).

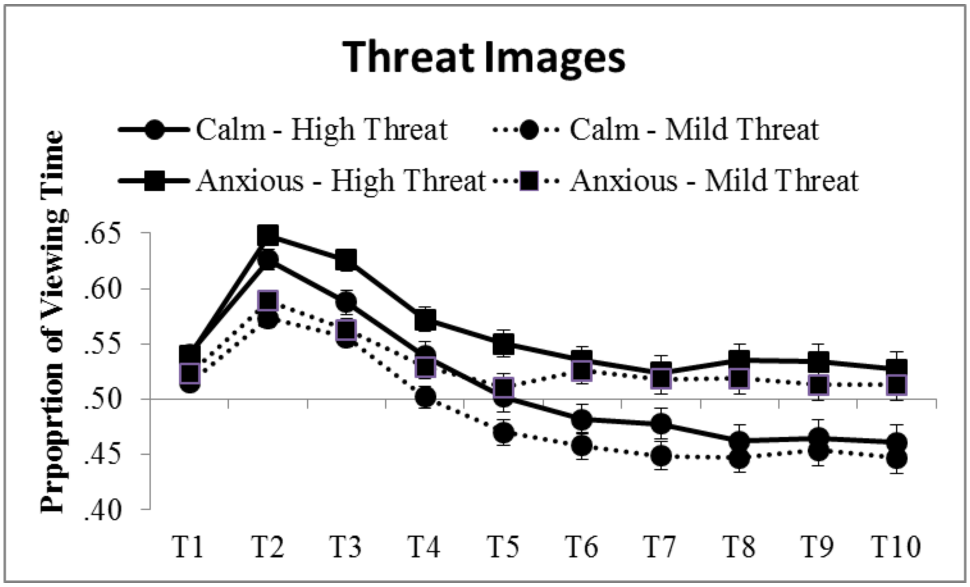

Figure 4. Study 3: Proportion of Viewing Time for Threat Images

Proportion of viewing time by threat image type (mild vs. high) and state anxiety condition over time (5000 ms). Time intervals are in 500 ms intervals. Error bars are +/- 1 standard error.

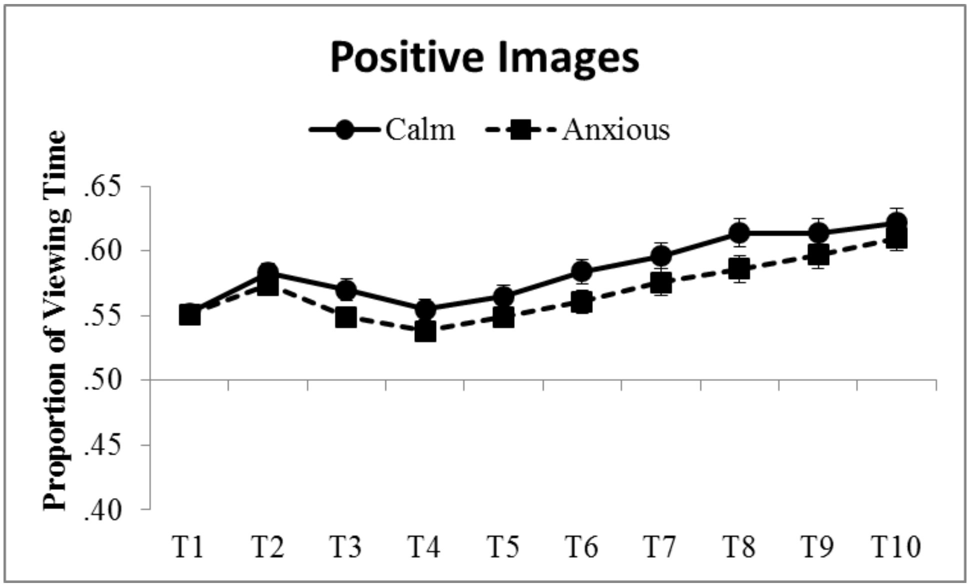

Figure 5: Study 3: Proportion of Viewing Time for Positive Images

Proportion of viewing time of positive images by state anxiety condition over time (5000 ms). Time intervals are in 500 ms intervals. Error bars are +/- 1 standard error.

To understand the nature of the 3-way interaction, three separate 2 (state anxiety: calm vs. anxious) x 10 (time: T1 vs. T2 vs. T3 vs. T4 vs. T5 vs. T6 vs. T7 vs. T8 vs. T9 vs. T10) repeated measures ANOVAs were conducted for the high threat, mild threat and positive image types.

For high threat images, this analysis resulted in main effects of state anxiety, $F(1, 161) = 21.73$, $MSE = .08$, $p < .001$, $\eta_p^2 = .12$, and time, $F(2.92, 470.59$ adj. $df) = 48.43$, $MSE = .05$, $p < .001$, $\eta_p^2 = .23$, and a state anxiety by time interaction, $F(4.35, 699.52$ adj. $df) = 4.03$, $MSE = .02$, $p = .002$, $\eta_p^2 = .02$. To further evaluate this interaction, paired-samples *t*-tests were used at each time point to assess for differences in PVT as a function of state anxiety. All time points showed significantly greater PVT when in a state of anxiety than when calm, *t*s(163) = 2.11 to 4.52, *p*s <.05, *except* at the first time point, $t(163) = .18$, $p = .86$.

For mild threat images, this analysis resulted in main effects of state anxiety, $F(1, 161) = 16.95$, $MSE = .09$, $p < .001$, $\eta_p^2 = .10$, and time, $F(3.22, 518.59$ adj. $df) = 30.97$, $MSE = .04$, $p < .001$, $\eta_p^2 = .16$, and a state anxiety by time interaction, $F(4.71, 757.87$ adj. $df) = 6.29$, $MSE = .02$, $p < .001$, $\eta_p^2 = .04$. Paired sample *t*-tests at each time point showed significantly greater PVT when in a state of anxiety than when calm beginning at T4 (1501-2000 ms) through to T10 (4501-5000 ms), *t*s(163) = 2.13 to 4.49, *p*s <.05, but not at T1-T3, *p*s > .22.

For the positive image however, this analysis revealed only a main effects of state anxiety $F(1, 163) = 8.42$, $MSE = .03$, $p = .004$, $\eta_p^2 = .05$ and time, $F(3.91, 636.69$ adj. $df) = 16.73$, $MSE = .03$, $p < .001$, $\eta_p^2 = .09$, such that participants viewed positive images slightly less when in an anxious state ($M = .57$) than a calm state ($M = .59$), and the proportion of time viewing positive images relative to neutral images increased over time (e.g., T1 $M = .55$; T10 $M = .62$).

