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**INDIVIDUAL DIFFERENCES IN THE IMPACT OF ATTENTIONAL BIAS
TRAINING ON CARDIOVASCULAR RESPONSES TO STRESS**

Thesis submitted for the Degree of Doctor of Philosophy

Niamh Higgins, B.A., H.Dip. (Psychology)



School of Psychology
National University of Ireland, Galway
Galway
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**Supervisor of Research:
Dr Brian M. Hughes**

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ABSTRACT

Introduction. The present research examines the effect of threat-related attentional bias — the tendency to direct attention towards information in the environment that is threatening or negative — on anxiety responses to stress. Three methodological refinements were incorporated to help advance understanding of the effects of threat-related attentional bias on anxiety responses when exposed to stress. Firstly, attentional bias for threat-related information was experimentally manipulated prior to stress exposure in order to examine the direction of the relationship between threat-related attentional bias and anxiety responding to stress. Secondly, physiological indices of anxiety, in the form of cardiovascular parameters, were employed to provide objective measurement of anxiety responses to stress, thereby addressing the existing reliance in the literature on subjective measures of anxiety (i.e., self-report measures). Thirdly, individual differences in personality were examined in order to assess the influence, if any, of individual temperaments on the adoption of an attentional bias and on subsequent anxiety responding when presented with a stress task.

Methods. Three empirical studies are reported. In a sample of 77 female college students, Study 1 examined the influence of an attentional bias intervention that trained attention either towards or away from threatening linguistic stimuli on anxiety responses to a stress task, and considered the role of individual differences in personality on this effect. In Study 2, in order to address limitations in ecological validity associated with linguistic stimuli, a sample of 68 female college students completed an attention training protocol

involving emotionally positive and emotionally threatening photorealistic facial stimuli before completing a standard stress task. In Study 3, 80 female college students were presented with an attention training protocol similar to that employed in Study 1 but in which the linguistic stimuli were replaced with photorealistic facial stimuli.

Results. Study 1 indicated that attentional bias manipulation causally affected physiological indices of anxiety responding to stress. Participants with high neuroticism who completed the negative training intervention and participants with low neuroticism who completed the anti-negative training intervention showed increased systolic blood pressure responding to stress. When neuroticism was replaced with psychoticism in the analyses, the same pattern of findings was evident. In Study 2, priming participants with emotionally threatening facial images causally affected their subsequent anxiety response to stress. Individual differences in psychoticism, but not neuroticism, determined the precise nature of these effects. In Study 3, there was no effect of training on anxiety responses to stress but participants' responses to the protocol in general were again dependent on individual differences in personality. A vascular hemodynamic response profile was evident for participants with high neuroticism in response to the stress task and for participants with high psychoticism at the post-intervention time point prior to the stressor.

Conclusions. The findings affirm cognitive approaches to anxiety which suggest that an attentional bias for threat-related information is a causal factor in the experience of exaggerated anxiety responding to stress. Anxiety responding to stress in those who were trained to attend towards threatening

information as compared to those trained to direct their attention away from threatening information was only seen to differ when both individual differences in personality and physiological variables were considered. As such, between-group differences in anxiety were evident for physiological but not for self-report measures of anxiety and were contingent on individual differences in personality. These findings highlight the importance of individual differences and physiological variables in establishing the relationship between threat-related attentional bias and exaggerated anxiety responding to stress.

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LIST OF ACRONYMS

ANOVA: Analysis of variance

ANCOVA: Analysis of covariance

bpm: Beats per minute

BMI: Body mass index

CO: Cardiac output

DBP: Diastolic blood pressure

EPQ-R: Revised Eysenck personality questionnaire

HR: Heart rate

lpm: Litres per minute

MI: Myocardial infarction

mmHg: Millimetres of mercury

ms: Milliseconds

pru: Peripheral resistance units

RT: Reaction time

SBP: Systolic blood pressure

STAI: State-Trait Anxiety Inventory

SV: Stroke volume

TPR: Total peripheral resistance

LIST OF WORKS

Below is a list of publications and conference presentations stemming (directly and indirectly) from this thesis:

PUBLICATIONS

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1. **Higgins, N. M.**, & Hughes, B. M. (2012) Individual differences in the impact of attentional bias training on cardiovascular responses to stress in women. *Anxiety, Stress, & Coping*, 25, 381-395. (Chapter 2).

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3. Hughes, B. M., & **Higgins, N. M.** (2010). Habituation-sensitization of cardiovascular reactivity to repeated stress in smokers and non-smokers: An anthropometrically matched trial. *International Journal of Psychophysiology*, 76, 34-39.
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PRESENTATIONS

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- differences*. Paper presented at STAR 2011: 32nd World Conference on Stress and Anxiety Research, Münster, Germany.
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Chapter 1: INTRODUCTION

Overview of Anxiety

The term *anxiety* is one of the more familiar terms used to describe emotional states in everyday culture. However, despite its ever-present nature, the psychological notion of anxiety has proved difficult to pin down conceptually. Anxiety has been described as an “aversive emotional and motivational state” that occurs in threatening circumstances (Eysenck, Derakshan, Santos, & Calvo, 2007, p. 336); as a co-ordinated, cognitive, affective, physiological, and behavioural response to the presence of stress (Beck, Emery, & Greenberg, 1985; Beck & Clarke, 1997); and as an emotional quality that can be distinguished in terms of *state* (i.e., current environmentally-dependent levels) and *trait* (i.e., individual differences in disposition) manifestations (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983). Other attempts to describe anxiety have sought to contrast it with closely related terms. For example, anxiety has frequently been differentiated from *fear*. Fear can be attributed to a specific threatening stimulus or event, it tends to be episodic, and diminishes with the removal of threat. By contrast, the precise source of threat from which anxiety stems can often be difficult to identify, and anxiety may persist even in the absence of threat resulting in a state of heightened vigilance (Rachman, 2004). Further descriptions of anxiety have been more functional in

their focus. Many commentators have conceived of anxiety as constituting a normal, innate response to stress that serves an adaptive function.

Notwithstanding such variability in taxonomy, it is generally agreed that exaggerated and enduring anxiety is very much a bad thing, and serves to threaten both psychological and physiological health.

Perhaps reflecting the archetypal nature of the term, the study of anxiety in psychology has traversed four main domains: psychodynamic; behavioural; biological; and cognitive. Freud's (1920; 1924) approach was to distinguish between objective anxiety, neurotic anxiety, and moral anxiety. According to this approach, objective anxiety is generally rational and is evoked in response to an objectively dangerous object that is foreseen; neurotic anxiety is attributable to conflict between the *id* and the *ego* as unconscious material threatens to enter consciousness; and moral anxiety is the result of conflict between the sexual desires and impulses of the *id* and the control imposed over these socially unacceptable impulses by the *superego* (Endler & Kocovski, 2001). This approach was constructed on the basis of evidence from case studies and other forms of anecdotal evidence, and the difficulty in replicating such findings using empirical research has proved to be one of the major limitations of the psychodynamic approach to anxiety (Rachman, 2004).

Behavioural models of anxiety are based on the principles of classical conditioning first described by Pavlov (1927), and further developed to incorporate the principles of operant conditioning by Skinner (1953). According to this approach, anxiety is learned through conditioning processes (i.e., by being repeatedly paired with an anxiety evoking stimulus, a previously neutral stimulus comes to elicit a conditioned anxiety response in the absence of the anxiety

evoking stimulus), and maintained through operant ones (i.e., by being reinforced by environmental contingencies). The behavioural approach continues to be influential in the treatment of anxiety disorders, most especially when combined with the cognitive approach (i.e., cognitive behavioural therapy). Despite the merits of behaviourism in this context however, one of the most notable limitations of the approach is its failure to take into consideration the role of information processing (i.e., thoughts and perceptions) in the experience of anxiety.

The biological approach to anxiety emphasizes the role of genetic heritability and also implicates individual variability in neurobiological functioning in the experience of anxiety. Much of the evidence on the role of genetic heritability in anxiety has been extracted from twin studies which show that 30-40% of the individual variability in risk of developing an anxiety disorder is attributable to genetic factors (Hettema, Neale, & Kendler, 2001a). A number of studies have shown that elevated activity in brain regions implicated in emotion regulation, such as the amygdala, in response to threatening or negative information is associated with high anxiety in adults and children (Hare et al., 2008; Somerville, Kim, Johnstone, Alexander, & Whalen, 2004). The mechanisms by which genetic factors influence the experience of anxiety are not limited to neurological pathways alone as genetic factors also influence the way in which individuals interact with their environment and this in turn determines the level of anxiety that will be experienced. The biological approach to anxiety continues to attract much research. The ability to directly test hypotheses regarding the role of genetics and neurological processes in the experience of anxiety represents one of the major strengths of this approach.

Proponents of cognitive approaches to anxiety suggest that the way in which we attend to, interpret, and process information in our environment directly influences our experience of anxiety. According to this approach, individuals high and low in trait anxiety differ in their cognitive processing of threat-related stimuli. In this context the term ‘threat’ refers to emotionally negative information or information that communicates the possibility of harm to the individual. Some of the more common types of threat include verbal threat (i.e., words that communicate the presence or possibility of threat) and non-verbal threat (i.e., threat that is depicted in pictorial images such as facial images of angry expressions). Whether or not a particular stimulus is perceived as threatening, and indeed the extent to which it is perceived to be so will differ for different populations (e.g., those with or without a specific phobia).

Individuals with high trait anxiety possess a cognitive processing bias in which the threat value of a given stimulus is exaggerated. A number of researchers have proposed that this hyper-vigilance for, or systematic bias towards, threatening information constitutes a cognitive vulnerability factor for anxiety (e.g., Eysenck, 1992; Mogg & Bradley, 1998; Williams, Watts, MacLeod, & Mathews, 1988, 1997). Cognitive theories recognize the role of learning and of biological processes in the experience of anxiety but place greatest emphasis on the individual’s interpretation of events. The cognitive approach to anxiety then can be viewed as favorable to alternative approaches outlined due to its acknowledgement of important facets of other approaches and the strong empirical research both on which it is founded and to which it has lead as will be discussed below.

The present thesis will employ an experimental design consisting of the manipulation of attentional bias for threat-related information and exposure to an anxiety-eliciting stress task. Primarily, given the extent of correlational research that features in the anxiety literature, an experimental approach will be important in providing a basis to consider the *causal* nature of anxiety-related phenomena. In particular, establishing whether anxiety *is exaggerated by* negative attentional bias, or whether it is itself a factor that exaggerates such biases, can only be satisfactorily resolved using methods that allow researchers to manipulate the biases themselves. In so doing, the present thesis aims to extend the existing literature concerning threat-related attentional bias and anxiety responses to stress in two important ways: (i) by examining physiological indices of responses to anxiety-provoking tasks following the manipulation of attentional bias, in addition to the traditional approach of using self-report measures; and (ii) by investigating the influence of individual differences in personality on the adoption of attentional biases and their impact on subsequent anxiety responses.

Attentional Bias

The concept of “negative” (or “threat-related”) attentional bias is used in cognitive theories of anxiety to describe a person’s tendency to direct attention towards stimuli in the environment that are perceived as being negative or threatening in nature. Negative attentional biases are believed to exacerbate anxiety levels, and to be a core adverse feature of clinical anxiety and depression. Some of the earliest cognitive theories of anxiety were proposed by Aaron T. Beck and colleagues. Beck et al. (1985) emphasized the role of cognitive schemas in interpreting, attending to and remembering information. According to

this approach, individuals will orient their attention towards cues that are congruent with their existing schemas. Therefore, anxious individuals will allocate their attentional resources to stimuli that communicate the possibility of threat or harm, and ambiguous stimuli will also be interpreted as presenting a threat.

Expanding on this work, Beck and Clarke (1997) outlined a three-stage schema-based information processing model according to which anxiety occurs when excessive or inappropriate threat value is attributed to an innocuous situation or stimulus. The first stage of information processing, termed the *orienting mode*, assigns processing priority (i.e., attentional resources) to stimuli that signal a threat to the individual's survival. The second stage activation of the primal threat mode occurs on recognition of a personally relevant negative stimulus and results in a coordinated behavioural, physiological, affective, and cognitive anxiety response aimed at ensuring safety and survival. The third and final stage, secondary elaboration, involves more strategic, constructive consideration of the threatening stimulus that is schema driven, and secondary appraisal in which individuals evaluate their coping resources for dealing with the threatening stimulus. The outcome of this three-stage process will be one of the following: further escalation of anxiety as a more realistic reappraisal of the stimulus is prevented and the primal threat mode continues to dominate; a decline in anxiety following reappraisal and the decision that severity of threat is less, or availability of resources is greater than first appraised; a reduction in anxiety due to a defence mechanism being engaged.

Other cognitive models of anxiety that have been supported by research findings include those of Eysenck (1992), Williams et al. (1997), and Bradley

and Mogg (1998). Eysenck's hyper-vigilance theory (1992) suggests that individuals high in trait anxiety can be distinguished from those low in trait anxiety by a cognitive vulnerability factor of systematic biases or hyper-vigilance for threat that is activated under conditions of stress and/or high state anxiety. According to Williams et al. (1997) attentional bias for threat is determined by two mechanisms: the affective decision mechanism (ADM) which appraises the threat value of a stimulus and the resource allocation mechanism (RAM) which decides on the appropriate allocation of attentional resources based on the input of the ADM. The operation of these mechanisms is influenced by trait anxiety such that individuals with high trait anxiety will consistently attend to threat-related stimuli, becoming more vigilant for threat as threat value increases, and those with low trait anxiety will direct attention away from threatening stimuli, becoming more avoidant of threatening stimuli as its threat value increases.

In contrast to Williams et al.'s (1997) model, the cognitive motivational model of Mogg and Bradley (1998) proposes that both individuals high and low in trait anxiety will show greater vigilance for severely threatening stimuli than stimuli that are mildly threatening. This model proposes that anxiety is the product of a Valence Evaluation System that assesses the threat value of a stimulus and a Goal Engagement System that establishes the appropriate allocation of attentional resources. The distinction between those high and low in anxiety then is that those with high trait anxiety are likely to appraise a stimulus as more threatening than are those with low trait anxiety. In instances where the stimulus is of a high threat value this model proposes that individuals high and low in anxiety will show increased vigilance for the stimulus. Bearing in mind the evolutionary perspective that vigilance and effective detection of threat is

vital to ensuring the survival and well-being of the organism, it would appear that the cognitive motivational model of Mogg and Bradley (1998) offers a more probable account of the nature of attentional bias responding to threat. Even individuals with low levels of trait anxiety would be expected to attend to information in their surroundings that signifies a threat to their well-being.

Mogg et al. (2000) carried out two experiments to examine which of the two proposed models, that of Williams et al. (1997) or Mogg and Bradley (1998) more accurately represents individual patterns of response to threat-related stimuli. Reaction times in each experiment showed that as the threat value of the stimulus increased, participants' attentional bias became relatively more vigilant and less avoidant irrespective of trait anxiety. These results support the cognitive motivational model of Mogg and Bradley while contradicting the view of Williams et al. (1997) that as threat increases, low trait anxious individuals will show more avoidance of threat. These findings were corroborated by Koster, Crombez, Verschuere, and De Houwer, (2006) who reported that high threat pictures captured attention in all individuals with low trait anxious participants avoiding mild threat pictures but orienting towards high threat pictures.

Attentional Bias and Anxiety

In evolutionary terms, traits evolve because they are useful and confer an advantage in terms of survival. For a trait to be naturally selected it must vary in the population. In considering the idea that anxiety is an evolved mechanism, it can be noted that individuals vary in the extent to which they are prone to experiencing anxiety (Rachman, 2004). In cognitive terms, individual differences

in sensitivity to threatening information could be said to underlie this variation in anxiety. Accordingly, vigilance towards stimuli that pose a threat to the individual's safety and survival serves an adaptive function. Individuals who are sensitive to signs of threat in their surroundings (i.e., who exhibit a threat-related attentional bias) will likely be quicker to respond to signs of threat and better prepared to take appropriate action to prevent or minimize harm or danger to their well-being. In this way anxiety acts as a defence mechanism. However, preferential processing of threatening information in the environment becomes problematic when the individual is overly sensitive to or displays a hyper-vigilance for threat, and then fails to attend to stimuli that signal the absence of threat. In understanding why it is that this hyper-vigilance may come about, it is helpful to consider the view proposed by Nesse (2005) that although natural defences such as anxiety incur a cost when they are expressed, the cost of this defence to the individual tends to be less than the cost that would be felt if the defence was not expressed in the presence of threat (i.e., although the cost of the defence mechanism may be high, it remains lower than that which would be experienced if the individual failed to respond in the presence of an actual threat). This can result in a number of "false alarms" whereby the defence is expressed in the absence of a real or significant threat to the organism. This principle is referred to as the *smoke detector principle* (Nesse, 2001b).

It can be noted that the type of anxiety response that is activated in response to the possibility of threat can be excessive or over-exaggerated when compared to the nature of the threat that is encountered. Anxiety responses, consistent with the fight-or-flight response (Cannon, 1929), include physiological responses such as increased heart rate and concentration of blood flow to vital

organs like the heart and the lungs. Such responses served to mobilize our ancestors to respond to a life-threatening danger such as that posed by a predator. Present day environments rarely involve the types of life-or-death situations encountered by our ancestors, leading to the question of why survival skills such as threat vigilance and defensive responses such as anxiety continue to exist. This can best be understood by considering the nature of evolutionary adaptation. Although the environment continues to change, evolution occurs such that tiny changes are made over long periods of time. The types of defence mechanisms and survival skills that continue to be passed on through the generations represent those that were needed by our ancestors and thus we carry this legacy.

Beck et al. (1985) distinguished between anxiety that is normal (i.e., aroused by a realistic danger that diminishes when the danger is no longer present) and anxiety that is pathological (i.e., disproportionate to the risk and severity of possible danger and persisting even in the absence of danger). Beck and Clark (1997) proposed that this distinction is one of “degree” and not “kind” implying that continuity exists between anxiety that is “normal” and that which is “pathological”. In a review of the literature, Mathews and MacLeod (2005) noted that all individuals must attend to threat that poses an actual danger, and suggested that there exists a threshold below which signals of threat can be ignored and above which they must be attended to. Accordingly, individual differences in attentional bias will arise based on this threshold with those more prone to anxiety exhibiting a lower threshold for attending to threat. The allocation of attentional resources towards threatening stimuli is thus determined by the severity of threat, by the individual’s level of trait anxiety, and by attentional control.

An increasing literature supports the hypothesized relationship between threat-related attentional bias and anxiety. Research findings indicate that the relationship between attentional bias and anxiety is of low-to-medium effect size and that attentional bias is evident in both clinical and non-clinical high anxious samples but is not evident in non-anxious samples (Bar-Haim, Lamy, Pergamin, Bakermans-Kraneburg, & van Ijzendoorn, 2007; Cisler & Koster, 2010). Based on their meta-analysis of 172 samples, Bar-Haim et al. (2007) reported that attentional bias was significantly associated with all clinical disorders tested - (viz., generalized anxiety disorder, panic disorder, post-traumatic stress disorder; social phobia and simple phobia) with no difference in the magnitude of threat-related bias as a function of anxiety disorder.