To assess for attentional biases, one-sample *t*-tests were used to compare the PVT to .5 for each state (calm and anxious) at each time point by image type collapsed across trait anxiety group. For high threat images in a calm state, these analyses indicated biases towards threat at the first four time points (0-2000 ms), *t*s(163) = 2.95 to 14.63, *p*s <.005 and then *away* from threat on the last three time points (3501-5000 ms), *t*s(163) = -2.25 to -2.63, *p*s <.03. For high threat images in an anxious state, these analyses indicated biases towards threat at the first six time points (0-3000 ms), *t*s(163) = 2.68 to 18.12, *p*s <.01, as well as for T8 and T9 (3501 – 4500 ms), *t*s(163) = 2.19 to 2.30, *p*s <.03. For mild threat images in a calm state, the analyses indicated biases towards threat at the first three time points (0-1500 ms), *t*s(163) = 2.49 to 9.39, *p*s <.02, followed by biases *away* from mild threat at T5 to T10 (2000 – 5000 ms), *t*s(163) = - 2.43 to -4.00, *p*s <.02. For mild threat images in an anxious state, biases reached significance towards threat at the first four time points (0 – 2000 ms) and then at T6 (2501-3000 ms), *t*s(163) = 2.16 to 10.21, *p*s <.04 only. For positive images, all time points indicated bias towards positive images when in a calm and anxious state, *t*s(163) = 4.85 to 12.54, *p*s <.005.

Lastly, we calculated the correlations between trait and state anxiety and the eye movement indices when in a calm and anxious state. The results for the first fixation indices are in Table 13 and those for the PVT are listed in Table 14. The Pearson's correlation between the STICSA-Trait and STICSA-State completed at baseline was $r = .69$, $p < .001$ and between the STICSA-Trait and STAI-Trait was $r = .82$, $p < .001$.

Table 13. Study 3: Correlations among Trait and State Anxiety and First Fixation Indices

	Anxiety Scale and Anxious State					
	STICSA-T		STAI-T		STICSA-S	
Index and Image Type	Calm	Anxious	Calm	Anxious	Calm	Anxious
Proportion of First Fixations						
High Threat	.03	.03	-.02	.08	.02	.05
Mild Threat	-.07	.12	-.04	.13	-.04	.18*
Positive	-.04	.01	-.06	.04	-.08	.10
First Fixation Gaze Durations						
High Threat	.04	.05	.09	.07	.15*	.06
Neutral w/High Threat	-.11	-.07	-.09	-.08	.01	.03
Mild Threat	-.03	.06	.03	.08	.12	.14'
Neutral w/Mild Threat	-.01	-.01	-.03	-.04	.07	-.01
Positive	.00	.01	-.02	.01	.10	.07
Neutral w/Positive	.01	-.06	.04	-.04	.16*	-.02
First Fixation Gaze Bias						
High Threat	.14'	.11	.18*	.15'	.17*	.05
Mild Threat	-.02	.08	.07	.14'	.06	.19*
Positive	-.01	.09	-.08	.07	-.03	.14'

Note. STICSA-T = State Trait Inventory of Cognitive and Somatic Anxiety - Trait; STAI-T = State Trait Anxiety Inventory - Trait; STICSA-S = State Trait Inventory of Cognitive and Somatic Anxiety - State; STICSA-S for the calm and anxiety conditions were the measure post calm and anxiety inductions, respectively.

* $p < .05$. ** $p < .01$. ' $p < .09$

Table 14. Study 3: Correlations among Trait and State Anxiety and the Proportion of Viewing Time

	Anxiety Scale and Anxious State					
	STICSA-T		STAI-T		STICSA-S	
Proportion of Viewing Time	Calm	Anxious	Calm	Anxious	Calm	Anxious
High Threat						
T1 (0-500)	.01	-.03	-.02	.04	.02	-.05
T2 (501-1000)	.04	.04	.05	.06	.01	-.04
T3 (1001-1500)	.05	.13	.09	.06	.05	.06
T4 (1501-2000)	.06	.10	.08	.10	.06	.12
T5 (2001-2500)	.04	.01	.04	.04	.03	.09
T6 (2500-3000)	.04	.00	.04	.03	.05	.06
T7 (3001-3500)	-.01	-.02	.05	.03	.03	.01
T8 (3501-4000)	-.03	-.01	.04	.02	.03	.06
T9 (4001-4500)	.00	-.05	.07	.00	.05	.06
T10 (4501-5000)	-.02	-.04	.02	-.02	-.04	.05
Mild Threat						
T1 (0-500)	.00	.11	.03	.11	.03	.16*
T2 (501-1000)	-.07	.09	.02	.09	.01	.17*
T3 (1001-1500)	-.06	-.03	-.01	-.04	-.01	.01
T4 (1501-2000)	-.06	-.09	-.02	-.09	-.02	-.02
T5 (2001-2500)	-.07	-.07	-.05	-.07	-.04	.03
T6 (2500-3000)	-.02	-.03	.01	-.02	-.02	.08
T7 (3001-3500)	.02	.05	.08	.06	.04	.14'
T8 (3501-4000)	-.03	-.01	.05	.07	.03	.09
T9 (4001-4500)	.08	-.07	.12	.02	.09	.02
T10 (4501-5000)	.02	-.05	.08	.00	.10	-.01
Positive						
T1 (0-500)	-.01	-.01	-.03	.04	-.09	.10
T2 (501-1000)	.05	-.04	.05	-.03	-.02	-.01
T3 (1001-1500)	-.05	-.13	-.06	-.09	-.02	-.12
T4 (1501-2000)	-.13	-.03	-.18*	.04	-.14'	.00
T5 (2001-2500)	-.07	.06	-.10	.04	-.15'	-.05
T6 (2500-3000)	.06	.04	.07	-.01	-.03	-.04
T7 (3001-3500)	.09	-.05	.10	-.06	.02	-.05
T8 (3501-4000)	.07	-.09	.08	-.08	.01	-.05
T9 (4001-4500)	.06	-.08	.02	-.02	-.07	-.01
T10 (4501-5000)	.02	-.05	-.01	.00	-.11	-.05

Note. STICSA-T = State Trait Inventory of Cognitive and Somatic Anxiety - Trait; STAI-T = State Trait Anxiety Inventory - Trait; STICSA-S = State Trait Inventory of Cognitive and Somatic Anxiety - State; STICSA-S for the calm and anxiety conditions was the measure post calm and anxiety inductions, respectively.