Measurement of Threat-Related Attentional Bias

Emotional Stroop Task

The role of selective processing of negative/threatening information in the experience of anxiety has been examined using the so-called *emotional Stroop task* (Mathews & MacLeod, 1985; Watts, McKenna, Sharrock, & Trezise, 1986) which is a variant of the original Stroop task (Stroop, 1935) and more recently the visual probe detection paradigm (dot-probe task) and the visual search paradigm (face-in-the-crowd task). In the emotional Stroop task, participants view a series of emotionally-valenced and neutral words presented in various colours. Participants must ignore the meaning of the word and identify the colour in which the word is presented. Increased reaction times in colour

naming are indicative of distraction due to attention being directed towards the meaning of the word rather than its colour. The results of studies employing the emotional Stroop task are generally consistent in showing that both clinically and non-clinically anxious individuals display disproportionately longer colour naming latencies for threat-related words than do non-anxious control participants (Williams, Mathews, & MacLeod, 1996).

Dot-probe Task

The dot-probe task was developed by MacLeod, Mathews, and Tata (1986) to test the hypothesis that anxious participants would show faster reaction times to probes that replaced threat stimuli than to probes that replaced non-threat stimuli. Pairs of linguistic or pictorial stimuli (one neutral and one negative/threatening stimulus) are presented briefly on a computer screen at equal intervals and for an equal amount of time each. Each pair is followed by a probe which the participant must identify as a single or double dot. In the negative training condition, the dot always replaces the negative stimulus (i.e., the dot is presented in the same location on screen as was occupied by the negative stimulus in the pair). In this way attention is consistently directed towards negative stimuli and although the participant is not explicitly instructed to attend to the negative stimuli, the training contingency creates a bias in attention for threat-related stimuli. In the anti-negative training intervention (also referred to as the neutral condition), the dot always replaces the neutral stimulus. In training attention away from negative stimuli, the anti-negative training condition represents the control condition.

The Face-in-the-Crowd Effect

The evolutionary perspective that there exists an innate bias for processing threat-related information is supported by numerous studies that have employed the visual search paradigm first employed by Hansen and Hansen (1988). In the classic search asymmetry design participants are presented with either an angry face in a crowd of happy faces or a happy face in a crowd of angry faces. For half of the trials, all but one face shows the same emotional expression (e.g., eight happy faces and one angry face). On remaining trials, all faces show the same expression. Participants use a key press to indicate the presence or absence of a discrepant emotional expression. Faster reaction times for detecting the angry face in the crowd as compared to the happy face in the crowd have been taken to indicate an attentional bias for threatening stimuli and this is commonly described as the *face-in-the-crowd* or the *anger superiority* effect. A number of studies have also examined this effect using the constant distractor paradigm in which reaction times to detect an angry face versus a happy face in a crowd of neutral faces is assessed.

Experimental Studies

Research Findings from the Dot-probe Task

The dot-probe task has been employed in numerous studies investigating the association between biased attention for threat-related stimuli and heightened anxiety levels. Researchers have examined attentional bias across samples of individuals with generalized anxiety disorder, social anxiety disorder, generalized social phobia, and high trait anxiety. Much of the research has been

concerned with examining the efficacy of attention training away from threat (i.e., training attention towards the neutral stimulus in a threat-neutral stimulus pair or training attention towards the positive stimulus in a positive-neutral stimulus pair) in reducing both self-report levels of anxiety and the ratings of clinicians and independent assessors using various measures of anxiety. The association between threat-related attentional bias and anxiety is supported by and large by such studies, as will be discussed below, and a number of authors have proposed that the efficacy of this approach in reducing anxiety could make it an important method of treatment for those individuals who experience elevated levels of anxiety.

Amir, Beard, Burns, and Bomyea (2009) examined the effectiveness of an attention modification program delivered in eight sessions over 4 weeks in reducing anxiety levels in 29 individuals meeting criteria for generalized anxiety disorder. A dot-probe task with threat-neutral word pairs was presented to participants in both the attention modification group and the attention control group. For participants in the attention modification group the probe always replaced the neutral word, while for participants in the control condition the probe replaced the threat and neutral words with equal frequency. The findings revealed that those participants exposed to the attention modification showed a significant decrease in both self-report state and trait anxiety from the pre- to the post-assessment point in contrast to participants in the attention control group who showed no significant differences in anxiety. Independent assessors also rated participants in the attention modification group as significantly less anxious at the post-assessment point as compared to the pre-assessment point. Finally, 50% of participants in the attention modification group no longer met the DSM-

IV criteria for generalized anxiety disorder at post-assessment as compared to 13% of participants in the control group. These findings are limited by the small sample size of 29 participants, which undermines the generalizability of the results. Furthermore, the dot-probe task protocol was described to participants as an experimental procedure to determine the efficacy of a computer treatment for anxiety. The possibility that participants' self-report anxiety levels were influenced by this information cannot be ruled out.

A further paper by Amir and colleagues (Amir et al., 2009) employed an attention modification program of a similar design and examined the effectiveness of the training in reducing symptoms of social anxiety in a sample of 44 individuals with a diagnosis of generalized social phobia. The training sessions were followed by a four month follow-up to assess the duration of treatments effects. The computerized attention modification program presented a dot-probe task with a threat-neutral facial stimuli pair on 80% of trials and a neutral-neutral facial stimuli pair on the remaining 20% of trials. For participants in the attention modification group the probe consistently following the neutral facial stimuli. For participants in the control group, the probe replaced the threat and neutral face with equal frequency. The results showed that relative to the control group, participants in the attention modification group had reduced self-report and independent assessor ratings of social anxiety from pre-assessment to post-assessment and were less functionally impaired. In addition, 50% of participants in the attention modification program no longer met DSM-IV criteria for generalized social phobia after training. While these findings show that participants' self-report and assessor-rated symptoms of generalized social phobia were attenuated following the intervention, they don't permit conclusions

relating to the experience of anxiety in the presence of stress. This limitation applies to the earlier study of Amir et al. (2009) also. A more warranted assessment of the effectiveness of the intervention in training a bias away from threat would involve exposure of the participant to a stressful situation post-intervention. An experimental design of this nature would also permit the testing of hypotheses regarding the direction of causality between attentional bias for information of a threatening valence and elevated anxiety levels.

Research Findings from the Face-in-the-Crowd Task

Hansen and Hansen's (1988) investigation of the face-in-the-crowd effect, considered the pioneering study in this area, consisted of three experiments in which matrices of real faces were presented to a healthy non-clinical population. The study found that angry faces were detected faster in happy crowds than were happy faces in angry crowds. These findings, which have since been undermined due to the presence of a visual confound in the stimuli used (Purcell, Stewart, & Skov, 1996), have nonetheless been replicated by other researchers using schematic (i.e., line drawn faces/sketch-like images; e.g., Ohman, Lundqvist, & Esteves, 2001) and photorealistic facial images (e.g., Horstmann & Bauland, 2006). This faster detection of angry faces relative to happy faces has been reported independent of the number of distractors presented in the crowd (Frischen, Eastwood, & Smilek, 2008). Rosset et al. (2011) reported that angry faces were identified as efficiently when presented amongst two, five or eight distractor faces, whereas efficiency in detection of happy faces decreased as the number of distractor faces increased.

Pinkham, Griffin, Baron, Sasson, and Gur (2010) have criticized previous studies using real faces for presenting a crowd of faces that was comprised of a single identity (i.e., a homogenous crowd comprised of the same face repeated a number of times), arguing that such crowds lack the ecological validity of a heterogeneous crowd and are also likely to act as a confound in that the degree of similarity between distractor faces will influence participants' visual search performance. To overcome such limitations, Pinkham et al. (2010) employed a face-in-the-crowd task with a heterogeneous crowd comprised of real faces. On each trial, participants were presented with a crowd of nine individual faces and instructed to press the 'S' key if all faces showed the same expression and the 'L' key if one face showed an expression that differed from the others. Reaction times and accuracy in detecting the discrepant emotional expression were recorded. Consistent with previous findings, the results of the study showed that participants were faster and more accurate in detecting an angry face amongst a crowd of distractor faces (i.e., in a crowd of happy faces or a crowd of neutral faces) than a happy face amongst a crowd of distractor faces. While this study presents a robust test of the face-in-the-crowd effect that captures its core evolutionary underpinnings, it is limited by its small sample size of 26 participants. This limitation appears common to a number of studies in this area. Krysko and Rutherford (2009b), who also employed a sample of 26 participants, reported faster reaction times and increased accuracy in detecting angry compared to happy faces.

The face-in-the-crowd effect has been reported in both clinical and non-clinical samples. Gilboa-Schechtman, Foa, and Amir (1999) examined attentional bias for facial expressions in individuals with generalized social

phobia and reported greater attentional bias for angry faces than for happy faces in a background of neutral faces. Evidence for the existence of the face-in-the-crowd effect in both clinical and non-clinical child samples has also been reported. Rosset et al. (2011) presented a visual search task to a sample of 30 children with autism spectrum disorder and 30 typically developing children. The authors hypothesized that typically developing children would show superior detection of angry faces as compared to happy faces but that this effect would not be evident for children with autism spectrum disorder given the difficulties in the processing of social and emotional cues that characterize their disorder. Contrary to this latter hypothesis however, the findings revealed more efficient detection of angry faces than happy faces both for typically developing children and for children with a diagnosis of autism, with the efficiency of children with autism spectrum disorder being superior to that of typically developing children. Rosset et al. (2011) concluded that these findings demonstrate the presence of preferential processing of threatening information from childhood for those with typical and atypical development of socio-emotional skills. These findings lend support to the evolutionary perspective that there exists a predisposition to detect the presence of threat. A note of caution is warranted in making inferences from these findings however as they are based on participants' accuracy scores in detecting the angry face and not on their reaction times as is more common in such studies.

The findings of Rosset et al. (2011) are consistent with those of Krysko and Rutherford (2009a) who investigated the existence of an anger superiority effect in 38 male volunteers, 19 of whom were high functioning adults with a diagnosis of autism spectrum disorder and 19 of whom had a history of typical

development, who completed a face-in-the-crowd task. On half of the trials a discrepant emotional face was presented amongst distractor faces and on the other half of trials all faces displayed the same emotional expression. The results showed that overall, angry faces were detected more quickly than happy faces by both participants with autism spectrum disorder and individuals with a history of typical development (i.e., the control group). The control group evidenced a general threat-detection advantage with faster reaction times and greater accuracy in responding to angry faces compared to happy faces. Individuals with autism spectrum disorder showed similar reaction times to the control groups but their overall accuracy in detection of the discrepant emotional expression was lower than that of the control group. LoBue (2009) reported faster detection of the angry face in both adults and children and pointed to its existence in children as indicative of the evolutionary nature of attentional bias for threat. With the exception of a small number of studies (e.g., Juth et al., 2005), the research findings discussed thus far point to the existence of a face-in-the-crowd effect in adults and children from both clinical and non-clinical populations and serve to strengthen and consolidate existing arguments of an evolutionary basis to the face-in-the-crowd effect and to attentional bias for threatening stimuli.

Cause and Effect

The research outlined above confirms the association between biased attention for threat-related information and exaggerated anxiety responses to threat. Such findings, though informative, are correlational in nature and prevent conclusions being reached in terms of which variable is exerting an influence on the other. This raises the highly important question as to what is the direction of

causality between attentional bias and anxiety. Is it the case that individuals orient towards threatening information because they have higher levels of anxiety or, alternatively, does the tendency to direct attention towards threatening information cause heightened anxiety responses to a stressful experience? One limitation common to many of the existing studies is the use of correlational designs which, although informative in terms of establishing the existence of an association between attentional bias and anxiety, prevents inferences being made regarding cause and effect between the variables in question. Individuals will differ in their readiness to preferentially process emotional information of a particular valence. In order to establish the direction of causality between attentional bias and anxiety, attention must first be experimentally manipulated towards or away from threatening stimuli and anxiety responding to a subsequent stressor must then be examined.

MacLeod, Rutherford, Campbell, Ebsworthy, and Holker (2002) were the first authors to investigate the direction of causality in the relationship between attentional bias for threat-related stimuli and anxiety responding to stress.

Numerous authors in this area (e.g., Amir et al., 2009; Bar-Haim, 2010; Eldar, Ricon, & Bar-Haim, 2008) have pointed out that causality can only be examined when an experimental intervention is implemented to train attentional bias towards or away from threat and responding to a subsequent stress task is examined. The authors carried out two studies, each consisting of a sample of 64 undergraduate students, in which the dot-probe task was used to train participants' attention either towards or away from negatively toned linguistic stimuli before presentation of a stressful anagram task that they were told was being video-recorded. Participants indicated their response to the stress task

using a visual analogue mood scale. The findings showed that participants in the anti-negative (neutral) training group self-report significantly lower anxiety responding to the stress task than participants in the negative training group. These findings indicate that individual differences in the preferential processing of negative information can causally affect anxiety responding to an experimental stressor. The use of analogue mood scales to assess anxiety responding to stress following the attentional bias intervention is a significant methodological weakness of this study. The authors accept that the findings of the study are limited by the difficulty in dissociating anxiety from depression in the mood scale scores. The use of a more objective measure of anxiety such as would be represented by cardiovascular responses to anxiety-provoking stimuli would serve to overcome this limitation and strengthen the generalizability of these findings.

Taylor, Bomyea, and Amir (2011) also examined reactivity to stress following the manipulation of attentional bias but did so using an intervention that trained attention in the direction of positive information. Participants were presented with a dot-probe task with word pairs comprised of one social-evaluative word of positive valence and one neutral word that was followed by a stress task (i.e., an impromptu speech). Measures of state anxiety and positive affect were obtained post-intervention (prior to the stress task) and on completion of the stress task. The findings showed that participants showing the greatest shift in attention towards positive stimuli following the intervention, as evident from analyses of reaction times to positive stimuli pre- intervention and post-intervention, evidenced the least anxiety reactivity to stress. This effect was evident in the attention training group but not in the control group where there

was no contingency associated with the processing of threatening cues. In addition, the authors also examined whether individual differences in social anxiety moderated the extent to which an attentional bias for positive information was adopted. The findings showed that higher levels of social anxiety were associated with reduced attention towards positive information. This finding points to the fact that there is variability in the extent to which an attentional bias will be adopted and highlights the importance of examining individual difference variables that may influence the adoption of an attention bias.

The studies conducted by MacLeod et al. (2002) and Taylor et al. (2011) were conducted in controlled laboratory settings which permitted control over the confounding effects of extraneous variables. It can be argued, however, that the patterns of behaviour observed in a contrived laboratory setting do not correspond to those that might be observed in everyday situations as the types of stressors individuals encounter differ to those presented in the laboratory and a number of other distracting or extraneous variables are likely to play a role in the way in which the individual interacts with their environment and with others. To address this issue in the present context, See, MacLeod, and Bridle (2009) investigated the effects of an attentional bias modification programme on anxiety responding in a sample of 40 Singaporean high school graduates who were due to depart to Australia to begin third level education as the transition to another country to undertake a qualification constitutes a stressful life event that is capable of eliciting an anxiety response. For 16 days prior to their departure, participants completed a dot-probe attentional bias modification program delivered via the internet and completed in their own home. Participants in the anti-negative training group were presented with the training contingency

designed to induce an attentional avoidance of negative information. For participants in the control group, there was no training contingency. Participants completed measures of state and trait anxiety prior to the attentional bias modification program and within three hours of their arrival in Australia.

The results of See et al.'s (2009) study showed that although both experimental groups showed elevated state anxiety at the post-assessment point (i.e., within three hours of their arrival in Australia), participants who were trained away from threat had a smaller increase in state anxiety than that experienced by those in the control group. In addition, while the two groups did not differ in their trait anxiety scores at baseline, participants in the control group showed an increase in their trait anxiety scores at the subsequent assessment point while participants who received the training away from threat showed a decrease. These findings support those of MacLeod et al. (2002) and Taylor et al. (2011) of a causal role for attentional bias for threat in anxiety responses to a stressor. The authors acknowledge that the findings are limited both by the sample (i.e., Singaporean high school students emigrating from their home country) and by the stressor (i.e., emigration to another country to attend university) used and also by the reliance on self-report measures of anxiety. The sample size of 16 males and 24 females was also small. Furthermore, although this study sought to examine the effect of attentional bias manipulation on anxiety responding to a stressor occurring naturally in real life, the achievement of this necessitated that a number of possible extraneous variables go uncontrolled (e.g., as this intervention was delivered via the internet and completed by participants in their own home, it is possible that factors within the

home impinged upon or distracted participants in their completion of the task such as the presence of other individuals).

Linguistic Stimuli v Pictorial Stimuli

Bradley, Mogg, Falla, and Hamilton (1998) argue that one of the major limitations of recent research on anxiety-related attentional biases is the use of single words as threat stimuli. Such stimuli are likely to have a limited range of threat value. Once their meaning has been extracted all relevant information has been communicated and there is no further benefit to be gained from attending to the word. Bradley et al. (1998) also point to subjective frequency of usage (threat-related words are likely to have a higher frequency of use and thus greater salience among high trait anxious individuals) and degree of personal relevance as further potential confounds associated with word stimuli that make the interpretation of findings more difficult. More recently, researchers have replaced linguistic stimuli with pictorial representations of threat (i.e., facial images of threat). Pictorial representations of threat are likely to be more potent, more biologically significant, and more informative and thus maintain attention. It can also be argued that the ability to detect the threat valence of a facial image constitutes a more primal response than the ability to detect the threat valence of linguistic stimuli as individuals learn to recognize faces from birth, before they learn to recognize words. In addition, such stimuli more closely represent the types of threat encountered in everyday life and thus can be said to possess greater ecological validity. This aligns with arguments made by those conducting research on the face-in-the-crowd effect (e.g., Horstmann & Bauland, 2006) that

the use of photorealistic facial stimuli is to be preferred to schematic line drawn faces that cannot fully capture the complexity of a facial expression.

Eldar et al. (2008) sought to replicate, in a sample of children, the findings of MacLeod et al. (2002) of exaggerated anxiety responding to stress following the induction of an attentional bias for threat-related stimuli. Using a dot-probe task in which the linguistic stimuli were replaced with facial images, the authors implemented an attentional bias intervention in which one group of children were trained towards threat and the other group of children were trained away from threat and directed towards neutral stimuli. On completion of the attentional bias intervention, participants were presented with a three-minute stress task. The findings indicated that children who were trained to direct their attention towards angry faces developed attentional vigilance towards threat-related information, as evident from probe discrimination latencies, and evidenced increased self-report anxiety following stress induction. Probe discrimination latencies showed that the training procedure was ineffective in inducing an attentional bias away from threat with children in this training group showing no difference in anxiety from pre-assessment to post-stress assessment points. The authors also assessed behavioural responses to the stress task and these measures were consistent with the self-report data showing that children trained towards threat showed a higher frequency of stress-related behaviours such as negative vocalizations and major postural changes as compared to children trained away from threat. The small sample size of 26 participants limits the ability to generalize from the findings of this study.

Research concerning attentional bias in individuals with social anxiety disorder is consistent in showing reduced social anxiety in those participants who

are trained to direct their attention away from threat stimuli. Amir, Weber, Beard, Bomyea, and Taylor (2008) presented an attentional bias manipulation using a dot-probe task with facial stimuli prior to the presentation of a stress task, to examine the direction of causality between attentional bias and anxiety reactivity to stress in a sample of 94 socially anxious individuals. Participants were randomly assigned to the attention modification group in which the probe consistently replaced the neutral face, or the attention control group in which the probe was presented with equal frequency in the prior location of the threat and neutral faces. All participants then completed a video-recorded speech. Participants self-report their level of anxiety prior to the training, immediately after the training, and post-stress task. In line with previous findings, the results showed that participants exposed to the attention manipulation reported lower anxiety scores on completion of the stress task than those in the control group, and received a higher rating for the quality of their speech task, indicating superior performance, than did participants in the control group. The authors point to the lack of a significant difference in anxiety scores from pre- to post-attention training as evidence that the training itself did not exert an influence on participants' anxiety state. This allowed them to conclude that differences observed in anxiety levels following the stress task were as a result of individual differences in anxiety responding to the stress task brought about by the attention modification program.

Pishyar, Harris, and Menzies (2004) also investigated attentional bias for threat-related stimuli in those with social anxiety. Participants were undergraduate students with high and low social anxiety who completed a dot-probe task with facial stimuli and with linguistic stimuli. The authors reported

that participants with low social anxiety preferentially attended towards happy facial images and away from threatening ones, while participants with high social anxiety showed preferential attention for threatening facial images and directed attention away from happy ones. This finding was replicated in a second similar study reported in the same paper. Interestingly, there was no significant effect found for the dot-probe task with linguistic stimuli. The authors suggest that this might indicate that the dot-probe task with facial images is a more sensitive index of attentional bias in social anxiety. Faces convey information about personal acceptability and social value that is of particular relevance to individuals with social anxiety. This finding strengthens the argument in favour of facial stimuli over linguistic stimuli. Schmidt, Richey, Buckner, and Timpano (2009) also employed a dot-probe task with facial stimuli, in which they replaced threatening facial expressions with facial expressions of disgust, to implement an attention modification program in individuals with social anxiety disorder. The authors reported significantly greater reductions in self-report social anxiety and trait anxiety in participants who completed the attention modification program as compared to participants in the control group.

Psychophysiology

Physiological Correlates of Anxiety

A small number of recent studies have examined neurophysiological indices of responding to stress following an attentional bias intervention (e.g., Holmes, Bradley, Kragh Nielsen, & Mogg, 2009) and physiological indices in the form of skin conductance reactivity (Heeren, Reese, McNally, & Philippot,

2012), and cortisol levels (Dandeneau, Baldwin, Baccus, Sakellaropoulo, & Preussner, 2007). Overall, however, the existing literature regarding anxiety symptoms and anxiety responses to stress following implementation of an attentional bias intervention, is founded solely on self-report indices of anxiety responding to stress and the assessments of independent raters or clinicians. This is surprising given that the cognitive model of Beck et al. (1985) and Beck and Clark (1997) describes anxiety as a complex cognitive-affective-*physiological*-behavioural response pattern. The proposal that physiological responses play a role in the experience of emotional states is not unique to the work of Beck and colleagues and has a long tradition in psychology. The James-Lange theory of emotion, which represents the work of William James and Carl Lange in the 1880s, proposed that the perception of a stimulus elicits bodily changes (i.e., physiological and visceral changes) which in turn generate emotion (Izard, 1990). This theory was later critiqued by Cannon in the 1920s based on evidence showing that emotions can be experienced in the absence of physiological arousal, as animals in whom there is an absence of visceral sensory impulses due to surgical disconnection are capable of expressing emotion-related behaviour (Barlow, 2002). Furthermore, the same pattern of physiological arousal can result in the experience of different emotional states. Schachter's theory of emotion (1964), originally formulated as the Schachter-Singer or Two-Factor Theory of Emotion (Schachter & Singer, 1962), proposed that emotional states arise due to the interaction between physiological arousal and cognition such that when a stimulus elicits physiological arousal, the context in which the arousal occurs is appraised and cognitive processes attribute this arousal to the causal stimulus. According to this theory, the emotional state that is expressed in response to a

given stimulus will depend on the cognitive interpretation of that stimulus, while the intensity of this emotion is determined by the level of physiological arousal.

Self-report measures are limited in accuracy and reliability. Participants' self-report anxiety responses are likely to be affected and possibly confounded by demand characteristics of the study (i.e., the participant's beliefs as to what the aims and hypotheses of the study are) and also by their willingness to disclose personal information, feelings, and views to the experimenter. Physiological correlates of anxiety are less amenable to demand characteristics and to social desirability effects and thus serve to shed light on the psychosomatic outcomes of increased anxiety responding to stress. MacLeod, Koster, and Fox (2009) argued that the research on anxiety responding following attentional bias manipulation should be extended to include outcome measures other than self-report measures which can be confounded by participants' judgments and inferences. They argue that behavioural and somatic indices would supplement information obtained from self-report measures.

A well-established literature on dissociation between subjective and autonomic response patterns, commonly referred to as *verbal autonomic response dissociation* (e.g., Schwerdtfeger, Schmukle, & Egloff, 2006), suggests that caution is warranted in interpreting and generalizing from findings concerned with self-report emotional arousal. This dissociation between self-report and physiological responses is evident in those adopting a *repressive* coping style and in those with *alexithymia*. As outlined by Myers (2010) those with a repressive coping style report low levels of distress and anxiety when exposed to a stressful situation while showing heightened physiological arousal. Individuals in whom the personality trait of alexithymia is evident show an

inability to adequately describe and identify emotions resulting in diminished reports of negative affect to emotional stressors coupled with heightened physiological responses (Schwerdtfeger et al., 2006; Taylor, Bagby, & Parker, 1997). In addition, Eysenck (2000) suggested that individuals with high trait anxiety may self-report levels of anxiety that are higher than what they are experiencing physiologically.

Cardiovascular Reactivity

The cardiovascular system has been shown to be sensitive to psychological stress such that elevations in response are proportionate to perceptions of stress (Turner, 1994). Hughes (2012) distinguished between a blood pressure response (i.e., a shift in blood pressure following exposure to a stressor) and blood pressure reactivity (i.e., an individual's characteristic blood pressure response pattern across time). Individual blood pressure reactivity has been shown to be consistent across time (e.g., Hassellund, Flaa, Sandvik, Kjeldsen, & Rostrup, 2010; Kelsey, Ornduff, & Alpert, 2007) and across contexts (Frankish & Linden, 1991). The fight-or-flight response, as described by Cannon (1929), proposed that changes in physiological homeostasis brought about by a stressful encounter serve to prepare the individual for responding to stress. Psychological stress can provoke a level of cardiovascular responding in excess of that which is metabolically necessary to meet the demands of the stressor. The *reactivity hypothesis* proposes that exaggerated cardiovascular reactivity to psychological stress may contribute to the development of cardiovascular disease (Obrist, 1981) and is supported by findings that link

heightened cardiovascular reactivity with adverse cardiac outcomes such as atherosclerosis (e.g., Jennings et al., 2004; Roemmich et al., 2011), hypertension (e.g., Carroll et al., 2012; Chida & Steptoe, 2010), and coronary heart disease (e.g., Schwartz et al., 2003; Treiber et al., 2003).

The reactivity hypothesis is based on the premise that individual patterns of cardiovascular reactivity observed in the laboratory under controlled conditions are representative of individuals' everyday functioning and in addition, that patterns of reactivity to a stressor generalize beyond initial stress exposure to subsequent exposures. Research findings support the ecological validity of laboratory assessed cardiovascular reactivity to stress (Zanstra & Johnston, 2011). However, a number of studies have demonstrated that with repeated exposure to the same or similar stress evoking tasks, cardiovascular responses show adaptation (i.e., habituation, namely *diminished* cardiovascular reactivity to prolonged or repeated stress; or sensitization, namely *increased* cardiovascular reactivity on exposure to ongoing or recurrent stress). Howard and Hughes (2012) reported significant cardiovascular habituation in a sample of healthy female students on successive exposures to cognitive stress (mental arithmetic) in the laboratory. These findings are consistent with other studies reporting different patterns of cardiovascular adaptation to recurring stress (e.g., Hughes & Higgins, 2010; Hughes, Howard, James, & Higgins, 2011; Kelsey, Soderlund, & Arthur, 2004). These findings imply that examination of cardiovascular reactivity to a minimum of two consecutive stress exposures may be warranted in order to obtain a measure of responding that approximates closely with physiological functioning in everyday life.

More recently, it has been proposed that the negative cardiovascular health outcomes associated with elevated cardiovascular reactivity may also be associated with attenuated cardiovascular reactivity. Phillips (2011) and Lovallo (2011) suggest that a pattern of smaller-than-normal reactivity to stress, referred to as a ‘blunted’ response, may also be indicative of impaired regulation of homeostatic balance and increased risk of ill-health. Phillips (2011) reported that low reactivity was associated with elevated levels of depression and obesity. These findings are consistent with those of a number of other studies. Salomon, Clift, Karlsdóttir, and Rottenburg, (2009) reported attenuated cardiovascular reactivity to a stress protocol in a sample of participants with a diagnosis of major depressive disorder as compared to a healthy control group. Similarly, York et al. (2007) reported a negative relationship between depression and cardiovascular reactivity to laboratory induced stress as participants with increased depressive symptomology exhibited reduced cardiovascular reactivity to a stressful speech task. Overall, it is evident that reactions to stress can range from very low to very high with a more “normal” or adaptive response falling within the middle range of responses. Responses that fall at the extremities (high and low) appear to be markers of potential disease risk.

Hemodynamic Variables

Cardiovascular reactivity to stress is typically examined in terms of increases in systolic blood pressure (SBP; arterial pressure at the peak of ventricular contraction), diastolic blood pressure (DBP; arterial pressure measured between ventricular contractions), and heart rate (HR; the number of

full cardiac cycles occurring per minute). Blood pressure levels are regulated by the underlying hemodynamic variables of cardiac output (CO; the volume of blood that is pumped from the heart per minute) and total peripheral resistance (TPR; the overall resistance to blood flow offered by the entire vascular system) whose reciprocal relationship means that an increase in one of the two parameters is generally accompanied by a compensatory decrease in the other parameter. When this occurs, the profiles of responding that occur can be characterised, in their extremes, as either *myocardial* or *vascular*.

A myocardial profile, also termed a *cardiac* profile, is characterized by an increase in CO and a decrease in TPR and is most evident in response to active tasks such as mental arithmetic or anagram tasks. Myocardial responses are said to represent an adaptive coping response to stress (Obrist, 1981). Zanstra, Johnston, & Rasbash, (2010) assessed hemodynamic reactivity before, during, and after an active coping task (i.e., delivering a speech) in a sample of 26 males and obtained participants self-report appraisals of the stressfulness of the task. The findings showed that participants' appraisal of the stressor predicted their hemodynamic response to it. Appraisals of the task as challenging, as opposed to threatening, were accepted as being indicative of an active coping response and were associated with higher CO responding to the task. These findings then support the association between an active coping response to stress and a myocardial hemodynamic response profile.

A vascular hemodynamic profile describes an increase in TPR and a decrease in CO, is evident in response to passive tasks such as the cold pressor task, and represents a more passive response to stress (Gregg, Matyas, & James, 2002). A pattern of responding in which both parameters are seen to increase, or

decrease, at the same time is termed a 'mixed response'. The importance of examining hemodynamic response profiles is evident from the fact that blood pressure responses of a similar magnitude may be accompanied by different patterns of hemodynamic response. In addition, while blood pressure patterns may appear stable, the underlying hemodynamic profile may be significantly altered (James, Douglas Gregg, Matyas, Hughes, & Howard, 2012; Sherwood & Turner, 1993).

Anxiety and Cardiovascular Health

An increasing research literature points to anxiety as a prognostic factor, independent of depression, in the experience of adverse cardiac outcomes in initially healthy individuals (e.g., Roest et al., 2010; Denollet et al., 2009), persons with coronary heart disease (Martens et al., 2010), persons with stable coronary artery disease (Frasure-Smith & Lesperance, 2008), and persons who have experienced myocardial infarction (Roest et al., 2010). Given the established role of attentional bias in exaggerated anxiety responding it is reasonable to assume that threat-related attentional bias will result in individual differences in cardiovascular responses to stress. This in turn implies that attentional bias for threatening stimuli may have important implications for cardiovascular health outcomes.

Individual Differences in Personality

The literature to date shows little consideration of the impact of individual difference variables on the adoption of an attentional bias and on subsequent anxiety responding to stress. The influence of individual differences in personality on responses to an attentional bias manipulation and on subsequent responses to stress offers a potential source of important knowledge that may shed further light on the relationship between attentional bias and anxiety. As discussed above, Taylor et al. (2011) reported that the effect of an attentional bias manipulation for positive information was moderated by individual differences in social anxiety. Evidently then, individual difference variables do exert an influence over the adoption of an attentional bias for information of a particular valence: people do not respond to the manipulation of attentional bias in a uniform manner. Furthermore, research shows that individual differences in personality, particularly in neuroticism, influence cardiovascular responding to stress and can be associated with the experience of anxiety. In a recent review by Smith and MacKenzie (2006), the authors stated that individuals with high neuroticism are at increased risk for the development of anxiety and mood disorders. This suggests a high likelihood that individual differences in personality will be influential in the relationship between attentional bias and anxiety, particularly when anxiety is assessed by means of physiological indices.

Theories of personality vary according to a number of different approaches including the psychoanalytic approach, the behavioural approach, the social cognitive approach, the humanistic approach, and the trait approach (which relates closely to the biological approach). The trait approach to personality proposes that all individuals can be characterized according to broad

dispositions to behave in particular ways. Personality traits are said to be relatively stable and dimensional constructs, which means that while all individuals possess a given personality trait, there are individual differences in the extent to which a personality trait is expressed. The biological underpinnings of personality (i.e., the role of evolution, genetic inheritance, and brain functioning) are emphasized by proponents of the trait approach. Trait theories of personality have been criticized on the grounds that they fail to consider important situational variables that bring about variability in behaviour that is unaccounted for by stable personality traits. In addition, despite the use of factor analysis to establish the basic, fundamental components of personality, researchers have failed to agree on the number of core factors that can be said to account for variability in behaviour (Pervin, Cervone, & John, 2005). These criticisms aside, however, the strengths of the trait approach include the fact that it has resulted in the formulation of scientifically falsifiable hypotheses and the central role that is attributed to biology can be experimentally tested. A further strength of the trait approach has been the development of various psychometric measures of personality that on their own provide a useful means of assessing personality and which in a broader context can be employed in examining the role of personality in psychological and physiological health and well-being.

Biological influences on personality have long been proposed. In the second century, Galen expanded on the work of a fellow Greek physician, Hippocrates, in describing four basic personality types that are determined by bodily fluids or *humors*. This theory proposed that an excess of either of the four humors resulted in the expression of an associated personality type such that an excess of blood produced a *sanguine* personality characterized by energy and

optimism; an excess of yellow bile produced a *choleric* personality characterized by irritability and impulsiveness; an excess of black bile resulted in a *melancholic* personality characterized by depressed mood; and an excess of phlegm resulted in a *phlegmatic* personality characterized by apathy and emotional stability (Cloninger, 2004). Although this model no longer holds weight as an explanatory framework for understanding the basis of personality, its influence on present day biological approaches to personality is evident.

One individual difference variable that is highly likely to be relevant to an investigation of the relationship between attentional bias for threat and the experience of anxiety is neuroticism. Neuroticism is one of the three personality factors in Eysenck's (1981) trait theory of personality, which proposes that individual differences in personality can be captured by three super-factors: namely; neuroticism; extraversion; and psychoticism. This theory is also referred to as the "PEN" theory. Neuroticism also features as one of the five personality dimensions in the "Big Five" trait theory of personality (Costa & McCrae, 1992) which also includes extraversion, openness to experience, agreeableness, and conscientiousness. Opposite ends of the neuroticism continuum are referred to as *emotional stability* and *emotional instability*. Individuals who score high on measures of neuroticism can be characterized as irritable, prone to anxiety, worry, and negative affect, hostile, self-conscious, and vulnerable (Lahey, 2009).

Eysenck (1967) proposed a biological basis to individual differences in personality. According to this view, neuroticism levels are determined by autonomic nervous system reactivity with higher levels of neuroticism indicative of intense autonomic nervous system activity and slow rates of habituation to stress (Barlow, 2002). In addition, Eysenck (1967) proposed that differences in

the neurophysiological functioning of the brain's cortex underlie individual differences in introversion-extraversion. Extraverted individuals tend to experience less cortical arousal than introverted individuals and as a result seek out social experiences that will stimulate cortical arousal levels. For introverts, intense social stimuli result in their becoming over aroused and for this reason they avoid such stimuli. Less is known about the biological basis of psychoticism (Pervin, Cervone, & John, 2005), but research findings suggest that psychoticism is associated with deficits in neuropsychological functioning in the form of diminished inhibition of neural impulses (Corr, 2010). The biological basis of these personality traits points to the likelihood that these variables will have a significant influence on physiological correlates of anxiety responding to stress post-intervention.

The effects of individual differences in personality on cardiovascular reactivity to stress have been examined by Jonaissant et al. (2009). In this study, baseline cardiovascular parameters were assessed and measures of personality were obtained prior to the completion of two stress tasks, one an emotional stress task (anger recall) and the other a cognitive stress task (mental arithmetic), the delivery of which was counterbalanced across participants. The authors hypothesized that reactivity to stress would be associated with participants' levels of neuroticism and extraversion. The findings showed that higher neuroticism was associated with heightened cardiovascular reactivity during the emotional stress task but with decreased reactivity during the mental arithmetic task. Extraversion was associated with decreased reactivity during the emotional stress task.

Hughes et al. (2012) also reported an effect of individual differences on cardiovascular reactivity to stress. In this study participants with high neuroticism showed reduced cardiovascular reactivity to stress consistent with a 'blunted response'. This finding is consistent with those of Chida and Hamer (2008) who conducted a meta-analysis on 729 studies concerned with the associations between psychosocial factors and physical responses to laboratory induced stress, and reported that neuroticism was associated with decreased cardiovascular reactivity and with poor cardiovascular recovery following exposure to stress. These findings point to the importance of taking individual differences in personality into consideration in examining cardiovascular parameters of the stress response following attentional bias intervention.

Schneider (2004) proposed that those high in neuroticism exhibit negative biases in the processing and retrieval of emotionally relevant information. Using a sample of 57 healthy undergraduates, Schneider (2004) examined the influence of personality on the appraisal of an imminent stress task and on responses to the task when it was presented. Participants completed measures of personality and prior to their exposure to the stress task (a serial subtraction stressor task) were asked to appraise how stressful they thought the task would be. The findings indicated that high levels of neuroticism predicted higher threat appraisals and this was related to negative emotional experience, as measured on the Positive and Negative Affect Scale (Watson, Clark, & Tellegen, 1988), and poor task performance. Schneider (2004) concluded that those higher in neuroticism are more vulnerable to experiencing stress when the task is construed as threatening.

Bolger and Zuckerman (1995) examined the influence of personality on exposure and reactivity to stress. They employed a daily diary methodology in

which participants recorded the occurrence of interpersonal conflict, the manner in which they coped with the conflict, and their level of distress each day for a total of fourteen days. Analyses of the results showed that participants with high neuroticism reported greater exposure to, and greater distress following, interpersonal conflict. In addition, based on the findings of a number of studies, Carver and Connor-Smith (2010) stated that neuroticism predicts the tendency to appraise events as highly threatening. Overall these findings suggest that individual differences in neuroticism are highly relevant to an investigation of the impact of attention training towards threatening information on anxiety responding to stress.

An individual differences variable that is also likely to be influential in the relationship between attentional bias for threat-related information and anxiety responding to stress is psychoticism. As mentioned above, psychoticism is one of the three factors in Eysenck's (1981) PEN theory of personality and importantly, is distinct from the clinical condition of psychopathy (Chapman, Chapman, & Kwapil, 1994). The defining characteristics of psychoticism include impulsiveness, stubbornness, lack of empathy and regard for others, lack of conformity, and aggressiveness (Corr, 2010). Such characteristics would suggest that psychoticism is associated both with poor emotional and poor health outcomes through difficulties in social interaction and the adoption of behaviours that negatively impinge on one's health. Ciarrochi and Heaven (2007) examined the impact of psychoticism on the emotional well-being of teenagers using a sample of 660 second level students who completed measures of psychoticism and of positive and negative affect at two time-points that were twelve months apart. The findings showed that at the follow-up time point, psychoticism was

significantly associated with increased hostility, sadness, and fear in females and with decreased joy in males.