* $p < .05$. ** $p < .01$. ' $p < .09$

3.7.4 Motivation Ratings

Three participants were missing data on the motivational ratings for negative images for 1-6 data points; all present data was included in the analyses. Only the motivational ratings towards (*M* = 4.15, *SD* = 1.47) and away from negative images (*M* = 4.29, *SD* = 1.63) were analyzed given our primary interest in motivation towards threat stimuli. The association between the motivation to look towards and away from threat images was $r = -.37$, $p < .01$ indicating a small to moderate association, but not redundancy in measurement.

The correlation coefficients among the motivation ratings towards and away from negative images and eye movement indices are presented in Table 15. In general, the motivation ratings towards and away from negative images were not significantly associated with early indices of ABT, but were associated with many indices over time. Associations among the trait anxiety measures (STICSA-T and STAI-T) and motivating ratings were assessed and only the STIA-T and motivation to look towards threat reached significance, $r = .21$, $p < .01$ (see Nelson, Purdon, Quigley, Carriere, & Smilek, in press for more motivation analyses). These results suggest that the greater the trait anxiety, the more motivated they were look toward threat, but not away from it.

Table 15. Study 3: Correlations among Motivation Ratings and Eye Movements Indices

	Anxious State			
	Calm		Anxious	
	Motivation			
Index and Image Type	Towards	Away	Towards	Away
Proportion of First Fixations				
High Threat	.11	-.01	.16*	-.03
Mild Threat	.08	-.01	.04	-.13
First Fixation Gaze Durations				
High Threat	.27***	-.16*	.33***	-.23**
Mild Threat	.29***	-.17*	.27**	-.16*
First Fixation Gaze Bias				
High Threat	.17*	-.14'	.29***	-.21**
Mild Threat	.25**	-.17*	.23**	-.14'
Proportion of Viewing Time				
High Threat				
T1 (0-500)	.08	0	.10	.03
T2 (501-1000)	.08	.03	.13	.03
T3 (1001-1500)	.18*	-.22**	.27***	-.21***
T4 (1501-2000)	.23**	-.24**	.39***	-.30***
T5 (2001-2500)	.28***	-.28**	.40***	-.34***
T6 (2500-3000)	.33***	-.28***	.33***	-.35***
T7 (3001-3500)	.34***	-.32***	.32***	-.37***
T8 (3501-4000)	.39***	-.36***	.39***	-.38***
T9 (4001-4500)	.38***	-.37***	.45***	-.36***
T10 (4501-5000)	.34***	-.35***	.49***	-.39***
Mild Threat				
T1 (0-500)	.10	.02	.02	-.14'
T2 (501-1000)	.13	.01	-.04	.00
T3 (1001-1500)	.31***	-.14'	.17*	-.17*
T4 (1501-2000)	.38***	-.22**	.35***	-.37***
T5 (2001-2500)	.35***	-.28**	.31***	-.40***
T6 (2500-3000)	.36***	-.35***	.29***	-.37***
T7 (3001-3500)	.29***	-.38***	.31***	-.42***
T8 (3501-4000)	.26***	-.36***	.32***	-.44***
T9 (4001-4500)	.28***	-.32***	.30***	-.43***
T10 (4501-5000)	.30***	-.31***	.36***	-.44***

* $p < .05$. ** $p < .01$. *** $p < .001$. ' $p < .09$

3.8 Discussion

The purpose of Study 3 was to directly compare the relative contributions of trait and state anxiety on multiple components of ABT over time, including the moderation of trait anxiety and ABT by threat intensity, and to explore the role of motivation on ABT. Each purpose and the corresponding hypotheses will be discussed below.

3.8.1 Trait and State Anxiety

Overall, the results indicated that all participants engaged in early facilitated orienting to, and maintenance of attention on, emotional stimuli (high threat, mild threat and positive images) relative to neutral stimuli. That is, participants were more likely to make their first fixations on emotional images, to maintain their gaze on emotional images, and spend the first 500 ms of viewing emotional images relative to neutral images, regardless of trait or state anxiety levels. These results are consistent with research (e.g., Calvo & Lang, 2004; Nummenmaa et al., 2006; Quigley et al., 2012) suggesting that facilitated attention to emotional stimuli is normative and likely adaptive in defending against harm. However, these results are not consistent with the hypothesis that HTA individuals show early (at or before 500 ms) facilitated biases to orient towards threat while LTA show no ABT (Bar-Haim et al., 2007). This discrepancy may be due to differences in methodology, issues of reliability (e.g., Waechter et al., 2014) and/or the precision of attentional bias indices over time given that the majority of research finding no biases in LTA groups has used response time tasks that infer attentional focus (Bar-Haim et al., 2007), whereas research demonstrating biases in LTA individuals has tended to assess eye movements that allow for the identification of the exact fixation locations over time (e.g., Quigley et al., 2012). Nevertheless, even the eye movement results are mixed (e.g., Study 1; Calvo & Avero, 2005) and further research is needed to clarify factors that can account for these varied results.

Although the current study demonstrated that all participants attend to threat-related stimuli (relative to neutral), the data did not indicate a significant moderating effect of threat intensity on trait anxiety and early ABT to support the hypothesis that HTA individuals show greater facilitated attention towards relatively mild threat stimuli (but not high threat) than

LTA (Mogg & Bradley, 1998; Wilson & MacLeod, 2003). Rather, all participants, regardless of trait or state anxiety levels, showed greater facilitated orienting biases (e.g., proportion of first fixations) towards high threat images relative to mild threat images, consistent with other research assessing threat intensity (Koster et al., 2006; Mogg et al., 2000[26]; but not in Yiend & Mathews, 2001). Given the relative nature of high versus mild threat stimuli, it is possible that we are not able to fully test this hypothesis adequately. Nevertheless, the data to date do not support the notion that trait anxiety effects on ABT are more likely to result from mild rather than more severe threat stimuli, and thus do not explain the mixed trait anxiety results across studies.

Moreover, despite the methodological advancements in the current study (i.e., larger number of trials, more participants, greater trial duration, calm mood state comparison), the results did not reveal any significant effects of trait anxiety on ABT. Rather, state anxiety alone was associated with greater maintenance of attention on high threat images following the first fixation and for threat stimuli in general over time, consistent with an associative network model (Bower, 1981). These results are also consistent with other studies that demonstrated associations between state anxiety and ABT (e.g., Bradley et al., 2000; Fox et al., 2001; Mathews & MacLeod, 1985; Mogg et al., 1997) however, they suggest that state anxiety is not associated with all components of ABT, but to the maintenance of attention over time once threat stimuli are detected. These results corroborate those of Quigley et al. (2012), which also indicated a state anxiety-linked attentional bias in the maintenance of threat over time and the absence of any significant trait anxiety effects. Thus, given the methodological improvements of the current study and the replication of past results, we can have greater confidence that the null trait anxiety effects are not simply due to inadequate statistical power or other methodological issues addressed in our current design.

There are at least two possible explanations for the present findings regarding the relative contributions of trait and state anxiety to ABT. The first is that threat-related attentional

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[26] Although Mogg et al., (2000) found an interaction involving threat intensity and trait anxiety on ABT, the results did not fully support the pattern of ABT predicted by Mogg & Bradley, 1998. Analyses to assess bias scores from chance levels were not included and thus, do not allow one to conclude whether biases were present or not.

biases are largely a phenomenon of state anxiety rather than trait anxiety. Other published eye tracking studies have also failed to find trait anxiety or anxiety disorder specific effects on the first fixations or in the first 500 ms of viewing (e.g., Armstrong et al., 2013; Buckner et al., 2010; Derakshan & Koster, 2010; Garner et al., 2006; Gerdes et al., 2009; Rohner, 2002; Schofield et al., 2012; Quigley et al., 2012; Waechter et al., 2014) and at later points in time (Calvo & Avero, 2005, for threat images; Derakshan & Koster, 2010; Gamble & Rapee, 2010; Waechter et al., 2014). Moreover, although Quigley et al. (2012) is the only previous study to assess and observe a state anxiety effect on ABT using continuous eye movement over time, a number of studies using response time paradigms have categorized participants according to state anxiety and have also provided support for a state anxiety effect on ABT (e.g., Bradley et al., 2000; Fox et al., 2001; Mathews & MacLeod, 1985; Mogg et al., 1997). Individuals who are high in trait anxiety are by definition likely to experience state anxiety more frequently and to a greater extent than LTA individuals, and therefore trait and state anxiety are highly confounded in previous research that has not measured or manipulated and compared both types of anxieties. Thus, it is possible that trait anxiety and anxiety disorder specific effects on ABT observed in previous studies (e.g., Armstrong et al., 2013; Garner et al., 2006; see Bar-Haim et al., 2007 and Armstrong & Olatunji, 2012 for reviews) may have actually been produced by state anxiety.

A second possible explanation for the present findings is that state and trait anxiety differentially influence the various components of ABT, such that trait anxiety is predominantly related to the *control* of attention and general distractibility (Eysenck, 1997). The delayed disengagement hypothesis argues that the attentional biases observed in trait anxiety are due to delayed or difficulty with disengagement of attention from threat once it has been attended (Fox et al., 2001; Fox et al., 2002; Koster et al., 2006; Koster, Crombez, Van Damme, Verschuere & De Houwer, 2004). Thus, this hypothesis proposes that HTA individuals have difficulty controlling their attention in the presence of threatening distractor stimuli. Similarly, the attentional control theory suggests that HTA individuals have a general deficit in controlling attention, regardless of the nature of the stimuli (Eysenck**,** 1997, Eysenck et al., 2007). The present study employed a free viewing paradigm and participants were not required to disengage or control their attention. There were, however, small associations between greater scores on the STAI-Trait and longer maintenance of attention following the first fixation on threat images (FFGB scores). This index of ABT is the most similar to other attentional bias tasks (e.g., the dot-probe task, spatial cueing) which typically require participants to disengage from an image in order to respond to a cue. Nevertheless, the current study was designed to assess the *preferences* of participants to engage and disengage from threat relative to neutral images, and thus was not designed to test the *ability* of participants to disengage attention from threat.

Perhaps, as discussed in Quigley et al., (2012), tasks that require participants to disengage their attention from threat or that involve greater attentional control ability may be more influenced by trait anxiety. This hypothesis is supported by neuroimaging studies that have found trait anxiety to be associated with reduced activation of brain regions involved in the control of attention (e.g., prefrontal cortex; Bishop, 2009; Bishop, Jenkins, & Lawrence, 2007) and state anxiety to be associated with increased activity in regions involved in the detection and evaluation of threat (e.g., amygdala; Bishop, Duncan, & Lawrence, 2004). Similarly, Pacheco-Unguetti et al. (2010) found that state anxiety was related to an increase in functioning of the alerting and orienting functions of attention and trait anxiety was related to deficient control of attention. In addition to its theoretical relevance, this possibility would also have important treatment implications, as ABM approaches that train disengagement from threat or that improve attentional control ability in the presence of threat may be more effective for the treatment of anxiety disorders than approaches that train individuals to not attend to threat and/or attend to neutral or positive information. Future research should evaluate the effects of trait and state anxiety on attention using a range of tasks where eye tracking can directly assess viewing behavior, particularly paradigms that require participants to control or disengage their attention (e.g., antisaccade task) to determine whether trait and state anxiety are differentially associated with attentional control in general (i.e., involving neutral stimuli) and specifically in the presence of threat. Further implications of this research will be considered in the general discussion below.

3.8.2 Motivation

Another purpose of the current study was to begin to evaluate participants' motivation and strategic processing when presented with threat-neutral image pairs in order to assess whether deliberate "top down" processing significantly influences the allocation of attention over time in a free viewing task. In the current study, participants ratings of motivation to look towards negative images was significantly associated with greater ABT on several indices of bias over time for high and mild threat images, while motivation ratings to look away from negative images were negatively associated with ABT, as expected. In other words, the more participants wanted to visually engage with or avoid the threat images, the more they did so. Relatedly, applied strategies to avoid threat (relative to no identified goal) have been shown to reduce ABT and subsequent distress (Johnson, 2009), but it is generally not known what participants intrinsic motivations are in this context and how such motivations may influence attention over time. Overall, the current data suggest that people vary in their motivation direction and intensity and that these ratings reliably predict viewing behaviour (unlike trait anxiety).