The findings of Ciarrochi and Heaven (2007) suggest that individual differences in psychoticism are likely to influence the manner in which individuals engage with, and respond to negative and threatening stimuli in their environments. Evidence supporting the proposal that psychoticism influences responding to threat-related information has been reported by Miskovic and Schmidt (2010). Participants in this study were 38 undergraduate students who completed a measure of psychoticism prior to performing an emotional spatial cueing task which involved identifying the location of a dot that appeared onscreen after an angry, happy or neutral face had been presented. The findings revealed reduced attention to angry faces, as evident from reaction time scores, in participants with high psychoticism but attentional vigilance towards happy and angry faces as compared to neutral faces in participants with low psychoticism. These findings imply that individuals with high psychoticism do not show preferential processing of threat-related stimuli. The authors suggest that this observed absence of a threat-vigilance in those with high psychoticism may be as a consequence of the lack of empathy and regard for social convention that characterize those individuals with high psychoticism.

Main Conclusions and Thesis Outline

With the exception of a small number of studies (MacLeod et al., 2002; Eldar et al., 2008; See et al., 2009), much of the research to date concerned with attentional bias and the experience of anxiety has served to examine associations

between threat-related attentional bias and anxiety without permitting definite conclusions to be reached about the direction of causality of this effect. The present thesis aims to test the hypothesis that preferential processing of threat-related information causally contributes to the experience of exacerbated levels of anxiety when presented with a stressor by implementing an attentional bias intervention prior to the presentation of a stress task in a controlled laboratory setting. Existing investigations of the role of attentional bias in anxiety responses have been reliant on self-report measures of anxiety which are inherently subjective, and thus inferior to more objective indices of anxiety such as physiological measures. With this in mind, each of the three studies reported in this thesis assess anxiety responses to stress by means of both self-report and, more importantly, physiological measures. It was hypothesized that individual differences in anxiety responding to stress after attentional bias manipulation would be discernible on analysis of the physiological indices of anxiety.

A further notable limitation of the existing literature relates to its failure to consider the influence of personality on attentional bias interventions that manipulate the cognitive processing of threat-related information. Individual differences in personality most likely determine the impact and effect of attentional bias manipulation and, in turn, will influence the level of anxiety experienced in response to stress.

Study 1. Does threat-related attentional bias causally contribute to exaggerated anxiety responding to stress as measured physiologically?

Study 1 (Chapter 2) examines the influence of an attentional bias intervention with threat-related stimuli on anxiety responding to a subsequent stressor. It constitutes a partial replication of MacLeod et al. (2002) in that the same dot-probe task was used and a similar protocol was employed (i.e., attentional bias manipulation followed by exposure to a stress task). This study sought to replicate the finding of MacLeod et al. (2002) that attentional bias for threatening stimuli causally contributes to the experience of elevated anxiety responding to stress. However, to address the reliance in the literature to date on subjective self-report measures of anxiety responding, the present study employs an objective (cardiovascular) measure of anxiety responding to stress. The third aim of this study was to assess the influence of individual differences in personality on individuals' responding to attentional bias intervention and in turn to the subsequently presented stress task. Based on the established literature outlined above showing a significant association between neuroticism and cardiovascular reactivity to stress and on findings relating to the appraisal of tasks as more threatening in those with high neuroticism, it was hypothesized that individual differences in neuroticism would be influential in determining physiological anxiety responses to stress following attentional bias manipulation.

Study 2. Assessing anxiety responding to stress following attentional bias manipulation using a face-in-the-crowd task

The use of threatening linguistic stimuli, as employed in Study 1 (Chapter 2) has been questioned by a number of researchers who argue that such stimuli do not approximate closely to the types of threatening stimuli that individuals encounter in their everyday environments. According to this view, the use of facial expressions of threat for the purpose of inducing an attentional bias towards or away from threat confers greater ecological validity. The main aim of Study 2 is to examine anxiety responding to stress following an attentional bias manipulation using the face-in-the-crowd task to overcome the shortcomings associated with linguistic stimuli. The findings of Study 1, that individual differences in neuroticism influenced responding to linguistic representations of threat, help to inform the hypothesis for Study 2. The facial stimuli employed in Study 2 are likely to communicate threat more readily than linguistic stimuli, thus eliciting a more visceral response. Individual differences in psychoticism, characterized by varying degrees of impulsivity are, in this case more likely to exert an influence on responding to such stimuli and in turn affect individuals' responding to subsequent stress. Therefore, it was hypothesized in Study 2 that individual differences in psychoticism exert the greatest influence on how individuals respond physiologically to stress tasks.

Study 3. Examination of anxiety responding to stress following attentional bias manipulation using a dot-probe task with facial stimuli

Study 3 (Chapter 4) replicates the methodology of Study 1 but with one modification: the linguistic stimuli used in the dot-probe task are replaced with facial stimuli based on the face-in-the-crowd paradigm, such that the threatening linguistic stimuli are replaced with ‘angry’ faces and the neutral linguistic stimuli replaced with ‘happy’ faces. In effect, Study 3 captures the core elements of both Studies 1 and 2 (i.e., the dot-probe task methodology from Study 1 and the photorealistic facial stimuli as employed in Study 2). This permitted examination of whether it was the nature of the stimuli used (i.e., linguistic stimuli or facial stimuli) that drives the effects observed in Studies 1 and 2. An important difference between the dot-probe task employed in Study 1 and the face-in-the-crowd task employed in Study 2 relates to the way in which attention is directed towards the threatening stimuli (i.e., the type of instructions delivered prior to commencing each task). Prior to commencing the dot-probe task, participants are instructed to attend to the probe appearing onscreen so as to identify whether it was composed of one single dot or two dots with no instruction given in relation to the negative and neutral linguistic stimuli that preceded the probe on each trial. It is expected that the training contingency whereby the probe always followed the negative stimulus in the negative training group and the neutral stimulus in the anti-negative training group serve to induce an attentional bias. In contrast, in the face-in-the-crowd task, participants are specifically instructed to identify the discrepant emotional facial expression, thereby directing their attention towards the pertinent emotional expression on each trial. Study 3 permits consideration of whether the way in which the attentional bias intervention is delivered (i.e., with

or without specific instruction to attend to the threatening stimulus) is influential in the impact of the attentional bias manipulation.

Chapter 2: STUDY 1

INDIVIDUAL DIFFERENCES IN THE IMPACT OF ATTENTIONAL BIAS TRAINING ON CARDIOVASCULAR RESPONSES TO STRESS IN WOMEN¹

Proponents of cognitive approaches to anxiety suggest that the way in which we attend to, interpret and process information in our environment directly influences our experience of anxiety. According to this perspective, the practice of allocating attentional resources to negatively toned stimuli can serve to exacerbate anxiety levels when faced with a stressful situation. As described above, this tendency to allocate attentional resources to stimuli that are perceived as negative or threatening is termed attentional bias (MacLeod et al., 2002). It describes a consistent pattern of selectively attending to negative information and a difficulty in ignoring it. A growing body of research indicates that individuals exhibiting a negative attentional bias respond with greater anxiety to a stressor than those who do not exhibit such a bias. The adoption of a negative attentional bias can also serve to maintain this level of heightened arousal as the individual fails to attend to information that indicates the absence of threat (Mobini & Grant, 2007).

¹ This chapter has been published with minor editorial modifications: Higgins, N. M., & Hughes, B. M. (2012). Individual differences in the impact of attentional bias training on cardiovascular responses to stress in women. *Anxiety, Stress & Coping*, 25, 381-395.

The relationship between attentional bias and anxiety has typically been examined using the dot-probe task devised by MacLeod et al. (1986) or a variation of the original Stroop task (Stroop, 1935). The dot-probe task provides a means of experimentally manipulating attentional bias and thus allows for the testing of hypotheses concerning the direction of the cause and effect relationship between attentional bias and anxiety. Using the dot-probe task, researchers have established that the nature of the relationship between attentional bias and anxiety is such that the adoption of a negative attentional bias is a causal factor in the experience of anxiety. MacLeod et al. (2002) presented the dot-probe task in two studies in which they examined the impact of attentional bias training on participants' subsequent response to an anagram stress task, as indicated on analogue mood scales. The results of both studies indicated that participants in the negative training group demonstrated an elevation in negative mood state in response to the stressor while participants who were trained to direct their attention away from negative stimuli (anti-negative group) showed no increase in negative mood state following exposure to the stressor.

A similar line of research has examined the effectiveness of interventions designed to direct attention away from negative stimuli in reducing anxiety. Amir et al. (2009) implemented an attention modification program using a version of the dot-probe task. Participants in this study met the diagnostic criteria for generalized anxiety disorder and were randomly assigned to the attention modification group in which the probe always followed the neutral word or the attentional control group in which the probe appeared in the location of the neutral and negative words with equal frequency. Post-intervention assessments of both groups revealed that participants in the attention modification program,

whose attention was consistently directed towards the location of the neutral word, were less anxious than at the pre-training assessment point and showed less bias for threat. Participants in the control group showed no reduction in their pre-training attentional bias or anxiety levels. These findings are consistent with those of a similar study by See et al. (2009) in which the authors assessed the impact of attentional bias manipulation on anxiety to a real life stressor (i.e., emigrating to another country to attend university).

The research findings discussed thus far successfully illustrate that the allocation of attention to threatening or negative stimuli is associated with greater anxiety on exposure to stress. It can be noted that such research relies mostly on subjective measures of anxiety. As is evident from the studies discussed above, a variety of methods including psychometric measures have been used to assess anxiety in this area of research. Considered in isolation, self-report measures of anxiety fail to completely capture the extent of an individual's anxiety response. Researchers are reliant on the individual's honesty and their ability both to recognise and express how it is they are feeling. On the other hand, physiological measures such as blood pressure and heart rate provide objective correlates of anxiety that minimize the effects of response bias and social desirability, and that can detect changes in individual responding which the individual themselves may be unwilling to report or are possibly even unaware of.

Physiological correlates of anxiety may shed light on individual differences in anxiety responding that are inaccessible to self-report measures and would otherwise go undetected. Furthermore, they serve to broaden our understanding of the psychosomatic consequences of exaggerated anxiety responding to stress and add to the already large and established literature on

cardiovascular responses to stress. The cardiovascular system has been demonstrated to be particularly responsive to psychological stress such that elevations in response are proportionate to perceptions of stress (Turner, 1994). In this context, the term *cardiovascular reactivity*, as described by Treiber et al. (2003), refers to the magnitude of one's cardiovascular responses (blood pressure and heart rate) to stress. According to the reactivity hypothesis, cardiovascular reactivity is an important risk factor in the development of cardiovascular disease (Obrist, 1981). Research findings posit a link between cardiovascular reactivity that is exaggerated or prolonged and the development of cardiovascular disease (Schwartz et al., 2003). Elevated heart rate and blood pressure in response to stress can bring about changes to both the heart's structure and to its functioning leading to hypertension (Philips & Hughes, 2011). Identification of the factors that influence cardiovascular reactivity is of importance in understanding the ways in which stress contributes to pathological cardiovascular states.

The extent to which individual differences in personality influence the adoption and the use of attentional biases remains largely unexplored in previous research. Neuroticism is one individual difference variable that warrants consideration in this context due to its established links with anxiety, cardiovascular reactivity and negative health outcomes (e.g. Smith & MacKenzie, 2006; Hughes et al., 2011). Specifically, neuroticism predicts differences in the degree to which people become physiologically aroused by stress. Jonaissant et al. (2009) report that individuals with high neuroticism respond with less cardiovascular reactivity to non-emotional, cognitive stress tasks than to an anger recall task that served to arouse emotion. Such findings

underline the need to examine the role of personality variables in pathways linking stress and health.

The present study sought to address the current absence of research concerning the impact of attentional bias on physiological responding to stress. Blood pressure and heart rate were assessed before and after attentional bias intervention and during exposure to a stressful task. Given the well documented finding that attentional bias is related to an increased anxiety response to stress, it was predicted that greater cardiovascular reactivity to stress would be evident in those trained to attend to negative stimuli as compared to those trained to direct their attention away from negative stimuli. In addition, this study sought to examine the extent to which individual differences, especially neuroticism, affect attentional bias manipulation and subsequent responses to stress in terms of both cardiovascular reactivity and self-report anxiety. Specifically, it was predicted that people who differ in neuroticism would differ in anxiety provoked by attentional bias.

Method

Participants

77 female undergraduate psychology students (mean age = 21.94 years; $SD = 6.96$) with normal BMI ($M = 21.78$, $SD = 2.62$) took part in the experiment. Published norms demonstrate that general population blood pressure levels increase across the lifespan to a statistically significant degree (Hart, Joyner, Wallin, & Charkoudin, 2012). To maximize the validity of cardiovascular measurements and ensure that all data was comparable it was decided to limit the

study to participants of a specific age group. Participants over 32 years of age in this study were natural outliers and therefore the cut-off was determined on this basis. Participants were included in the study if they were aged 32 years or less, were normotensive at baseline, and reported no history of heart trouble or hypertension.

Recruitment of participants was via classroom announcements and course credit was awarded for participation. Participation was voluntary and participants were free to withdraw at any time. All participants signed a consent form prior to participation (Appendix A). Due to the highly imbalanced gender distribution in the undergraduate psychology population and research suggesting gender differences in blood pressure (Hughes & Higgins, 2010; Turner, 1994), only female participants were included in the study. Smokers were included ($n = 15$) as were oral contraceptive users ($n = 17$; 5 of whom were also smokers). While it has been reported that no difference in cardiovascular reactivity exists between smokers and non-smokers (e.g., Ward, Swan, Jack, & Javitz, 1994), more recent research has reported that smoking status may have an important impact on stress tolerance (e.g., Hughes & Higgins, 2010; Phillips, Der, Hunt, & Carroll, 2009). The influence of oral contraceptive use on cardiovascular reactivity though acknowledged has been dismissed as grounds for exclusion of participants in such research (Schallmayer & Hughes, 2010). In the present sample there was no difference in mean SBP, DBP or HR at either of the three time-points tested (baseline, post-intervention and stress) for smokers and non-smokers or for oral contraceptive users and non-users.

Participants were randomly allocated to one of two experimental groups which resulted in a negative training group of 39 participants and an anti-

negative training group of 38 participants. In the negative training group participants completed training designed to induce an attentional bias toward negative information. Participants in the anti-negative training group were presented with training designed to induce an attentional bias away from negative information. Such a sample size is comparable to those of previous studies examining attentional variables (e.g., MacLeod et al., 2002) and so was deemed likely to be appropriate to the effects under scrutiny in the present study. Group-sizes of 30 provide sufficient statistical power to detect medium-to-large group differences with between 61% and 92% power in two-group designs. Blocking these cells for the purposes of including further factors creates a cell-size of approximately $n = 15$, which is sufficient to detect large effects in 2×2 designs with 80% power.

Experimental Tasks

Dot-probe task. The dot-probe task used in this study was based on that used by MacLeod et al. (2002), and the set of 96 stimulus word pairs used in this study, were those devised by MacLeod et al. (2002). Each word pair consisted of a word with negative connotations and a neutral word (see Appendix B). The authors note that the 96 word pairs were selected from an initial pool of 140 word pairs by 12 final year psychology student judges who rated the words on a 9-point scale (1 = very negative, 5 = neutral, 9 = very positive). Each word pair was matched both for letter length and frequency of usage. Examples of word pairs used include *dead* and *data*, *hopeless* and *feathers*, *terror* and *pupils*. As per MacLeod et al. (2002), the set of 96 word pairs were divided into two subsets of

48 word pairs (subset A and subset B) and each participant was presented with only one of the subsets for the attentional training trials. The second subset was presented in the attentional test trials (i.e., participants who were exposed to subset A in the attentional training trials, were presented with subset B for the attentional test trials and vice versa). Whether participants received subset A or B for their attentional training trials was determined on a random basis.

In the present study, the dot-probe task involved completion of 384 trials. This represents a 50% reduction in the number of trials used by MacLeod et al. (2002) and was chosen in order to facilitate cardiovascular monitoring across the experiment as a whole. The trials were presented as follows: 48 pre-training trials, 288 training trials and 48 post-training trials. For the 48 pre-training trials, all 48 word pairs in the subset appeared once with the probe appearing in the location of the negative word on 24 trials and that of the neutral word on 24 trials. The negative and neutral words within a subset that were followed by the probe were selected randomly. The purpose of the 48 pre-training trials and the 48 post-training trials was to assess the effectiveness of the dot-probe procedure in attention modification. The dot-probe procedure is deemed to have successfully induced an attentional bias when participants show faster probe reaction times at post-training to stimuli that are consistent with those presented in training (i.e., when participants in the negative intervention group show faster response times to probes appearing in the prior location of negative stimuli on post-training trials).

For the attentional training trials (of which there were 288), each word pair in the subset appeared in quasi-random order. All word pairs in the subset had to have appeared once before any word pair was repeated, all had to have

appeared a second time before being presented a third time etc. In effect, the subset was presented six times with each word pair appearing an equal number of times. As mentioned, the location in which the probe appeared was dependent on training group such that the probe always appeared in the location in which the negative word had been presented for participants in the negative training group and in the location in which the neutral word had been presented for participants in the anti-negative training group. The post-training trials were presented in exactly the same manner as the pre-training trials with the only difference being that the alternative subset was used.

The dot-probe task took 19 minutes to complete. The words “NEXT TRIAL” were presented in the centre of the computer screen for 500 ms at the beginning of each trial and served to focus attention on that part of the screen. The two members of a word pair were presented immediately following the “NEXT TRIAL” signal, with one of the words appearing above the location of the preceding “NEXT TRIAL” and one appearing below this location. The vertical distance between the two words was 3 cm. For each trial, there was an equal probability of the negative word being presented in either the upper or lower location on screen. The word pairs remained on screen for 500 ms and were immediately followed by the presentation of a probe. The probe was either a single dot (105 pixels) or two adjacent dots (each dot 105 pixels), determined at random. Participants were instructed to press the left mouse key if the probe was a single dot and the right mouse key if the probe was two adjacent dots. For each trial, participants had 1,500 ms to make a response and a time bar at the bottom of the screen indicated the amount of time remaining for that trial. Participants were informed that only their first response would be recorded on each trial and

that the program would only move on to the next trial once the allowed time for the current trial had elapsed. Feedback was not provided for any of the trials (i.e., pre-training, training or post-training trials). Participants' response times and the accuracy of their response were recorded. If a response was not detected in the allowed time, the program moved on to the next trial and an 'incorrect' response was recorded for that trial. The inclusion of a time limit for completion of each trial represented a deviation from the method used by MacLeod et al. (2002). It was introduced to standardize the time taken to complete the task and therefore to control for any effect that differences in time spent completing the dot-probe task might have on subsequent cardiovascular reactivity indices.

Speech performance task. Participants were presented with a set of 28 cards, each of which had a word printed on it and which were arranged in a random order by shuffling them. The participant was instructed to talk about the word on the first card for as long as they could, saying whatever came to mind and only moving on to the next card when they could think of nothing further to say. This procedure was repeated with each card for the duration of the 6-minute task. Participants were instructed to speak into the microphone, which was set up on the desk in front of them, and were informed that their performance was being recorded and would be evaluated at a later date. The words selected for use in this task were those used by Hughes and Callinan (2007), and so were standardized for word frequency and phonological length (see Appendix C). It was intended that the words prompt discussion on a wide range of topics. Examples of the words included *doctor*, *evening*, *funny*, and *poetry*. This procedure has been shown in previous studies to reliably precipitate increases in

cardiovascular parameters, including heart rate, in healthy adults (Hughes & Callinan, 2007).

Cardiovascular Measures

SBP, DBP, and HR were measured using a Dinamap Pro100 Vital Signs Monitor (GE Medical Systems, Tampa, Florida). Participants were seated at a desk in front of a computer throughout the procedure and the Dinamap was operated remotely by a female researcher seated in an adjacent room.

Psychometric Measures

Revised Eysenck Personality Questionnaire. Personality was assessed using the Revised Eysenck Personality Questionnaire (EPQ-R; Eysenck and Eysenck, 1991). The EPQ-R is founded on the theory that the personality constructs of neuroticism, extraversion and psychoticism can be attributed to inherent differences in biological functioning. Given the physiological focus of the present research, the EPQ-R was deemed most appropriate to the research questions under investigation. The scale consists of subscales measuring psychoticism, extraversion, and neuroticism, and a lie scale that amount to a total of 100 items with a yes- no response format. The neuroticism subscale consists of 24 items producing subscores ranging from 0 to 24, the extraversion subscale comprises 23 items which produce subscores ranging from 0 to 23, and the psychoticism subscale consists of 32 items producing subscores ranging from 0 to 32. Cronbach's alphas in the present sample for extraversion (.84) and for neuroticism (.81) were satisfactory. Scores on the extraversion and neuroticism

scales typically demonstrate adequate reliability (Caruso, Witkiewitz, Belcourt-Dittloff, & Gottleib, 2001). The manual of the EPQ-R reports that the reliability of the psychoticism subscale is low (Cronbach's $\alpha = .78$ for males and $.76$ for females). Caruso et al.'s reliability generalization study also reported that scores on the psychoticism subscale often have poor reliability. Cronbach's alpha for the psychoticism scale in the present sample was $.65$.

State-Trait Anxiety Inventory. Trait and state anxiety were assessed using the State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983). Both the state and trait scales consist of 20 items to which the participant responds on a four point Likert scale ranging from *almost never* to *almost always*. The STAI is one of the most widely used psychometric measures and has demonstrated good reliability and internal consistency. In the present sample, Cronbach's $\alpha = .92$ for the STAI state version and Cronbach's $\alpha = .83$ for the STAI trait version.

Procedure

All testing took place in the same laboratory at the participants' university. On arrival at the laboratory, the participant was seated at a desk with a computer and some writing space, and the blood pressure cuff was attached to their non-dominant arm. Participants completed a demographic questionnaire and the STAI trait scale (Spielberger et al., 1983) and then relaxed for a 20-minute period. Magazines were provided to facilitate relaxation and the establishment of cardiovascular baselines. This 20-minute resting period was followed by a further 6-minute baseline period in which formal baseline measures were assessed. Participants were then directed to the computer screen where

instructions for completing the dot-probe task were displayed. The computer task was followed by a 6-minute resting period during which cardiovascular measures were recorded. Participants then received instructions for completing the speech task during which cardiovascular responding was also measured. In each instance, cardiovascular measures were taken three times, at equal intervals (specifically at 30 seconds, 2 minutes 30 seconds, and 4 minutes 30 seconds). On completion of the speech task participants completed the STAI state scale and were then given a questionnaire pack containing further psychometric measures to complete outside the laboratory and return to the experimenter.

Results

Overview of Analyses

Mean levels of each cardiovascular parameter (SBP, DBP, and HR) were calculated as the arithmetic mean of the three readings for each phase (baseline, post-intervention and stress). Internal reliability consistency for each measure was good ($\alpha > .84$ for each SBP mean, $\alpha > .79$ for each DBP mean, $\alpha > .86$ for each HR mean). In order to test the hypothesis that attentional bias manipulation would induce different patterns of anxiety-related blood pressure responses to stress, while taking account of individual differences in personality, a $2 \times 3 \times 1$ mixed factorial analysis of covariance (ANCOVA) was carried out for each of the three cardiovascular variables. It should be noted that multiple ANCOVAs were deemed the most appropriate test of this hypothesis as the assumptions of MANCOVA concerning high cross-correlations among the dependent variables were not met. The between-subjects factor was group with two levels (negative

training group and anti-negative training group) and the within-subjects factor was time with three levels (baseline, post- intervention, and stress). Neuroticism was entered as the covariate in the first ANCOVA conducted in order to assess whether or not it affected the patterns of anxiety induced blood pressure responses to stress and a second ANCOVA was then conducted with psychoticism as the covariate to determine its effect on anxiety responses to stress. As the three levels of the within-subjects factor (time) were predicted to be associated with shifts in cardiovascular function, particular attention was paid to quadratic-level within-subjects contrasts when assessing main effects and interactions involving time. The effect under scrutiny spanned three time-points from baseline, to post-intervention, to the stress phase therefore logically necessitating the investigation of the quadratic level effects.

A $2 \times 2 \times 1$ mixed factorial ANCOVA was carried out to examine the effects of attentional bias manipulation on self-report anxiety. The between-subjects factor was group with two levels (negative training group and anti-negative training group) and the within-subjects factor was time with two levels (trait anxiety reported at baseline and state anxiety reported on completion of the stress task). Again, neuroticism was entered as a covariate in the first instance and this analysis was then repeated with psychoticism entered as the covariate.

Effect sizes are presented as partial η^2 for ANOVA effects, with values of .04, .25, and .64 being taken as representing small, medium, and large effect sizes, respectively (Cohen, 1988a, 1992). Partial η^2 , rather than simple η^2 , is recommended for ANOVA designs with multiple independent variables, as simple η^2 contains systematic variance attributable to other effects and interactions (Tabachnick & Fidell, 2007).

Demographics

Data from thirteen participants were excluded due to equipment failure ($n = 3$), outliers in terms of age ($n = 7$) and self-report history of heart trouble or hypertension ($n = 3$). The remaining 64 participants consisted of 30 participants in the negative training group and 34 participants in the anti-negative training group.

Descriptive Statistics

One-way ANOVAs showed that the experimental groups did not differ on baseline cardiovascular measures or on psychometric measures. Means and standard deviations for psychometric measures are presented in Table 1 and for cardiovascular measures at each assessment point and are presented in Table 2.

Table 1

Mean (and standard deviation) psychometric measures for each experimental group

Measure	Negative training group		Anti-negative training group	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Trait anxiety	1.00	.33	1.08	.38
State anxiety	1.05	.59	.94	.43
Neuroticism	.61	.19	.57	.19
Psychoticism	.21	.11	.21	.11

Table 2

Mean (and standard deviation) cardiovascular measures across the experiment for each experimental group

Measure	Negative training group						Anti-negative training group					
	Baseline		Post-intervention		Stress		Baseline		Post-intervention		Stress	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
SBP (mmHg)	106.39	8.46	105.24	9.35	111.92	10.46	107.09	8.26	106.3	8.15	113.09	11.70
DBP (mmHg)	65.66	4.85	65.32	5.96	72.02	6.99	63.31	6.41	64.75	5.75	71.13	7.46
HR (bpm)	73.44	10.15	72.45	9.87	80.77	10.61	73.80	8.73	72.47	10.51	82.17	12.10

Cardiovascular Response Patterns and Neuroticism

For SBP, the ANCOVA revealed a significant main effect for time, $F(1,60) = 6.62, p = .013, \eta^2 = .10$. SBP was higher for both groups during the stress phase of the experiment ($M = 112.54, SD = 11.06$) than it was at baseline ($M = 106.64, SD = 8.46$). There was a significant group \times time \times neuroticism interaction effect at the quadratic level, $F(1,60) = 4.49, p = .038, \text{partial } \eta^2 = .07$. The effect can be illustrated by subdividing the participants into groups based on a median-split of neuroticism scores. SBP responses for participants with high and low neuroticism in both the negative and the anti-negative training group are presented in Figure 1. Overall, it is evident that participants with high neuroticism scores in comparison to participants with low neuroticism scores exhibited lesser blood pressure reactions across time. In fact, the effects were such that opposite patterns of SBP responses were observed for participants at opposing ends of the neuroticism continuum. This significant interaction confirms specifically that patterns of SBP over time differed across groups depending on participants' neuroticism scores. In other words, neuroticism scores significantly predict group-specific reactions in SBP.

As can be seen from Figure 1, participants with high neuroticism scores in the negative training group experienced a suppressed dip in SBP following the intervention, followed by a more pronounced response to stress. Participants with high neuroticism scores in the anti-negative training group demonstrated a normal pattern of SBP responding (i.e., a dip following the training intervention and a rise in response to the stressor). The opposite pattern is true for emotionally stable participants. When exposed to the negative intervention, these participants showed a similar response to their neurotic counterparts exposed to the anti-

negative intervention (i.e., a dip in SBP post-intervention and a normal increase in SBP in response to stress). Correspondingly, emotionally stable participants in the anti-negative training group showed a stable SBP response to the intervention and higher reactivity to stress. In summary, the effects for neuroticism were such that high and low neurotic participants exhibited exactly opposite effects on SBP responses, as can be inferred from Figure 1.

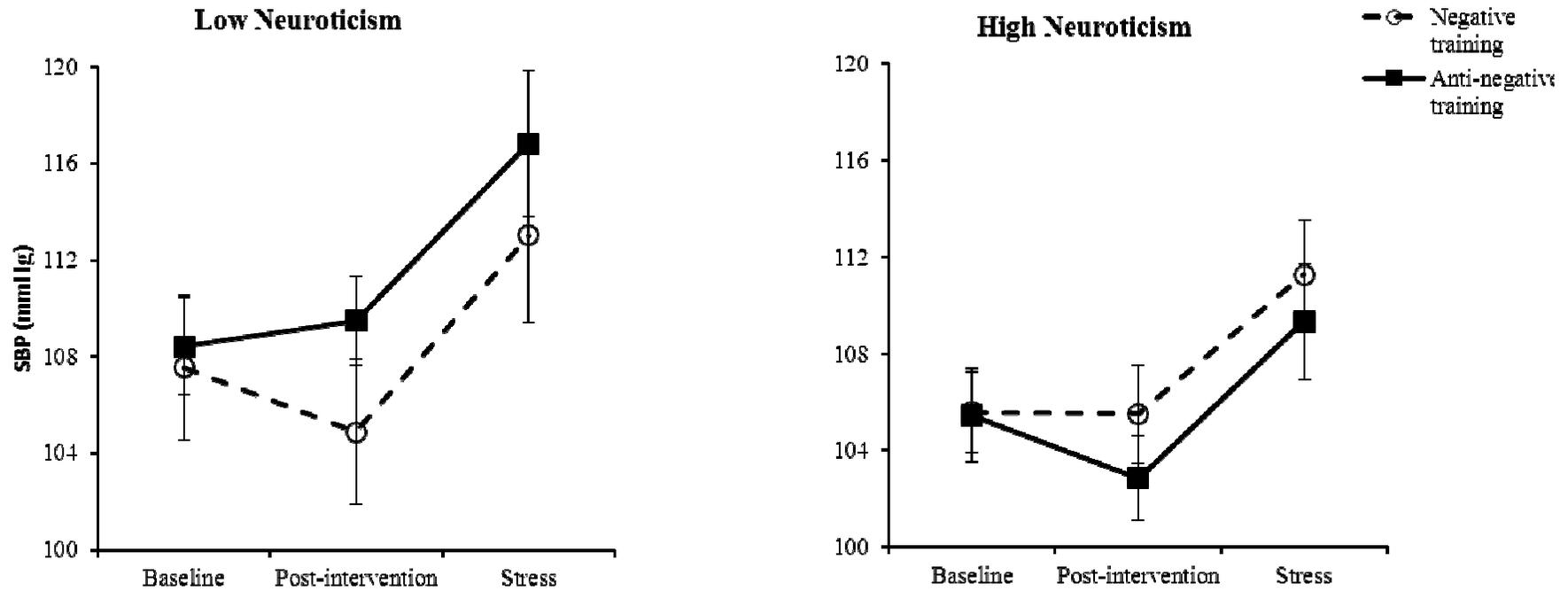


Figure 1. Time \times group \times neuroticism interaction for SBP for participants with low neuroticism (left) and high neuroticism (right). Error bars denote standard errors of the mean

For DBP, the ANCOVA showed a significant main effect for time $F(1,60) = 15.50, p < .01, \eta^2 = .21$, such that DBP increased in response to the stress task. There were no other significant main or interaction effects for DBP. For HR, the ANCOVA showed a significant time \times neuroticism interaction at the linear level $F(1,60) = 4.15, p = .046, \eta^2 = .07$. This interaction effect is demonstrated in Figure 2 in which a median-split of neuroticism was used to illustrate the effect. Post-hoc t -tests showed that participants with low neuroticism exhibited a significantly higher HR response to stress than participants with high neuroticism.

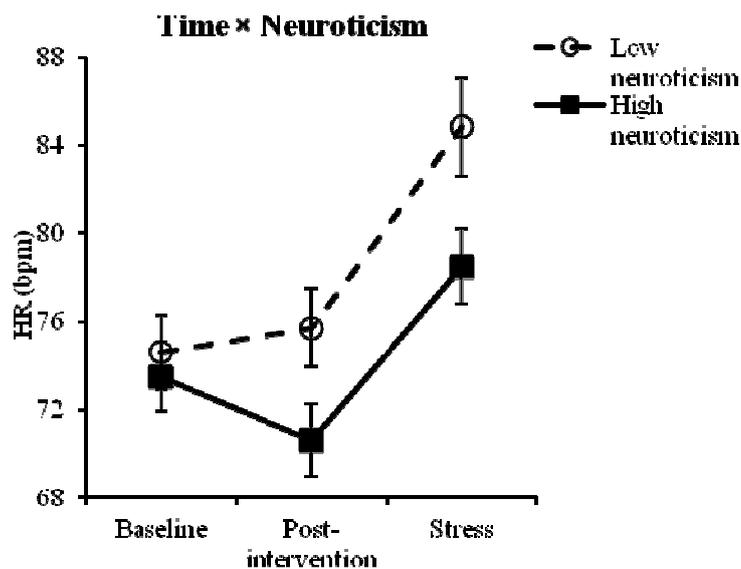


Figure 2. Time \times neuroticism interaction for heart rate illustrated with a median split of neuroticism. Error bars denote standard errors of the mean

Cardiovascular Response Patterns and Psychoticism

The 2 (group; negative training and anti-negative training) \times 3 (time; baseline, post-intervention, and stress) \times 1 (psychoticism) mixed factorial ANCOVA carried out for SBP revealed a significant main effect of time $F(1.50, 89.72) = 8.52, p = .001, \text{partial } \eta^2 = .12$ and a significant time \times group interaction at the quadratic level $F(1, 60) = 5.12, p = .027, \text{partial } \eta^2 = .08$. There was a significant time \times group \times psychoticism interaction at the quadratic level $F(1, 60) = 6.47, p = .014, \text{partial } \eta^2 = .10$. This effect was illustrated by subdividing the sample based on a median-split of psychoticism scores. As is evident from Figure 3, participants with high psychoticism who were exposed to the negative training intervention showed greater reactivity to the post-intervention stress task than participants with low psychoticism. In contrast, greatest reactivity to the post-intervention stress task following the anti-negative training intervention was evident for participants with low psychoticism.

The ANCOVA carried out for DBP showed a significant main effect for time $F(1.62, 97.41) = 26.03, p < .01, \text{partial } \eta^2 = .30$. There were no other significant main or interaction effects for DBP. The equivalent ANCOVA conducted for HR revealed a significant main effect for time $F(1.76, 105.77) = 12.04, p < .01, \text{partial } \eta^2 = .17$. There were no other significant main or interaction effects for HR.

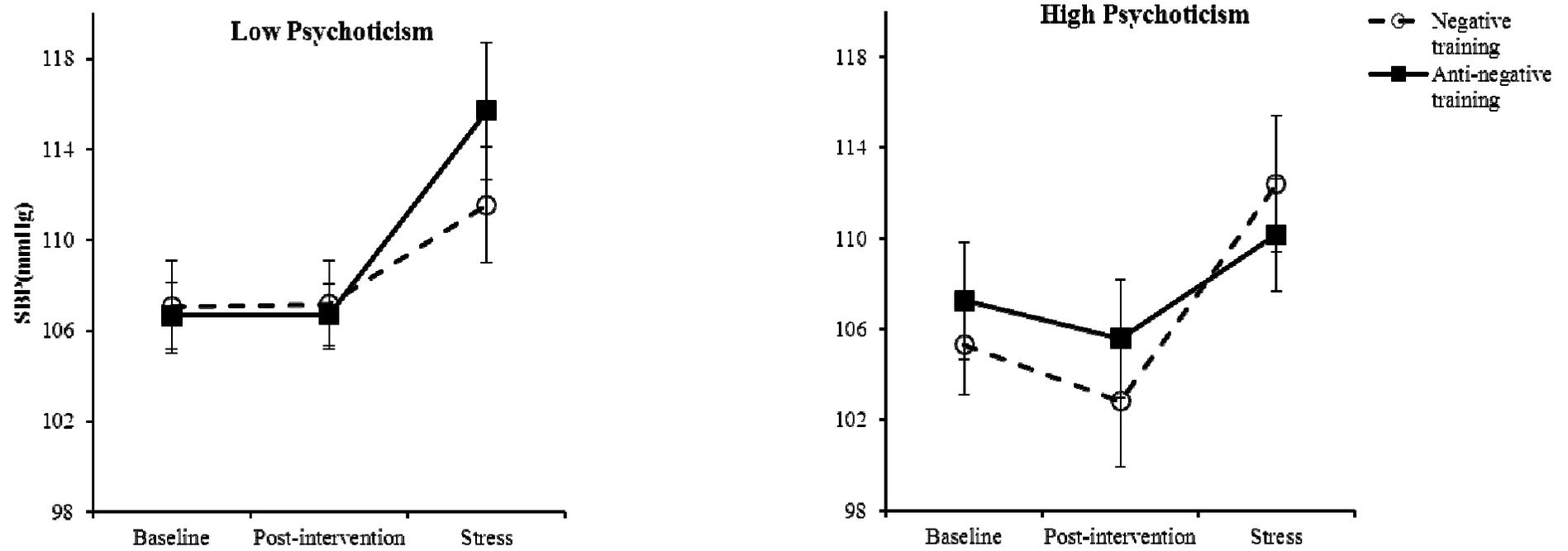


Figure 3. Time \times group \times psychoticism interaction for SBP for participants with low psychoticism (left) and high psychoticism (right). Error bars denote standard errors of the mean

Reaction Time

Observed differences in cardiovascular profiles may reflect differences in participants' behavioural interaction with the training procedures, such as the speed with which they responded to the stimuli. Median discrimination latencies for each participant for pre-training test trials and post-training trials were calculated. As per MacLeod et al. (2002), median discrimination latencies were used so as to minimize the influence of outlying data points. The resulting latencies, averaged across the participants in each group are presented in Table 3.