More specifically, motivation ratings had little or no effect on the initial orienting to threat (except a small positive association with motivation towards threat and high threat images) or in the first 1000 ms of viewing when assessed over time. These results are consistent with data suggesting that strategic instructions to avoid threat are less likely to reduce *early* indices of ABT (Nummenmaa et al., 2006; but also see Vogt et al., 2013).[27] Rather, such strategies may be more likely to result in a vigilance-avoidance pattern over time (Mogg & Bradley, 1998), such that early detection of threat is followed by a shift of attention away from threat once strategic processing is engaged. The results from the FFGD and FFGB scores are consistent with this notion and indicate significant associations between motivation ratings and gaze durations/biases in the expected directions. The average FFGD on high threat images was over 1000 ms, more than enough time for strategic processing to occur, thus those with greater motivation to avoid threat showed early vigilance (as was

[27] It is also highly possible that these null results are due to poor reliability of early indices of bias (Waechter et al., 2014).

found in all participants on average) followed by less time viewing threat once first fixated. Nevertheless, the vigilance-avoidance pattern was not found for HTA individuals as theory would suggest (Mogg & Bradley, 1998) and motivation to look towards threat images (not away) was only weakly associated with trait-anxiety. These results likely suggest that HTA individuals use a variety of strategies (e.g. monitoring, avoidance) to cope with their state anxiety and more research is needed to evaluate strategic as well as relatively automatic attentional processing over time (Cisler & Koster, 2010) in order to understand how attentional deployment may function to regulate emotion (e.g., Todd, Cunningham, Anderson, & Thompson, 2012).

3.8.3 Limitations

There are several specific limitations in this study to note. Limitations that apply to all three studies will be considered in the general discussion below. First, in the current study, the image types differed significantly in their IAPS arousal ratings and therefore, emotion and arousal were confounded. It is possible that state anxiety increases attention to arousing stimuli more generally rather than high threat stimuli specifically. This limitation applies to most other ABT research and is difficult to bypass given that threat stimuli are typically both negative and arousing by definition. Nevertheless, it would be valuable for future studies to control levels of arousal across emotional image types (e.g., high threat, high positive) to determine whether anxiety-related attentional biases are specific to negatively arousing (i.e., highly threatening) stimuli or extend to positively arousing (i.e., exciting) stimuli as well. Secondly, motivation to attend to and avoid negative information were measured by single items administered retrospectively; given the promising results, it will be important to assess motivation in greater depth with multiple items that can be shown to be valid and reliable. Furthermore, the ratings were made after the EMAT and thus, could simply be post-hoc reports of what participants did in the task, rather than their intrinsic motivation. Assessing motivation in advance of viewing behaviour would address this limitation.

3.8.4 Summary

In sum, the present study found that the induction of state anxiety increased the maintenance of attention towards threat following the first fixation and over time from 500 to 5000 ms while trait anxiety was not largely shown to be associated with indices of ABT in the free viewing task. The role of state anxiety on the components of ABT appears to have been overlooked thus far and deserves greater consideration in future research and in theoretical models of ABT. Similarly, while motivation and goal directed behaviours have been incorporated into models of ABT (e.g., Bar-Haim et al., 2007; Matthews & Mackintosh, 1998; Mogg & Bradley, 1998), relatively little research has assessed their role. Further research on the components, mechanisms and moderators of ABT is essential to understanding the nature of such biases and how they contribute to emotional distress in order to most effectively use strategies to alter attentional processes in the treatment of anxiety disorders.

Chapter 5
General Discussion

3.9 Summary of Research

The central purpose of the current research was to clarify the nature of anxiety-related ABT in order to identify potential maladaptive attentional processes that may contribute to the development and persistence of anxiety disorders. In general, the current data indicated that some components of attention (e.g., facilitated attention, delay in disengagement) show biases involving threat in all participants and that in general, state anxiety, but not trait anxiety, increased the maintenance of attention specifically to threat over time. Given that such attentional biases were not specific to HTA individuals, it seems that these biases are more normative rather than maladaptive. Therefore, the current data do not support the majority of current theories of ABT, but have identified a significant confound in the extant literature that when evaluated in future research, could considerably advance our understanding of the specific mechanisms and attentional processes associated with both trait and state anxiety in those with anxiety disorders. The current results will be briefly discussed in terms of the central tenants of the theoretical models, the vigilance hypothesis, maintenance hypothesis, and vigilance-avoidance hypothesis (Weierich et al., 2008), followed by theoretical and clinical implications.

The current research indicates that facilitated orienting of attention to threat is likely a normative process (e.g., Calvo & Lang, 2004; Nummenmaa et al., 2006) that occurs in most participants (on average) despite levels of state and/or trait anxiety, and transpires for emotional stimuli (negative and positive) in general. Of note, biases in initial orienting to threat and in the first 500 ms of viewing, when found, were relatively small and our ability to reliably measure this attentional processes with a free viewing eye movement task is likely poor (Waechter et al., 2014), making it difficult to interpret such small and null results. Nevertheless, while vigilance for emotional stimuli was found, these data do not support the specificity of the vigilance hypothesis for HTA populations proposed by many models of ABT (e.g., Bar-Haim et al., 2007; Beck & Clark, 1997) and the null results are not explained by differences in threat intensity (mild vs severe threat; Matthews & Mackintosh, 1998; Mogg & Bradley, 1998). Moreover, given that there was no significant interaction involving trait and state anxiety involving indices of facilitated attention as expected, Williams and colleagues (1988; 1997) interaction hypothesis was also not supported.

Similarly, a delay in disengagement of attention from threat was found when state anxiety was elevated in all participants and more specifically, state anxiety was shown to enhance the maintenance of attention to threat following the first fixation and over time (up to 5000 ms), consistent with the delayed disengagement hypothesis (Fox et al., 2001) and a general mood congruent effect (Bower, 1981). However, a delay in disengagement was not largely associated with trait anxiety when state anxiety was controlled for (Study 3), or specific to HTA, thus the current data do not support the specificity of the maintenance hypothesis (Weierich et al., 2008).

Lastly, the current results indicated that ABT does shift over time and thus, measuring indices of bias at one point in time is not sufficient for understanding the full phenomenology of attentional orienting to threat. When state levels of anxiety were not manipulated (Study 1), there was a general pattern of relative attention towards threat-related images followed by greater attention towards the neutral images, consistent with a vigilance-avoidance pattern. However, such a pattern was not specific to HTA individuals, as suggested by the vigilance-avoidance hypothesis (Mogg & Bradley, 1998). Rather, when state anxiety levels were elevated (Study 2), LTA participants showed some indication of biases away from threat images later in the time course (as did the full sample), but this viewing behaviour did not differ significantly from other participants and is generally not supported in the literature (e.g., Bar-Haim et al, Quigley et al., 2012). In contrast, it seems that participants varied substantially in their viewing behaviour over time and that this behaviour was not predicted well by trait anxiety, but by motivational factors, consistent with arguments made by Wells and Matthews (1994) and more recent research (e.g., Vogt et al., 2013) that has begun to assess the influence of goals and strategic processing on ABT.