Table 3

Mean and (standard deviation) reaction time in seconds for pre-training and post-training trials

	Negative training group		Anti-negative training group	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Pre-training trials				
Negative	.57	.12	.56	.08
Anti-negative	.57	.10	.56	.08
Post-training trials				
Negative	.53	.09	.55	.09
Anti-negative	.53	.09	.53	.08

To examine the effectiveness of the dot-probe task in inducing a between-group difference in reaction times to negative information, a 2 (time: pre-

training, post-training) \times 2 (experimental group: negative training group, anti-negative training group) mixed factorial ANOVA was conducted. This revealed a significant main effect of time $F(1, 56) = 4.74, p = .034, \text{partial } \eta^2 = .08$ such that participants overall were faster to respond to post-training trials ($M = .54, SD = .09$) than to pre-training trials ($M = .56, SD = .10$). The time \times group interaction effect was not significant indicating that participants exposed to the negative training intervention were no faster in responding to negative post-training trials than were participants in the anti-negative training group. A similar ANOVA was also conducted for anti-negative trials to examine whether those in the anti-negative training intervention were faster to respond to neutral words presented post-training than those in the negative training group. Again, there was a significant main effect for time $F(1,56) = 9.56, p = .003 \text{ partial } \eta^2 = .15$ such that participants overall were faster to respond to post-training trials ($M = .53, SD = .08$) than to pre-training trials ($M = .57, SD = .09$). The time \times group interaction effect was not significant. A series of follow-up ANCOVAs were conducted to examine whether controlling for reaction time impacted upon the pattern of statistical results observed for cardiovascular variables. Controlling for reaction time (either for negative and anti-negative trials separately, or both together) did not alter the pattern of significant findings reported above.

Self-report Anxiety

The 2 (time: trait anxiety reported at baseline, state anxiety reported in response to stress) \times 2 (experimental group: negative training group, anti-negative training group) ANOVA carried out to examine between-group differences in self-report anxiety to stress revealed no significant main or interaction effects. A 2 \times 2 \times 1 mixed factorial ANCOVA carried out to examine the effect of the attentional bias manipulation on self-report anxiety with neuroticism entered as a covariate showed a significant main effect for neuroticism $F(1,63) = 36.49, p < .001, \eta^2 = .37$. There were no other main or interaction effects, although the time \times group \times neuroticism interaction did approach significance $F(1,63) = 3.58, p = .063, \eta^2 = .05$. The inclusion of psychoticism as covariate in this analysis did not yield any significant main or interaction effects.

Discussion

The current findings are consistent with the suggestion that manipulating attentional bias has an impact on an individual's response to stress, although the precise nature of this impact is contingent on the individual's personality. Attentional bias training did not significantly influence cardiovascular parameters in the sample overall. However, when high- and low-neuroticism participants were examined as separate groups, attentional bias training influenced their subsequent cardiovascular stress responses in different ways. Equally, when individual differences in psychoticism were considered, there

were significant differences in physiological responding to the post-intervention stress task for those with high relative to low psychoticism.

The present study extends our understanding of the impact of attentional bias training by examining physiological indices of pertinent outcomes, as distinct from self-report indices as investigated in previous research (e.g. MacLeod et al., 2002). This use of physiological outcome variables is a key strength of the present study, as such measures help avoid the emergence of demand characteristics that arise when participants are influenced by their perceptions of the experimental procedures. The finding of a statistically significant group \times time \times neuroticism interaction showed that, as might have been expected, individual differences in neuroticism influence the extent to which attentional bias training affects the (physiological) experience of anxiety. The finding of a similar group \times time \times psychoticism interaction strengthens the argument for examining the role of individual differences in personality in this effect. In summary, these findings highlight the fact that both individual differences and physiological variables are particularly revealing in illustrating these types of effects. For example, the use of physiological correlates in combination with self-report measures facilitates consideration of whether the findings result from mood-induction rather than attentional-biasing. Given that self-report anxiety did not differ across groups, it appears that mood-induction effects were not driving change in physiological outcomes.

The observation of significantly greater SBP responding in individuals exposed to attentional bias manipulation prior to a stressor was, in this study, highly contingent on individual differences in neuroticism and in psychoticism. This finding highlights the value, in terms of additional knowledge and

understanding, of taking into account the role of individual temperaments both in cognitive processes and in physiological reactions. It was observed that individuals with high neuroticism scores fared worse on exposure to the negative intervention than to the anti-negative intervention. Individuals in whom the neuroticism personality trait is manifested are generally more prone to negative emotion (Suls & Martin, 2005) and are characterized by a greater propensity towards anxiety. Therefore the effect whereby the negative intervention impeded normal adjustment to the attentional bias training might be expected. In addition, it is likely that the negative training served to exaggerate the stress response of neurotic individuals to the stressor as it reinforced their tendency to focus on negative stimuli.

The findings revealed that for emotionally stable participants the anti-negative intervention was associated with disrupted coping and exaggerated stress responding. In this instance, it is reasonable to suggest that the anti-negative intervention, in directing attention away from negative stimuli, represented poor immediate preparation for coping with an aversive stress task that would likely elicit negative emotional responses. Emotionally stable individuals by their nature tend to be less prone to negative emotions and anxiety. While one might expect that emotionally stable people might find the performance of a stress task less stressful because of their emotional stability, past studies of neuroticism have repeatedly shown that the opposite is in fact the case (e.g., Hughes et al., 2012). Suls and Martin (2005) argue that individuals with different temperaments will create different environments and stressors for themselves. In contrast to individuals with high levels of neuroticism who are highly sensitive to negative events and who assign a negative valence to all

problems (Suls & Martin, 2005), emotionally stable individuals would generally be less likely to find themselves in anxiety-provoking situations or interactions. In turn emotionally stable individuals would be less practiced in dealing with stressful situations and so may find laboratory stressors more uncomfortable than neurotic people who are typically quite familiar with encountering stress. It would appear that the anti-negative intervention impeded normal adjustment to training for emotionally stable participants and increased their stress response. In summary, the findings suggest that the negative and anti-negative interventions exacerbated the adverse aspects of neuroticism and emotional stability, respectively.

This is consistent with the view that moderate intensities of such personality traits are more adaptive than extremes (either high or low). For example, extreme neuroticism and extreme emotional stability each carry disadvantages in terms of flexible adaptability to normal environments, which in the context of natural selection would be expected to lead to a preponderance of mid-range scores in the general population over time (e.g., Buss, 2008; Nesse & Williams, 1994; Stevens & Price, 1996). The present findings draw attention to the fact that, in certain circumstances, emotional stability can be associated with maladaptive coping, especially when persons are at the extreme of the neuroticism-emotional stability continuum. The idea that anti-negative bias can be counterproductive for emotionally stable individuals is consistent with descriptions of negative emotions that consider their adaptive, as well as maladaptive, dimensions. In seeking to explain why negative emotionality exists in the gene pool, researchers have noted the potentially protective effects of moderate levels of feelings such as anxiety, depression, or even low self-esteem

(e.g., Taylor & Brown, 1988). Proneness to a range of different emotions is believed to equip individuals with the capacity both to acquire accurate feedback from their environments concerning the consequences of their own behavior, and to perceive the varying emotions of other people. On the other hand, emotional stability, especially in extremes, may limit the extent to which people can adapt or respond to stressful situations.

Seegerstrom and O'Connor (2012) note that individual differences in personality may directly influence the type and the frequency of daily stressors that an individual experiences. It is likely that individuals with higher levels of neuroticism may experience sufficient life stress on a daily basis such that laboratory stress appears insignificant in comparison. Emotionally stable participants who tend to encounter less stress in their daily lives, in contrast, show a greater anxiety response to stress and are evidently more affected by acute laboratory stressors. The evidence of lesser HR reactions overall amongst the neurotic participants as compared to the emotionally stable group is to be expected in light of previous findings linking neuroticism to task disengagement and blunted stress responding (e.g., Connor-Smith & Flachsbart, 2007; Hughes et al., 2011; Tops et al., 2006; Watson & Hubbard, 1996). It would appear then that in terms of the expression of individual differences, moderate emotional lability is functionally adaptive and that mid-range scores on the neuroticism-emotional stability dimension are most functional.

As evident from the findings, the influence of individual differences in anxiety responding to stress following attentional bias manipulation was not limited solely to neuroticism. Although the finding of a significant effect for individual differences in neuroticism was consistent with the hypothesis of the

study, no specific hypothesis regarding the influence of psychoticism on the relationship between attentional bias and anxiety had been formulated in advance of carrying out the study. The finding that participants with high psychoticism showed greater reactivity to stress following negative attentional bias training and participants with low psychoticism evidenced greater reactivity to stress following anti-negative training mirrors the finding for neuroticism. The higher levels of aggressiveness and reduced ability to empathize with others that distinguish individuals with high psychoticism from those with low psychoticism might be argued to be responsible for the observed effect of greater reactivity to stress following negative attentional bias training.

The finding of significant differences in reaction time across groups in previous studies was not replicated in this study. This inconsistency may be due to the fact that a smaller number of training trials were used in the present study, making statistically significant differences more difficult to detect. The inclusion of a greater number of training trials in future research may help demonstrate an effect for self-report anxiety as well as that for physiological responding to stress. It may also be informative to explore whether neuroticism and training interact to influence reaction times to negative and neutral words in isolation. Clearly, reaction times are not the only way of illustrating successful manipulation of attentional bias. Given the study design, these group differences in physiological outcomes are logically attributable to the fact that participants were allocated to groups that differed in procedure. As this procedural difference related to the type of training received, it must be concluded that the training manipulation was effective in modifying participant stress responses. Notwithstanding the fact that the differences were not manifest in reaction time

or self-report data, the observed difference in physiological arousal of participants to the stress task indicates that clear differences in the impact of the training did occur, in a manner that was contingent on participants' neuroticism scores.

An important strength of the current study, as mentioned, is the examination of physiological indices of anxiety so as to obtain a more objective measure of anxiety responding following attentional bias manipulation. The equipment chosen to measure anxiety, the Dinamap Pro100 Vital Signs Monitor, provided readings of SBP, DBP and HR. While these parameters were sufficient in demonstrating the effects of the intervention on subsequent responding to stress, a more preferable approach would be to employ a more sophisticated piece of equipment capable of providing measures of hemodynamic response patterns to stress (i.e., CO and TPR). As these parameters constitute the underlying determinants of blood pressure it is likely that such measures would provide a greater insight and understanding of the pattern of responding exhibited by participants when exposed to the post-intervention stress task. This represents an important consideration for future studies. The presence of an effect for SBP but not for DBP in the present study is likely accounted for by the fact that SBP, which is based on detecting the presence of a muscular contraction, is a more reliable measure than DBP which is based on measurement of the absence of a contraction (i.e., the exact 'gap' between two contractions). Stronger statistical effects are to be expected for SBP as it has less measurement error.

While the sample size employed in the present study is comparable to those in the existing literature, the use of a larger sample size may also help in

detecting and demonstrating such effects. Furthermore, in measuring anxiety response in the current study, the STAI trait anxiety form was administered to obtain a measure of baseline anxiety while the state anxiety form was used as a measure of post-stressor anxiety. As this involves the comparison of current state anxiety with the more stable trait anxiety as represented by general function, there may be a threat to construct validity in that the two variables may not overlap sufficiently in conceptual terms. This is acknowledged as a limitation of the current study. A preferable approach for future research might be to administer the state form on each occasion in order to assess changes in anxiety over time. Similarly, given the conceptual overlap between neuroticism and anxiety (and the psychometric instruments used in their assessment), a further limitation of the present study is that statistical associations between the two are likely to reflect a degree of shared method variance. Such overlapping highlights the value of objectively assessed physiological correlates of anxiety in such research in the future.

A further consideration for future research is the type of stressor used to induce a state of anxiety. In this study a speech performance task was used to create a stressful situation. Previous research has used, among other forms of stress, a mental arithmetic stressor (e.g. Hughes & Callinan, 2007; Hughes et al., 2011). This might explain why in this study there were no group differences in self-report anxiety. It can be argued that the speech performance task would more likely impinge upon the emotional functioning of participants, by creating an environment in which they were being socially evaluated, than a cognitive stressor which might instead be associated with emotional disengagement. Given the finding that the impact of the stressor varies according to one's emotional

style, it would appear that the speech performance task represents a more effective method of illustrating the effects of attentional bias on anxiety reactivity.

The current study was conducted in a contrived laboratory setting which is, admittedly, somewhat artificial and which raises questions about the generalizability of the findings to more realistic settings. It is also acknowledged that the ecological validity of laboratory tasks as employed in this study is limited both by the artificial nature of such tasks and also by their brevity. In addition, all participants in this study were exposed to the same stressor regardless of their individual dispositions. As individuals typically occupy environments of their own choosing and select environments which are the most adaptive for them, it cannot be suggested that the individuals observed in this study would find themselves in conditions similar to those of the study in their day- to-day lives. For this reason, future research needs to examine the operation of attentional biases in more naturalistic settings, bearing in mind that specific stressors can be of more or less salience for individuals depending on their existing predispositions.

The sample used in this study consisted of psychologically healthy female university students, representative of young adults in general and conforming to the samples used in previous research. Future research may wish to examine individuals drawn from other demographic groups. Furthermore, future research may wish to examine patterns of physiological responding to stress in males following attentional bias manipulation so as to establish the existence, if any, of gender differences in this construct. In addition, some further personality variables might be important to consider, including those that are known to have

implications for emotional stress responding. One such construct is the repressive coping style (see Myers, 2010), which has been suggested differently affects self-report and physiological measures of anxiety response (Kohlmann, Weidner, & Messina, 1996). Persons who cope repressively may report less anxiety than is felt physiologically. As such, consideration of this personality variable may help elucidate the phenomena observed in the present study. The experimental design of this study allows for important conclusions to be drawn regarding the causality of attentional bias and individual differences in the experience of anxiety and in doing so verifies that this study has good internal validity.

In summary, the findings of the present study are consistent with the suggestion that the negative attentional bias intervention served to exacerbate the adverse effects of neuroticism, while the anti-negative intervention served to exacerbate the adverse effects of emotional stability. In addition, negative attentional bias training also exacerbated the adverse effects of high psychoticism while the anti-negative training elicited greater reactivity to stress in those with low psychoticism. The use of physiological measures of anxiety provides knowledge over and above that provided by self-report measures and should be used in addition to self-report measures to gain a more accurate understanding of this effect. The consideration of individual difference variables in studies examining the association between attentional biases and anxiety is fundamental in uncovering the pathways by which individuals become susceptible to experiencing anxiety. Having established that individual differences in anxiety responding to stress can be demonstrated in those in whom an attentional bias for threat-related information has been induced, the next study will address the issue of the ecological validity of the findings by employing an attentional bias

manipulation with photorealistic facial stimuli that more closely approximate to the types of threat encountered in daily life. In doing so, the next study will also address whether individual differences in anxiety following the inducement of an attentional bias are predominantly influenced by neuroticism and/or psychoticism.

Chapter 3: STUDY 2

INDIVIDUAL DIFFERENCES IN ANXIETY RESPONDING TO STRESS FOLLOWING ATTENTIONAL BIAS MANIPULATION USING A FACE- IN-THE-CROWD TASK

Recent research using the dot-probe task shows that training attention away from negative stimuli attenuates post-intervention anxiety to stress (See et al., 2009) and reduces the anxiety symptoms of individuals with clinical diagnoses of anxiety (e.g., Heeren et al., 2012; Schmidt et al., 2009). These findings are consistent with those of MacLeod et al. (2002) of a causal role for attentional bias in anxiety. One limitation of studies that employ the dot-probe task is that linguistic stimuli may not evoke a truly visceral stress response given that such stimuli first need to be cognitively decoded and interpreted by the viewer, who it is assumed has learned the relevant linguistic code. Stimuli that evoke stress responses without the need for either prior learning or multi-stage cognitive processing may better demonstrate the role of attentional biases. Using a dot-probe task in which the word pairs were replaced with pairs of facial images (one emotionally threatening face and one neutral facial expression), Eldar et al. (2008) showed that children trained to direct their attention towards angry faces showed increased anxiety following stress induction. Similarly, Amir et al. (2008) reported attenuated post-intervention anxiety in participants whose attention was trained away from emotionally threatening facial expressions. These findings, consistent with those reported in studies employing linguistic

stimuli, demonstrate the utility of facial images as more realistic and immediate representations of threat.

A further limitation of the existing literature, as discussed in Chapter 2, is that it is founded largely on participants' self-report anxiety levels (and on response detection latencies) with little consideration of the impact of attentional biases on physiological responses to stress. As these stress processes are instinctive and visceral, it should be possible to detect them physiologically. Physiological correlates of anxiety provide knowledge additional to that examinable by subjective measures of anxiety as physiological measurement is sensitive to responses that participants themselves are likely to be unaware of. Furthermore, physiological correlates of anxiety are less affected by social desirability and by demand characteristics arising from participants' expectations of the experimental procedure and thus offer a more objective assessment of participants' anxiety responding than that obtainable from subjective measures.

As outlined in Chapter 1, the role of personality in the acquisition and maintenance of attentional biases has received little consideration in the research literature to date. Study 1 found that neuroticism influenced the extent to which biasing people to anxiety provoking linguistic stimuli affected their subsequent response to stress. Participants high in neuroticism exhibited greater cardiovascular stress responsivity following an intervention that biased their attention towards negative verbal stimuli, while participants low in neuroticism exhibited greater responsivity after an intervention that biased their attention *away* from negative verbal stimuli. Individual differences in psychoticism exerted a similar effect. The findings showed that participants with high psychoticism responded with greater anxiety to the stress task following

completion of the negative training while participants with low psychoticism evidenced greatest anxiety responding to stress on completion of the anti-negative training.

It would appear then that artificially biasing people's attention towards or away from anxiety provoking linguistic stimuli seems to interfere with stress response mechanisms but this effect varies depending on trait emotionality. Truly visceral stress responses might be expected to be more influenced by individual differences in psychoticism than neuroticism. Neuroticism is characterized by, among other things, a proneness to rumination and worry and so its influence on stress responding might be less immediate when compared with the automaticity of attentional processes. On the other hand, psychoticism is characterized by varying degrees of impulsivity which might be more pertinent in attentional processes.

Individual differences in psychoticism might also be of particular relevance in the present study given the nature of the stimuli being employed to manipulate attentional bias (i.e., emotional facial expressions). Miskovic and Schmidt (2010) suggested that the disregard for social conventions and other's approval that is characteristic of individuals with high psychoticism may influence patterns of attention towards emotionally threatening facial expressions. As discussed in Chapter 1, Miskovic and Schmidt (2010) reported that participants with low psychoticism showed preferential processing of happy and angry faces as compared to neutral faces. Participants with high psychoticism, however, did not show an attentional bias for emotional facial expressions. These findings are important as they suggest that individual differences in psychoticism exert an influence on the processing of threatening

information such that individuals with high psychoticism fail to recognize, or perhaps chose to ignore, important information concerning the valence of a stimulus. However, this study was correlational in design. An emotional spatial cueing task in which the probe followed the angry, happy, and neutral facial stimuli with equal probability was employed with no systematic contingency employed to train attention either towards emotionally threatening or emotionally positive stimuli. In addition, the study is limited by its small sample size of 38 participants, in which there was an uneven distribution of males ($n = 10$) and females ($n = 28$).

The present study sought to employ visual rather than verbal stimuli and thus employed a face-in-the-crowd task to induce attentional biases in a manner more consistent with the automatic nature of visual stimuli. The study sought to address the current reliance on self-report measures of anxiety in the existing literature by examining physiological correlates of anxiety. It was hypothesized that greater anxiety responding to stress would be evident for those exposed to the negative training than for those in the anti-negative training group. A further aim of the present study was to establish whether trait neuroticism and psychoticism moderated the impact of attentional biases on subsequent stress responses. It was hypothesized that psychoticism would be more affected by visual stimuli, and particularly emotional facial expressions, leading to greater effects for psychoticism than neuroticism on anxiety responding following the attentional bias intervention.