The most clear and striking finding from the current program of research about the nature of anxiety-related ABT is that state anxiety increases the maintenance of attention following the first fixation and between 500 and 5000 ms of viewing threat-related, but not positive images. In Study 3, when in a calm mood state, participants showed a general vigilant-avoidant pattern of attention to threat over time, similar to Study 1; however, when in an anxious state, biases to threat were maintained over time, rather than shifting to the neutral images (on average). Notably, in Study 2, when state anxiety was elevated, a significant trait anxiety effect was found for viewing threat images when averaged over the full time course, such that HTA individuals showed a greater ABT than LTA, as predicted by models of ABT (e.g., Matthews & Mackintosh, 1998; Mogg & Bradley, 1998). However, results of Study 3 indicated that this trait anxiety effect was largely the result of state anxiety alone, rather than additive effects of trait and state, or an interaction, as proposed by some theories (e.g., Mogg & Bradley, 1998; Williams et al., 1997). Thus, these results suggest that trait anxiety effects in ABT could be accounted for, at least in part, by state anxiety given that most studies do not assess for both types of anxieties (Bar-Haim et al., 2007). Such a result has substantial implication for current theories of ABT, as well as for clinical treatments that are based on these theoretical models.

3.10 Theoretical and Clinical Implications

If biases in the maintenance of selective attention to threat are largely associated with state anxiety, rather than trait anxiety, this notion would have important theoretical implications for the causal role of attention in anxiety disorders. That is, a state anxiety-linked ABT would suggest that this bias is most likely a *result* of being state anxious, rather than a *cause* of anxiety disorders. The current data suggests that all individuals attend to threat on the first fixations and then maintain their attention on threat, particularly when in a state of anxiety. Given that the majority of individuals do not have pathological anxiety or go on to develop an anxiety disorder, ABT may play a weaker role in the development of anxiety disorders than previously thought, or may only lead to an anxiety disorder in conjunction or interaction with other risk factors. It could be that biases in the maintenance of attention are more involved in the persistence of anxiety, such that individuals with anxiety disorders experience greater and more frequent states of anxiety and consequently demonstrate greater biases in the maintenance of attention, which in turn maintains or exacerbates anxious states (Eysenck, 1997). These possibilities deserve consideration in future research and in theoretical accounts of anxiety-related ABT.

Consequently, attentional bias modification (ABM) treatments that attempt to alter ABT are based on the notion that such biases *cause* anxiety disorders (e.g., MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002). If a bias in the maintenance of attention on threat is a result of being state anxious, ABM treatments may target a consequence rather than a cause of anxiety. Even if such biases are involved in the maintenance or exacerbation of anxiety states in individuals with anxiety disorders, it is not clear that the reduction of ABT would address the root cause of the anxiety problem, although it may be helpful for symptom management or in combination with other treatment approaches. If ABT leads to pathological anxiety only in conjunction or interaction with other risk factors, this would suggest that treatments for anxiety disorders would need to focus on these other risk factors in addition to ABT, and that ABM may only be effective for certain individuals who exhibit an ABT and for whom an ABT was a vulnerability factor for their anxiety disorder. These potential issues with ABM may help explain, in part, the unreliable and relatively weak outcomes of such treatments on the reduction of anxiety symptoms (Hallion & Ruscio, 2011; Neubauer, van Auer, Murray, Petermann, Helbig-Lang, & Gerlach, 2013; Rapee, MacLeod, Carpenter, Gaston, Frie, Peters, & Baillie, 2013; also see Clarke, Notebaert, & MacLeod, 2014). Moreover, a large portion of the early literature focused on whether ABT were relatively early and *automatic* or late and *controlled* (for reviews see McNally, 1995 and Teachman, Joormann, Steinman, & Gotlib, 2012; for a discussion about the problems with this dichotomy see Anderson, 2011) with the implication being that more automatic processes would be less amenable to cognitive and verbally mediated treatments than more strategic biases (see Mobini & Grant, 2007). For instance, McNally (1995) concluded that anxiety disorders involve attentional processes that are largely automatic in that they are involuntary and sometimes unconscious and thus, treatments that attempt to use strategic processing to alter such ABT (e.g., cognitive therapy) would largely be ineffective. Rather, behavioral interventions, such as in vivo exposure treatments, would be more effective in reducing ABT and consequently, the resulting fear and anxiety (e.g., Öhman & Soares, 1994). In general, research has shown that indices of ABT (as measured by dichotic listening, Stroop and dot-probe tasks) are significantly reduced following Cognitive-Behavioral Therapy (CBT; see Tobon, Ouimet, & Dozois, 2011 for a review), yet no study to our knowledge has assessed ABT pre and post CBT using eye movement indices that can more clearly identify the nature of the biases. Moreover, no research to date has compared behavioral to cognitive therapy, nor assessed the relative influence of trait and state anxiety on ABT over the course of treatment. It may be that the reduction in ABT following treatment is due to a reduction in state, rather than trait, anxiety.

Furthermore, more recent research has begun to assess whether ABT predicts treatment outcome using CBT approaches and found that greater vigilance (Price, Tone, & Anderson, 2011; as measured by a dot-probe task) and slower disengagement from negative faces (angry and disapproving faces as measured by a spatial cueing task) predicted better treatment outcomes for those with social anxiety disorder (Niles, Mesri, Burklund, Lieberman, & Craske, 2013). Niles and colleagues (2013) suggested that participants who maintain their attention on threat, rather than avoid it, may have shown greater attention to their feared stimuli during the exposure exercises and consequently, profited more from the behavioral treatment. Nonetheless, research has not yet assessed attentional direction in this way during exposure treatments and would be an important direction for further research. While these recent attempts to extend experimental findings on ABT to assist in the treatment of anxiety disorders have been promising, the inconsistencies and limitations in the current experimental literature restrict our ability to clearly identify the central maladaptive attentional processes that contribute to the development and maintenance of anxiety disorders that would be favorable targets for psychological interventions.

The results of the exploratory analyses assessing associations between motivation and ABT point to a promising area that may advance our understanding of anxiety-related attentional biases. That is, vulnerability to anxiety disorders may not be the result of *where* attention is deployed, but *why* attention is directed where it is. Anxiety is generally thought to be associated with avoidance goals (e.g., Dickson & MacLeod, 2004) and behaviours (see Dymond & Roche, 2009 for a review) in order to protect one from harm. However, individuals with anxiety disorders and HTA individuals have greater expectancies of harm (see Taylor & Fedoroff, 1999 for a review of expectancy theory), even in the presence of safety cues (Liao & Craske, 2013), and thus, may place greater importance on avoiding negative outcomes and be more motivated to engage in a wide range of coping behaviours (monitoring, gaze aversion, physical escape) that reinforce their negative expectancies. Of note, general avoidance behaviours do not necessarily suggest that one would avert eye gaze from a threat since monitoring it could assist in avoiding harm. Consistent with this notion, trait anxiety was associated with motivation to attend toward negative stimuli, albeit weakly, but not to avoid negative images. What we want to know is what is it about the (trait or state) anxious individuals' experience that directs selective attention when presented with threat relative to other stimuli? As argued by Anderson (2011), attention is a consequence or an outcome of something (i.e., motivation, anxiety, emotion regulation), rather than a cause. Likewise, manipulating attentional direction may not be a viable mechanism or cause for ameliorating anxious symptoms, but rather a "place holder for that something" (p. 4, Anderson, 2011) that explains the empirical differences (e.g., ability to inhibit and/or control visual orienting; Amir & Conley, 2014). The current program of research suggests that simply the direction of attention on its own, to the extent that it is directed towards and away from threat over time, is not likely a direct cause of anxiety or anxiety disorders and we must begin to look more closely at what motivates anxious individuals and how motivation may influence behavioural, cognitive and emotional responses to threat, including attentional processes, that together contribute to and maintain anxious states and anxiety disorders.

3.11 Limitations and Directions for Future Research

Although the current program of research has numerous strengths, it also has several limitations that warrant further discussion and that highlight important areas for further research. First, Waechter and colleagues (2014) have found that the reliability of eye movement indices for first fixations and early time epochs is poor, which may account for the negative findings regarding the indices of early facilitated orienting. Although the randomization of stimulus location in Study 3 was designed to reduce participant’s tendency to look at the left or top images first, the reliability of this approach has not yet been assessed and further research on the reliability of eye movement indices in general is needed.

Second, it is important to note that the “threatening” stimuli were simply static images. It may be the case that when presented with stimuli that represent more realistic threats (e.g., live spiders for people afraid of spiders) and fear schema are fully activated, that viewing patterns may more closely follow those proposed by models of ABT (e.g., Beck & Clark 1997; Eysenck, 1992; Mogg & Bradley, 1998). Furthermore, participants were presented with only two images at a time, knowing that threat images would be present, whereas environments generally are much more complex with multiple competing stimuli that one cannot as easily predict will contain potential threats. Future research would benefit from using more complex stimulus displays and experimental paradigms where threat is unexpected and more unpredictable (Richards et al., 2014) to emulate more real world experience.

It is also worthy to consider that vigilance and avoidance may have much to do with the extent to which the individual appraises the imminence and severity of the threat as well as their capacity to flee or fight (e.g., Craske, 1999). If one is afraid of spiders and a spider appears in the room, it may capture attention if it is on the move, is very close, or is especially fearsome looking. However, if the spider stays at a distance and does not move, it may be less anxiety-provoking to ignore it. However, if one lacks the capacity for attentional control, such regulatory attempts may fail. It may be the case that attention retraining is successful in reducing anxiety (e.g., Amir, Beard, Taylor, Klumpp, Burns, & Chen, 2009) less because it overrides actual attentional biases and more because it helps individuals develop greater attentional control in the later stages of attentional processing (Koster, Baert, Bockstaele, & De Raedt, 2010). Thus, whereas bottom-up deployment of attention may depend to a large extent on detecting salient emotional stimuli, top-down deployment of attention may depend, at least to some extent, on the appraisal of the imminence, severity, and control one has over the threat, as well as the capacity to master attentional deployment, which in turn may help account for inconsistencies in findings across studies. In future research it might be worthwhile to match eye movements with stream of consciousness verbalizations in addition to further assessment of threat appraisal and motivation to monitor versus avoid the stimuli as used in the current program of research.

Relatedly, as discussed in Study 3, the free viewing paradigm did not require participants to control or disengage their attention from threat, and thus it is unknown whether trait anxiety effects would have been observed if attentional control, or the ability to disengage from threat, was assessed more directly. Further research is needed to disentangle the effects of trait and state anxiety on attention to threat during controlled attention tasks (e.g., anti-saccade tasks). If trait anxiety is associated with a difficulty disengaging attention from threat, above and beyond the effect of state anxiety, then this result would suggest that a mechanism likely involved in trait anxiety-related ABT, and perhaps anxiety disorders, involves distractibility and the difficulty focusing attention on a goal/task when potential threat is present (Eysenck, 2007) rather than simply a preference to attend to threat.

Moreover, a recent theoretical distinction between *selective attention* and *hypervigilance* may account for the mixed results in the literature and improve our understanding of anxiety-related ABT beyond the current models (Richards et al., 2014). That is, facilitated attention may result from a preference for processing threat (i.e., selective attention) *or* an alertness for threat signals (i.e., hypervigilance) that occurs more generally, even before threat is present. These two processes rely on separate attentional systems (orienting versus alerting, respectively), differ in mechanisms (e.g., broadening versus narrowing of attention, respectively) and result in distinct eye movement behaviours based on specific conditions (presence or absence of threat and task-relevance of threat) that indicate specific attentional outcomes, such as facilitated attention (common to both constructs), delayed disengagement (specific to selective attention) and difficulties focusing attention on a task (specific to hypervigilance). Richards and colleagues (2014) argue that eye movement research supporting anxiety-related selective attention of threat to date is mixed at best, while other research (e.g., using visual search and distraction paradigms) has more clearly indicated that trait and clinical anxiety is associated with greater hypervigilance, as indicated by a broadening of attention and fewer eye movements or excessive and rapid scanning and numerous eye movements, that overall, increase distractibility and reduce attentional control (Eysenck et al., 2007). Interestingly, they suggest, as does Gerdes and colleagues (2008), that there may be an "unspecific hypervigilance followed by a specific disengagement deficit" (p. 7). That is, anxious individuals show hypervigilance for all stimuli, irrespective of threat value if threat is possible, and then once detected, there is a deficit in disengaging threat stimuli specifically, rather than stimuli in general. While this theory does not articulate distinctions in relative roles of trait and state anxiety on these attentional processes, it does provides a broader framework for understanding potential maladaptive attentional processing associated with anxiety and links the processes to observable eye movement behaviours that can be empirically tested in combination with state and trait anxiety effects. For instance, is hypervigilance associated with state anxiety, trait anxiety, or an interaction between the two?