Method

Participants

The participants were 68 female undergraduate psychology students ranging in age from 17 to 34 years ($M = 20.53$, $SD = 3.72$) with normal BMI ($M = 23.04$, $SD = 3.72$). There was no difference in BMI between the two experimental groups, $t(66) = -.223$, $p = .824$. All participants were normotensive at baseline (resting blood pressure $< 140/90$ mmHg) and reported no history of heart disease. Owing to the highly imbalanced gender distribution in the undergraduate psychology population and to established gender differences in blood pressure (i.e., men tend to have higher resting blood pressure than do women; Turner, 1994), gender served as an inclusion criterion in this study. Smokers were included ($n = 18$) as were oral contraceptive users ($n = 4$; 1 of whom was also a smoker). Participation was voluntary and rewarded with course credit. Participants were randomly allocated to one of two experimental groups: anti-negative training group (35 participants, whose attention was consistently directed towards emotionally positive facial expressions) and negative training group (33 participants, whose attention was consistently directed towards angry/threatening facial expressions). This sample size is comparable to those of previous studies examining attentional bias (e.g., MacLeod et al., 2002) and to that employed in Study 1 and was thus deemed to be appropriate to the effects under scrutiny in the present study. The facial stimuli used for the training trials were taken from the NimStim set of facial expressions (Tottenham et al., 2009) which are discussed in more detail below (see p. 89).

Experimental Tasks

Face- in-the-crowd intervention. The face-in-the-crowd intervention was used to train attention either towards *or* away from negative stimuli. The design of the task employed in the present study was based on that of Pinkham et al. (2010). The present study employed a between-groups design (as opposed to the usual within-group design), such that participants were consistently presented with an angry face in a crowd of happy faces *or* a happy face in a crowd of angry faces. Participants received a basic verbal description of the task and more detailed task instructions were presented on the computer screen. The instructions stated that participants would be presented with a number of matrices, each consisting of 9 faces, and that for each matrix they were to identify whether all 9 faces showed the same emotional expression or whether one face differed from the other 8 faces in its expression. Using the computer keyboard, participants were instructed to press the 's' key if all faces showed the same expression and the 'd' key if one face differed. The need to respond as quickly and as accurately as possible, without making mistakes, and within a limited time was outlined. The training trials were preceded by 18 practice trials for the purpose of familiarizing the participant with the procedure.

Both the practice and the training trials consisted of a series of 9 faces in grey scale presented in a 3×3 matrix. An equal number of target trials, (i.e., trials in which there was a discrepant emotional face), and target free trials, (i.e., trials in which all 9 faces showed the same emotional expression) were presented in a random order. For participants in the anti-negative training group, target trials consisted of 8 faces with an emotionally threatening facial expression and one face with an emotionally positive (i.e., happy) expression and target-free

trials consisted of 9 faces with an emotionally threatening facial expression. The consistent presentation of the emotionally positive expression as the discrepant emotional expression served to prime the participant with emotionally positive expressions as on each occasion this was the expression to which they needed to respond. In the negative training condition, target trials consisted of 8 faces showing an emotionally positive expression and one face showing an emotionally threatening facial expression and target free trials consisted of 9 faces showing an emotionally positive expression. The consistent presentation of the emotionally threatening face as the discrepant face in this condition served to prime participants with threatening stimuli.

A total of 108 matrices (54 target and 54 target free) were presented at random for the experimental task. The same facial image never appeared more than once in a matrix. For the 54 target trials the face representing the target face was selected at random from the set of 9 possible faces with the constraint that each of the 9 faces appeared as the target face an equal number of times. The position of the target face in the matrix was determined at random as was the position of each of the other 8 faces. The task took approximately 9 minutes to complete. At the beginning of each trial, a fixation cross was presented in the centre of the screen for 500 ms. This was immediately followed by the presentation of the matrix which remained on screen for 2,000 ms or until the participant made a response. At this point the screen went blank up to the 4000ms point when the next trial began. Each trial therefore lasted for 4,000 ms.

Participants' response times and accuracy were recorded for each trial and an 'incorrect' response was recorded when no response was made in the time allowed. No feedback was provided for either the practice or the training trials. A

time limit for the completion of each trial was included to standardize task completion times and therefore control for any effect that differences in task completion times might have on subsequent cardiovascular reactivity indices. The happy and angry schematic facial stimuli used for the practice trials were taken from Öhman et al. (2001). The same angry face was repeated to create an angry crowd and the same happy face was repeated to create a happy crowd, i.e., the angry crowd consisted of 8 identical angry faces and the happy crowd consisted of 8 identical happy faces. As detailed above, the facial stimuli employed in the training trials were taken from the NimStim set of facial expressions (Tottenham et al., 2009). This set of facial stimuli consists of 672 racially diverse colour stimuli comprised of 43 professional actors (18 women and 25 men) each modeling 16 different facial poses which include happy, angry, sad, fearful, neutral, and calm. The stimuli have been rated for validity and reliability and have been employed in a number of other previous studies (e.g., Bar-Haim, Morag, & Glickman, 2011; LoBue, 2009). A total of 18 facial images, consisting of one angry and one happy facial image for each of 9 individuals (4 men and 5 women), were selected from this stimulus set (see Appendix D).

Serial subtraction stressor task. Participants were instructed to count backwards (aloud) in 13s, from the number 1,022, as fast and as accurately as possible. The researcher sat to the rear of the participant for the duration of the 2.5-minute task, providing instruction as to when to commence and when to stop the task and correcting them should they make an error, in which case they were instructed to resume their counting from that point onwards.

Cardiovascular Measures

Cardiovascular function was measured using a Finometer hemodynamic cardiovascular monitor (Finapres Medical Systems BV, BT Arnhem, The Netherlands). The Finometer is the successor to the TNO Finapres-model-5 and of the Ohmeda Finapres 2300e which have been used in previous research (Beckham et al., 2009; Gregg et al., 2002; Philippsen et al., 2007). Based on the volume-clamp method first developed by Peñáz (1973), the Finometer provides a non-invasive means of assessing cardiovascular variables. An appropriate sized finger cuff, positioned on the participant's middle finger, inflates to keep the arterial walls at a set diameter. An in-built infrared photo-plethysmograph detects changes in the diameter of the arterial wall. When the intra-arterial pressure increases, the diameter of the arterial wall expands and a dynamic servo-controller immediately causes the finger cuff to inflate, thereby maintaining the diameter of the artery at a constant position. When the volume clamp is active at the proper unloaded diameter, intra-arterial pressure equals that of the finger pressure cuff. The Finometer uses Physiological (Finapres Medical Systems, Amsterdam) to determine and maintain the pressure at which the finger artery is clamped (Wesseling et al., 1995). Physiological is an algorithm that establishes a setpoint level, providing for its periodic adjustment by a computer. This periodic adjustment is necessitated by changes in smooth muscle tone that would lead to errors in blood pressure measurement if a fixed setpoint was used. The Physiological criteria allows for correction of errors without interrupting continuous measurements (Wesseling et al., 1995).

Measures of stroke volume (SV; the volume of blood pumped by the heart per cycle), CO and TPR are provided based on the previously validated

Modelflow modeling method (Wesseling et al., 1993). CO and TPR are the underlying hemodynamic determinants of blood pressure. The reciprocal relationship of these variables, termed *hemodynamic profile* means that an increase in either of these variables is accompanied by a compensatory decrease in the other variable. Blood pressure responses of a similar magnitude may be the result of two different patterns of change in CO and TPR (i.e., an increase in CO with an insufficient decrease in TPR or an increase in TPR with an insufficient decrease in CO; James et al., 2012).

Individuals whose stress responses are marked by large increases in CO are classified as cardiac (or myocardial) reactors while those whose responses are marked by increases in TPR are classified as vascular responders. Myocardial responses have been linked with active tasks such as mental arithmetic and represent a normal healthy response to stress. Vascular responses have been linked with more passive tasks such as the cold pressor task and have been implicated in cardiovascular risk (Gregg et al., 2005). A change in either CO or TPR that is met with a compensatory response of the same magnitude may go undetected in gross measures of blood pressure. This highlights the importance of investigating hemodynamic profiles in addition to gross measures of blood pressure.

Age, sex, height and weight for each participant are entered into the Finometer prior to testing as the Modelflow method requires this information for improved precision trending of SV and CO. The Finometer has been shown to accurately assess absolute blood pressure in young participants (Schutte et al., 2003) and in cardiac patients (Guelen et al., 2003), to a standard that meets the

validation criteria of the Association for the Advancement of Medical Instrumentation.

Participants were seated at a desk in front of a computer throughout the procedure. All testing took place in the same laboratory at the participant's university so as to minimize any potential impact of environmental cues on cardiovascular responses. The researcher was present in the laboratory for the duration of the experiment but was separated from the participant by an opaque screen.

Psychometric Measures

Revised Eysenck Personality Questionnaire. The EPQ-R as described in Chapter 2 (p. 57, **Psychometric Measures**) was administered to measure both neuroticism and psychoticism. The neuroticism scale demonstrated good internal consistency in the present study (Cronbach's $\alpha = .88$), as did psychoticism ($\alpha = .73$) and extraversion ($\alpha = .85$). Trait anxiety (how the person generally feels) and State anxiety (how the person feels right now) were assessed using the State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983). These measures are also described in Chapter 2 (p. 57, **Psychometric Measures**). In the present sample, internal consistency was excellent for the trait scale ($\alpha = .93$) and for the state scale assessed at baseline ($\alpha = .91$) and post-intervention ($\alpha = .93$)

Procedure

Ethical approval for the present study was obtained from the University's ethics committee. On arrival at the laboratory, each participant's height and weight was measured using a digital balance (Seca, model 707; Seca, Hamburg, Germany) and inputted into the Finometer unit. The participant was seated at a desk with a computer and some writing space and informed consent was obtained. Participants completed a demographic questionnaire and the STAI state scale (Spielberger et al., 1983) and then relaxed until a 10 minute acclimatization period had elapsed. Magazines were provided to facilitate relaxation and the establishment of cardiovascular baselines (Jennings et al., 1992). The Finometer was attached to the participant's non dominant arm and finger. Formal baseline measures were initiated and assessed over a 10-minute resting period. On completion of this baseline period, participants were directed to the computer screen where instructions for the face-in-the-crowd task were presented. The computer task was followed by a 3-minute resting period. The instructions for completing the serial subtraction stressor task were communicated verbally by the experimenter during the last minute of this resting period. On completion of the serial subtraction task the Finometer was stopped and the arm and finger cuffs were removed. Participants completed the STAI state scale once again at this point. Before leaving the laboratory, participants were given a questionnaire pack consisting of further psychometric measures to be completed outside the laboratory setting in the participant's own time and returned to the experimenter.

Results

Overview of Analyses

Mean levels of each cardiovascular parameter (SBP, DBP, HR, CO, TPR, and SV) were calculated for each phase of the experiment, namely, baseline, task, post-intervention (rest) and stress task. Baseline levels were calculated as the average over minutes 3 (to allow time for the participant to habituate to the Finometer) to minute 9 (as instructions for the intervention were being delivered by the experimenter during the final minute of baseline). Post-intervention levels were calculated as the mean of minutes 1 and 2 with the final minute of this phase (minute 3) being omitted as instructions for the stress task were delivered during that period. Finally, stress task levels were calculated as the arithmetic mean of all readings recorded during that phase. Internal reliability consistency for each measure was excellent ($\alpha > .95$ for each SBP mean, $\alpha > .95$ for each DBP mean, $\alpha > .96$ for each HR mean, $\alpha > .98$ for CO mean, $\alpha > .85$ for each TPR mean, and $\alpha > .98$ for each SV mean). In order to test the hypothesis that attentional bias manipulation would induce different patterns of anxiety-related blood pressure responses to stress, while also taking account of individual difference variables, a $2 \times 3 \times 1$ mixed factorial analysis of covariance (ANCOVA) was carried out for each cardiovascular variable. The between-subjects factor was group with two levels (negative training group and anti-negative training group) and the within-subjects factor was time with three levels (baseline, post-intervention, and stress). Neuroticism was included as a covariate in the first instance and identical ANCOVAs were then carried out for each cardiovascular variable with psychoticism included as the covariate in order to establish whether or not patterns of anxiety induced blood pressure responses

were affected by neuroticism or psychoticism. As the repeated-measures variable had three levels that were predicted to be associated with shifts in cardiovascular function, particular attention was paid to quadratic-level within-subjects contrasts when assessing main effects and interactions involving time. Equivalent $2 \times 2 \times 1$ mixed factorial ANCOVAs were carried out to examine the effects of attentional bias manipulation on self-report anxiety. The between-subjects factor was 'group' with two levels (negative training group and anti-negative training group) and the within-subjects factor was 'time' with two levels (state anxiety reported at baseline and again on completion of the stress task). Again, neuroticism was entered as a covariate in the first set of ANCOVA analyses and psychoticism was included as a covariate in the second set of ANCOVA analyses.

Demographics

Data from four participants were excluded owing to equipment failure thus reducing the sample to 64 participants. The number of correct responses made by each participant (practice and training trials combined) on the face-in-the-crowd task as a percentage of the total number of trials (i.e., accuracy score) was calculated. The mean accuracy score for participants overall ranged from 13% to 99% ($M = 81\%$, $SD = 20$). Participants who correctly completed less than 45% of trials ($n = 5$) were excluded from the final analyses of the study as they were deemed to have completed too few trials correctly for the intervention to have been successful in inducing an attentional bias. This resulted in a final

sample of 59 participants of whom 28 participants were in the negative training group and 31 participants were in the anti-negative training group.

Descriptive Statistics

One way ANOVAs showed that with the exception of a significant between-groups difference in baseline SBP ($F(1, 58) = 4.50, p = .038$), there were no between-group differences in baseline cardiovascular measures or in psychometric measures. The between-groups difference in SBP was such that participants in the negative training group ($M = 122.67, SD = 7.84$) had significantly higher SBP at baseline than those in the anti-negative training group ($M = 118.45, SD = 7.43$). Means and (standard deviations) for cardiovascular measures at each phase of the experiment are presented in Table 4 and for psychometric measures are presented in Table 5.

Table 4

Mean (and standard deviation) cardiovascular measures across the experiment for each experimental group

Measure	Negative training group						Anti-negative training group					
	Baseline		Post-intervention		Stress		Baseline		Post-intervention		Stress	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
SBP (mmHg)	122.67	7.84	130.11	9.79	141.91	14.78	118.45	7.43	124.98	9.43	137.88	13.16
DBP (mmHg)	74.36	6.24	79.09	7.33	87.95	10.31	72.15	5.46	76.24	5.90	86.13	8.05
HR (bpm)	79.67	9.87	78.54	8.33	88.33	8.95	82.63	11.58	80.69	10.42	89.55	10.40
CO (lpm)	5.98	.88	5.86	.94	6.51	1.25	5.89	1.47	5.80	1.54	6.57	1.64
TPR (pru)	1.02	.23	1.24	.72	1.36	1.04	1.02	.28	1.12	.41	1.12	.40
SV (units)	76.20	11.84	75.56	12.11	74.33	12.67	71.33	12.64	73.52	15.39	73.52	15.39

Table 5

Mean (and standard deviation) psychometric measures for each experimental group

Measure	Negative training group		Anti-negative training group	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
State anxiety ^a	1.63	.47	1.62	.37
State anxiety ^b	1.73	.51	1.87	.44
Trait anxiety	1.98	.57	1.95	.44
Neuroticism	.52	.25	.23	.04
Psychoticism	.25	.13	.19	.12

Note. ^a Baseline; ^b Stress

Cardiovascular Response Patterns and Psychoticism

The 2 (group; negative training and anti-negative training) \times 3 (time; baseline, post-intervention, and stress) \times 1 (psychoticism) mixed factorial ANCOVAs carried out for each cardiovascular variable revealed significant main effects of time for SBP, $F(1,51) = 8.23, p = .006$, partial $\eta^2 = .14$, for DBP, $F(1,51) = 12.15, p = .001$, partial $\eta^2 = .19$, for HR, $F(1,51) = 25.27, p < .01$, partial $\eta^2 = .33$ and for CO, $F(1,52) = 11.86, p = .001$, partial $\eta^2 = .19$. There was no significant main effect of time for TPR or SV. The ANCOVA revealed a significant time \times group \times psychoticism interaction at the quadratic level for SBP, $F(1,49) = 5.08, p = .029$, partial $\eta^2 = .03$. This effect can be illustrated by subdividing the participants into groups based on a median-split of psychoticism scores (see Figure 4). Participants with low and high psychoticism scores who completed the anti-negative training intervention showed identical patterns of

responding to the post-intervention stressor. In the negative training group, participants with low psychoticism showed an exaggerated response to the post intervention stressor indicating that they were more aroused by the stressor than participants with high psychoticism. For DBP there was also a time \times group \times psychoticism interaction, $F(1,49) = 4.58, p = .037, \text{partial } \eta^2 = .09$. As was evident for SBP, participants with low and high psychoticism who completed the anti-negative training showed precisely the same pattern of DBP responding to the stressor. In the negative training group, participants with low psychoticism exhibited a more heightened reactivity to stress than did participants with high psychoticism. For HR, the ANCOVA showed a significant group \times psychoticism interaction $F(1,49) = 5.19, p = .027, \text{partial } \eta^2 = .10$ such that participants in the negative training group had higher psychoticism than participants in the anti-negative training group.

The ANCOVA for CO revealed a significant time \times group \times psychoticism interaction, $F(1,49) = 7.12, p = .010, \text{partial } \eta^2 = .13$, as did the ANCOVA for SV $F(1,49) = 4.77, p = .034, \text{partial } \eta^2 = .09$ and the ANCOVA for TPR $F(1,49) = 4.86, p = .032, \text{partial } \eta^2 = .09$. In each instance, participants were subdivided into groups of low and high psychoticism scores using a median split to illustrate these effects (see Figure 4). All participants (high *and* low psychoticism scores) exposed to the anti-negative training intervention showed a cardiac response to the stressor (i.e., increased CO in response to the stressor) consistent with a normal, healthy response to an arithmetic stressor. For participants exposed to the negative training, post-intervention responding to the stressor was contingent on their psychoticism score. Participants with low psychoticism, showed increased CO in response to the stressor with little change

in TPR from post-intervention to the stressor. This indicates a cardiac hemodynamic profile. In contrast, participants with high psychoticism showed increased TPR to the post-intervention stressor with little change in their levels of CO responding. This indicates a vascular hemodynamic profile.

Cardiovascular Response Patterns and Neuroticism

The 2 (group; negative training and anti-negative training) \times 3 (time; baseline, post-intervention, and stress) \times 1 (neuroticism) mixed factorial ANCOVAs carried out for each cardiovascular variable revealed significant main effects of time for SBP, $F(1, 49) = 17.38, p < .01$, partial $\eta^2 = .26$, DBP, $F(1, 49) = 19.11, p < .01$, partial $\eta^2 = .28$, HR, $F(1, 49) = 9.01, p = .004$, partial $\eta^2 = .16$, and CO $F(1, 49) = 15.80, p < .01$, partial $\eta^2 = .24$. There was no main effect of time for TPR or SV. For SBP there was a significant time \times neuroticism interaction $F(1,49) = 4.63, p = .036$, partial $\eta^2 = .09$. Post-hoc t -tests indicated that participants with high neuroticism scores had greater SBP responding during the stress task than participants with low neuroticism scores. For DBP there was also a significant time \times neuroticism interaction $F(1, 49) = 4.25, p = .045$, partial $\eta^2 = .08$. Post-hoc t -tests revealed that participants with high neuroticism scores had greater DBP during the stress task than participants with low neuroticism scores. For CO, the time \times group \times neuroticism interaction was bordering on significance $F(1, 49) = 3.92, p = .053$, partial $\eta^2 = .07$.