Finally, the current study used an undergraduate sample that varied in levels of trait anxiety given that the effect sizes of ABT appear to be similar to clinical samples (e.g., Bar-Haim et al., 2007). However, further research is needed to assess the relative contribution of trait and state anxiety in a clinical sample with diagnosed anxiety disorders relative to non-anxious controls in order to extend the current research to the populations we are most interested in understanding and treating.

3.12 Conclusion

In brief, the current program of research indicates that elevating state anxiety can cause attention to be biased more towards threat once it has been fixated and thus, anxious mood states influence the maintenance of attention on threat over time. Once manipulating and controlling for state anxiety, the current research found no substantial effects of trait anxiety on ABT in a free viewing task that would indicate potential maladaptive attentional processes likely to contribute to the development and persistence of anxiety disorders. In other words, there was no support for the hypothesis that trait anxiety, or a trait vulnerability to anxiety disorders, is associated with a general preferences in orienting of attention towards threat-related stimuli relative to neutral stimuli any more so than other people who are in a similar state of anxiety. Rather, maladaptive attentional processes associated with anxiety disorders are likely much more complex and may only occur in specific situations, such as when threat stimuli are task-irrelevant and interfere with a conflicting task/goal (e.g., Eyesenck et al., 2007). In order to understand what factors put someone at risk of developing and maintaining an anxiety disorder over time, state anxiety must be accounted for in future theory and research design, while attempting to identify the conditions that contribute to trait anxiety related ABT. Once such maladaptive attentional processes are clearly identified, then more effective treatments can be developed to specifically target these central processes with the goal of ameliorating anxiety-related distress and disorders.

Appendix A

Test Stimuli for Study 1

Table 16. Study 1: Test Stimuli

Threat	Neutral	Harm	Neutral
2683	7496	3010	4510
2811	2512	3064	4542
3500	2595	3100	4500
3530	2397	3140	4530
6212	8460	3170	2050
6242	2395	3181	2025
6312	2396	3301	2280
6313	4599	3550	2500
6315	4700	9250	2579
6350	2160	9252	4533
6510	2650	9410	8010
6560	4605	9415	2594
6570	6570.2	9420	2360
9423	2560	9635.1	9635.2

Appendix B

Test Stimuli for Study 2

Table 17. Study 2: Test Stimuli

Threat	Neutral	Harm	Neutral	Positive	Neutral
2683	7496	3010	4510	2070	2250
2811	2512	3064	4542	2080	9070
3500	2595	3100	4500	2165	2214
3530	2397	3140	4530	2209	2480
6212	8460	3170	2050	2304	2271
6242	4100	3181	2025	2311	2312
6312	2396	3301	2280	2340	2383
6313	8050	3550	2500	2370	2570
6315	2485	9250	2579	2530	2850
6350	2372	9252	4533	2550	2516
6510	6250.2	9410	8010	7325	2840
6560	4605	9415	2594	8180	8160
6570	6570.2	9420	2495	8380	8060
9423	2560	9635.1	9635.2	8461	2870

Appendix C

Mood Induction Instructions

Before we begin the visual task I am going to ask you to get into a mood that makes you as [anxious or calm] as you feel comfortable. You can do this by thinking about an event in your life where you felt especially (same mood word). I know that this may not be the easiest thing to do, but it is very important for our research.

I've done this a few times myself so I'll tell you a few things about it. I found that since I was the one asking myself to become (same mood word) by thinking about events in my own life, I was very much in control of the mood. I could intensify, lessen, and later even end the mood quite easily by changing my thoughts.

I'll begin by turning on some music that people usually find helpful for getting into mood that makes them feel (same mood word). While you are listening to the music, please think about a particular event from your past where you were especially (same mood word). While you are listening to the music I'd like you to relive this event. When I did this, I thought about the time...(give a personal example). It is important to remember that the more detail you can re-create in your mind about the event, the more intensely you'll re-live that same feelings.

But I also want to reassure you that I will take time at the end of the session to make sure you are feeling normal again before you leave today. Remember that the goal is to feel as (same mood word) as possible for this short period of time. I know this may not be easy, but are you willing to try?

I'll leave you alone now with the music and your thoughts (dim room lighting). Please relax in the chair while you think about these events and put your feet up if you like. I'll be coming back in in a few minutes. Please try to stay focused on the events you are re-living. If you want to stop at any time, don't hesitate to tell me.

Appendix D

Test Stimuli for Study 3

Table 18. Study 3: Test Stimuli for Image Set 1 and 2

Image Set 1

High Threat	Neutral	Mild Threat	Neutral	Positive	Neutral
2683	7496	1111	7080	1722	7320
2811	2512	1270	7950	1811	5510
3180	2830	1301	1510	2050	2240
3500	2595	2120	2230	2165	2214
3530	2397	2661	5520	2209	2480
6210	7110	2681	2410	2216	2320
6243	2215	3280	2280	2303	2487
6315	4700	4621	2570	2340	2383
6350	2500	6020	7235	2550	2516
6510	2221	6211	2518	4640	2510
6530	2515	6241	7090	5780	5740
6540	9700	6410	9210	5831	8465
6570.1	4536	6610	7035	5910	7590
6571	7030	6840	5455	8162	5395
6821	4617	9120	9360	8185	8280
6838	2580	9160	2600	8200	2490
9620	5390	9404	7620	8350	4571
9630	7170	9417	7150	8496	2520
9911	7234	9592	7050	8497	2270
9921	5410	9912	7140	8501	5720

Image Set 2

High Threat	Neutral	Mild Threat	Neutral	Positive	Neutral
6212	8050	1051	1313	1710	5534
6230	5533	1200	1910	2070	2250
6242	2880	1220	1616	2080	9070
6260	7025	2100	2200	2304	2271
6300	7060	2130	2385	2391	7550
6312	2396	2682	2440	2530	5875
6313	4598	2691	2485	4641	7490
6360	2575	2692	5535	5621	7207
6370	8320	6190	7503	5626	7920
6550	7190	6200	7020	5830	7705
6560	2630	6244	2210	7325	2840
6830	2381	6561	8010	7330	5500
6834	2749	6800	7004	7580	5250
9520	1850	6940	7710	8170	5900
9560	1450	7361	7031	8190	7211
9600	7491	9230	2620	8210	8311
9800	2495	9470	7500	8370	7096
9810	7495	9584	7040	8380	8060
9910	7595	9594	7100	8461	2870
9920	7217	9621	7130	8531	7285

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