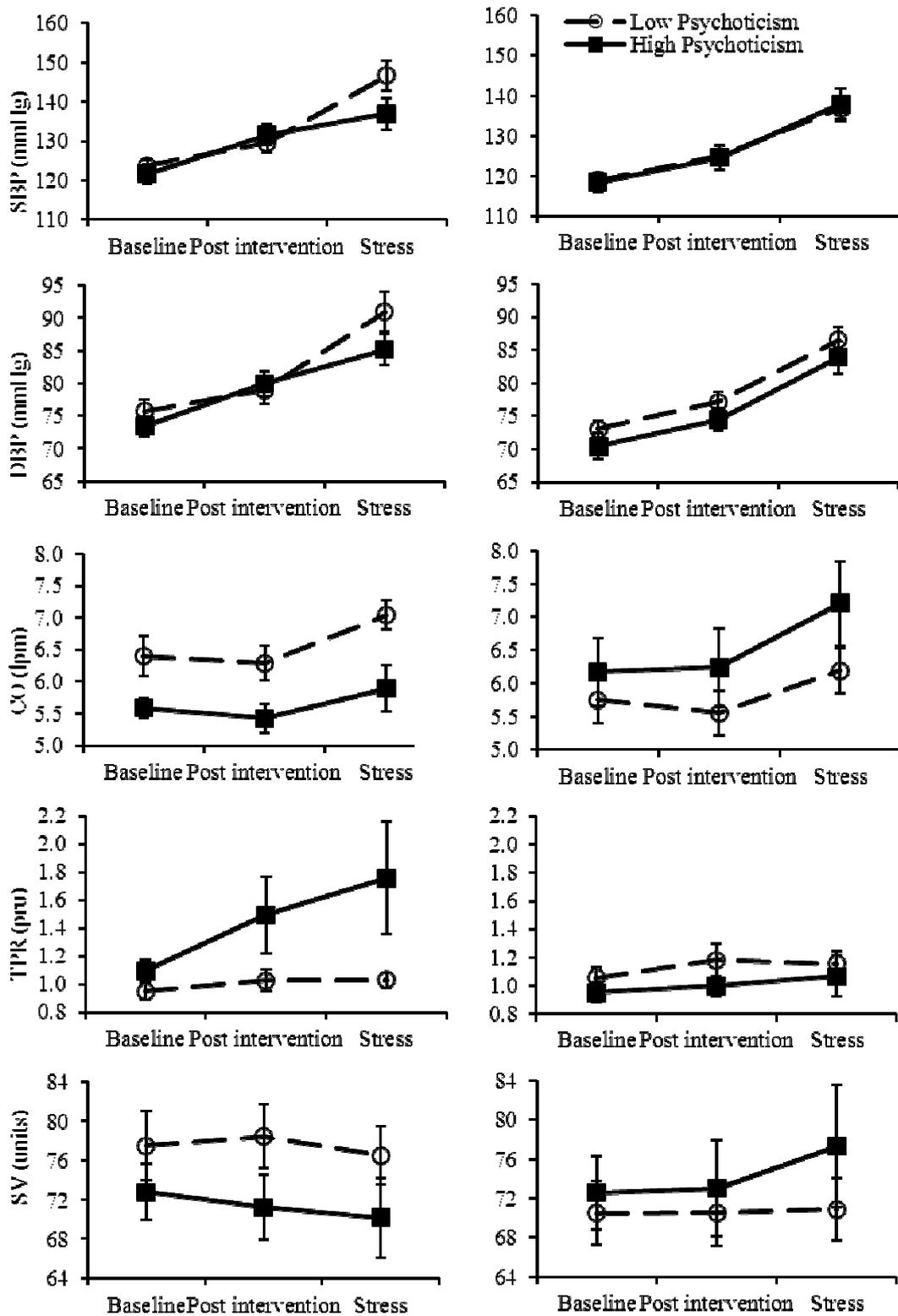


Figure 4. Time \times group \times psychoticism interactions for SBP, DBP, CO, TPR, and SV for the negative training group (left) and the anti-negative training group (right). Error bars denote standard errors of the mean

Self-report Anxiety

The 2 (group; negative training group and anti-negative training group) × 2 (time; state anxiety reported at baseline and again on completion of the stress task) × 1 (neuroticism) mixed factorial ANCOVA carried out to assess the effect of training attention towards emotional faces showed a significant main effect for neuroticism, $F(1, 49) = 10.93, p = .002$, partial $\eta^2 = .18$, such that those with high neuroticism scores in both training groups reported greater anxiety at baseline and post-intervention than those with low neuroticism scores. It also revealed a significant main effect of time $F(1, 49) = 9.44, p = .003$, partial $\eta^2 = .16$, such that STAI scores reported on completion of the stress task were higher ($M = 1.79, SD = .47$) than those reported at baseline prior to commencement of the experiment ($M = 1.61, SD = .40$). This verifies the effectiveness of the stress task. The equivalent $2 \times 2 \times 1$ ANCOVA carried out with psychoticism as the covariate showed no main or interaction effects.

Reaction Time

Median discrimination latencies for each participant for practice trials and for training trials were calculated based on trials for which a 'correct' response had been recorded. Trials for which an 'incorrect' response had been recorded were excluded from the reaction time analysis. The resulting latencies, averaged across the participants in each group are presented in Table 6.

Table 6

Mean and (standard deviation) reaction times in milliseconds for practice trials and training trials

	Negative training group		Anti-negative training group	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Target trials				
Practice trials	1092.15	188.87	1136.21	186.24
Training trials	1121.38	156.10	1234.09	155.42
Target free trials				
Practice trials	1274.86	261.20	1331.22	231.82
Training trials	1544.58	166.28	1622.87	146.93

A 2 (trial type; practice trials, training trials) \times 2 (experimental group; anti-negative training group, negative training group) mixed factorial ANOVA was conducted to test for differences in mean reaction time between the two experimental groups for trials on which a target face (i.e., discrepant emotional expression) was presented. There was a significant main effect for group such that those in the negative training group were quicker to detect the target face than those in the anti-negative training group on both practice and training trials $F(1,56) = 6.90, p = .011, \text{partial } \eta^2 = .11$. In other words, participants who were required to detect an angry face in a crowd of emotionally positive faces were faster to do so than participants required to detect an emotionally positive face in a crowd of angry faces.

A one-way ANOVA was also conducted with accuracy score as the dependent variable and training group as the between-subjects factor to establish

whether participants in the negative training group made a greater number of accurate responses than did participants in the anti-negative training group. The ANOVA revealed a significant between-group difference in accuracy scores $F(1, 57) = 9.67, p = .003$ such that participants in the negative training group ($M = 90.09\%$, $SD = 9.7$) responded with greater accuracy than participants in the anti-negative training group ($M = 79.71\%$, $SD = 14.79$). Together these findings of greater accuracy, and speed in the detection of negative facial images are consistent with the face-in-the-crowd effect.

A 2 (trial type; practice trials, task trials) \times 2 (experimental group; anti-negative training group, negative training group) mixed factorial ANOVA was also conducted to test for differences in mean reaction time between the two experimental groups for trials on which a target face was not present. There was a significant main effect for time, $F(1, 56) = 74.18, p < .01$, partial $\eta^2 = .57$, such that participants overall responded more quickly to the practice trials ($M = 1304.98$, $SD = 245.38$) than to the training trials ($M = 1586.43$, $SD = 159.77$) but no significant effect for experimental group.

Discussion

The results of this study confirm that the experimental manipulation of threat-related attentional bias has a causal influence on anxiety responding to stress as measured physiologically and indicate that differences in individual temperaments underlie such effects. Although attentional bias training did not significantly disrupt cardiovascular parameters in the sample overall (i.e., there were no main effects of training) consideration of participants' psychoticism

scores revealed that the intervention did impact participants' subsequent stress responses in different ways. The findings highlight the fact that both individual differences and physiological variables are particularly revealing in illustrating these types of effects. Given the experimental design of the study, it is possible to draw important conclusions as to the direction of causality between attentional bias and anxiety. As between-group differences were limited to the type of training to which participants were exposed, the patterns of physiological responding to the stress task that were observed can be attributed to the manipulation of attentional bias.

Similar to Study 1, the measurement of physiological outcome variables is a key strength of the present study as physiological indices of anxiety, as discussed, facilitate detection of responses that cannot be revealed by self-report or reaction time data alone and render more objective measures of anxiety that are less susceptible to confounds such as response bias or repressive coping. The present study represents an incremental advance on Study 1 in the use of the Finometer hemodynamic cardiovascular monitor (as opposed to the Dinamap Pro 100 Vital signs monitor). Use of the Finometer facilitated examination of participants' hemodynamic response profile to stress in addition to the blood pressure and heart rate responses assessed in Study 1. Given that (i) the absence of an observable shift in blood pressure scores can be accompanied by marked changes in hemodynamic responses, and (ii) that shifts in blood pressure responses of the same magnitude in separate individuals can be the result of different underlying hemodynamic response profiles, the analysis of hemodynamic responses provided further knowledge and understanding of the true impact of attentional bias manipulation on anxiety responses. Analysis of

participants' self-report data in the current study suggested that there were no between-group differences in anxiety responding to stress following attentional bias manipulation. Reliance on these measures alone would likely have led to a Type II error.

While the current study considered the role of both psychoticism and neuroticism in the relationship between attentional bias and stress responses, the findings revealed that the role of psychoticism was of a much greater pertinence. This is consistent with the expectation that neuroticism, given its association with rumination, would exert less influence on automatic responding to stimuli that are distinctively threatening. All participants in the anti-negative training group showed the same pattern of physiological responding (i.e., a cardiac hemodynamic profile) regardless of their individual scores for psychoticism. However, participants in the negative training group responded differently to the post-intervention stressor depending on their psychoticism scores. Participants with low psychoticism showed exaggerated blood pressure responding to the stressor i.e., a change in the *quantity* of their response, while those with high psychoticism exhibited a vascular hemodynamic profile that differed from the cardiac hemodynamic profile of all other participants in the study. Therefore, these participants differed in the *type* of responding to the stressor.

The findings indicate that individuals differ in how they respond to an intervention aimed at modifying specific patterns of cognitive processing and in their response to a subsequently presented stress task. Priming people to attend to emotionally positive faces (anti-negative stimuli) does not affect their ability to cope with a subsequent stressor. Priming people to attend to angry faces (negative stimuli), however, appears to make it harder for them to cope with

stress. Although it would appear at first that individuals with low psychoticism fared worst given their exacerbated blood pressure response to the stressor, examination of hemodynamic profiles revealed that participants with high psychoticism did not escape the adverse effects of being primed with angry faces. These participants showed a vascular response to the stressor which is linked to passive coping and adverse cardiac outcomes. Overall, these findings are consistent with existing research demonstrating that attentional bias towards threatening stimuli results in exacerbated anxiety responding to stress. The findings also suggest a pathway by which levels of anxiety that are high or exaggerated contribute to cardiovascular related ill-health. The finding that participants in the negative training group (whose training required that they identify an angry face in a crowd of emotionally positive faces) were faster to detect the target expression than were participants in the anti-negative training group (who were required to identify an emotionally positive face in a crowd of angry faces) is also consistent with the literature concerning the face-in-the-crowd effect.

The use of photorealistic facial stimuli is a further strength of the present study. A weakness of traditional research is the need for the participant to first interpret the data, (typically pairs of linguistic stimuli), and to then express their reaction to it. The ability to attach valence to a linguistic stimulus is essentially a learned response. This study's use of facial expressions of threat, with physiological measurement of anxiety provided a more accurate measure of automatic stress responding to threat. Unlike the dot-probe task in which participants are focused on the dot that follows the threatening stimulus and not the threatening stimulus itself, the face in the crowd task, as employed in the

present study, specifically instructs participants to focus on the threatening stimulus (i.e., in the negative training condition). Therefore, given that participants were specifically focused on the threatening stimuli, the finding of individual differences in responding for those with high and low psychoticism suggests that it was the visceral nature of stimuli that was operational. Importantly, the use of photorealistic facial stimuli also addresses concerns regarding external validity of the findings as facial images are more congruent with the types of threat encountered in daily life and from an evolutionary perspective possess greater ecological validity. In this way, the present study's use of photorealistic facial stimuli represents an additional incremental advance of this study on Study 1.

The design of the face-in-the-crowd task employed in the present study differed from that which has been employed in previous studies (e.g., Pinkham et al., 2010). As mentioned earlier, previous studies that have employed the face-in-the-crowd task consist of cross-sectional investigations of the anger superiority effect, and have employed a within-subjects design in which participants receive trials on which the discrepant emotional expression is threatening *and* trials on which the discrepant emotional expression is positive. A between-subjects design was adopted in the present study to facilitate testing of the hypothesis that threat-related attentional bias causally contributes to exacerbated anxiety responding to stress. The present study successfully illustrated the presence of an anger superiority effect in that participants in the negative training group were faster to identify the discrepant emotional expression and did so with greater accuracy than did participants in the anti-negative training group. This in itself is an

important finding and one that is consistent with previously reported findings, including those of Pinkham et al. (2010).

Notwithstanding the benefits of employing facial stimuli to induce a threat-related attentional bias, it is reasonable to argue that the design of the intervention delivered in this study might be identified as having had a confounding effect on the pattern of results observed. Participants in the anti-negative training group were consistently presented with crowds of emotionally threatening facial images in which they had to identify the presence of an emotionally positive facial image. This resulted in their being exposed to a greater number of emotionally threatening facial images on each trial as compared with participants in the negative training group for whom the crowd of faces was comprised of emotionally positive facial expressions. Arising from this greater overall exposure to emotionally threatening stimuli on each trial, the possibility exists that the emotionally threatening faces served to distract the participant's attention as they searched for the emotionally positive facial expression. The findings relating to reaction time data show that participants in the negative training group were indeed faster to detect the presence of a discrepant emotional expression than were participants in the anti-negative training group.

In spite of the fact that participants in the anti-negative training group were exposed to a greater number of emotionally threatening stimuli on each trial, the impact of the emotionally threatening facial images on participants in the anti-negative training group would necessarily have been minimal given that explicit instructions were delivered both verbally and onscreen at the outset of the intervention, that participants should respond as quickly as possible and with

as much accuracy as possible. These instructions served to focus the attention of participants overall on the pertinent emotional expression for their training group. Dandeneau et al. (2007) employed a similar attentional bias intervention in which participants were instructed to identify a smiling facial expression in a matrix of frowning facial expressions in order to train participants' attention away from emotionally rejecting facial expressions in an attentional bias intervention. As compared to a control group, participants in the experimental training group reported lower self-report anxiety levels to a social evaluative stressor. This finding supports the efficacy of this task design in inducing a threat-related attentional bias. Nonetheless, this issue warrants consideration in future research. The use of the dot-probe task with photorealistic facial stimuli represents an alternative means by which to induce an attentional bias manipulation that retains the merits of ecological validity achieved in the present study while also avoiding the confound of mere exposure to threatening facial images for those in the anti-negative training group.

Both the self-report and physiological data indicate that the stress task employed (serial subtraction stressor task) was effective in arousing a stress response in participants. In contrast to the speech task used in Study 1 which constituted a social evaluative stressor and thus elicited social and evaluative threat, the mental arithmetic task employed in the present study elicited a cognitive stress response. Al'Absi et al. (1997) presented participants with multiple presentations of mental arithmetic and public speaking tasks and predicted that public speaking would produce greater and more stable physiological responses, including blood pressure responses, than mental arithmetic. Their findings confirmed that the public speaking stressor

consistently produced greater endocrine and hemodynamic responses than did the mental arithmetic task. These findings indicate the importance of examining stress responding to different types of stress tasks. Acknowledging the fact that individuals tend to select environments that are most adaptive for them (Suls & Martin, 2005) and that particular stressors pose greater or less salience for individuals based on their existing predispositions and on past experiences, future research should examine the operation of attentional bias in more naturalistic settings across a number of different stressful scenarios such as, for example, sitting exams. In addition, a limitation of the present study is the absence of a post-intervention measure of reaction times which could be used to assess the effectiveness of the attention bias training intervention. The reaction times recorded reflect performance as the intervention was ongoing as opposed to reaction times once the intervention had been completed. To this end, future research employing this design should employ pre- and post-intervention trials as employed in Study 2.

The present study employed a sample size, similar both to that employed in previous studies in the literature and to the sample size of Study 1, consisting of psychologically healthy female undergraduate students. The use of a similar sample to that of Study 1 was desirable in the present study to facilitate comparisons between the findings of the two studies. As acknowledged in Study 1, the use of a larger sample size and the consideration of participants drawn from other demographic populations warrants consideration in future research. The exclusion of males in the current study, though necessary to control for underlying gender differences in cardiovascular function, is acknowledged as a limitation of the current study. Future research should investigate gender

differences in the extent to which threat-related attentional biases are adopted and in turn influence anxiety responses to stress.

In conclusion, the findings of the present study indicate that the negative attentional bias intervention impacted participants' responses to the stressor and the nature of this effect was determined by participants' psychoticism scores as participants with low psychoticism showed a more exaggerated anxiety response to the stressor and those with high psychoticism showed a vascular hemodynamic profile that is more detrimental to cardiovascular health outcomes. This suggests that more readily discernible representations of threat (emotionally threatening facial images) are of a greater significance to individual differences in psychoticism than neuroticism. The study also highlights the importance of physiological measurement of anxiety responses and adds both to the growing literature on attentional bias, and to the well-established literature on cardiovascular stress responses. The finding that anxiety responses to stress following attentional bias manipulation were contingent on participants' psychoticism scores raises the question of whether it was the type of task employed (i.e., dot-probe task or face-in-the-crowd), the nature of the stimuli used (i.e., linguistic or pictorial) or the way in which attention was directed towards threat (i.e., indirectly in the dot-probe task, or directly towards threat in the face-in-the-crowd task) that resulted in the observed effects for psychoticism. Accordingly, the next study examines this question by examining anxiety responding to stress following the delivery of an attentional bias manipulation consisting of a dot-probe task with pairs of photorealistic facial images.

Chapter 4: STUDY 3

INDIVIDUAL DIFFERENCES IN ANXIETY RESPONDING TO STRESS FOLLOWING ATTENTIONAL BIAS MANIPULATION USING A DOT- PROBE TASK WITH FACIAL STIMULI

A number of key research questions arising from the existing literature on attentional bias and anxiety have been highlighted and addressed in Chapters 2 and 3. The findings of both studies show that the experimental manipulation of attentional bias towards or away from threat-related stimuli disrupts subsequent anxiety responding and that this effect is evident when examining physiological parameters of the anxiety response. The importance of examining individual differences in responding to attentional bias intervention and stress is attested to in both studies. Study 1 (which employed linguistic threat stimuli) showed that participants' post intervention responding to the stress task was contingent on their level of trait neuroticism and independent of this was also contingent on their level of trait psychoticism. The findings of Study 2 (which employed photorealistic facial stimuli) showed that participants' responding to a post-intervention stress task varied according to whether they were high or low in trait psychoticism.

Study 2 sought to control for the limitations associated with verbal stimuli as employed in Study 1 and to this end presented a face-in-the-crowd task with photorealistic facial stimuli that were readily identifiable as threatening in

nature, so that they would closely resemble the types of threatening stimuli encountered in naturalistic settings and thus maximize ecological validity. This use of a different type of stimuli and a different paradigm to that of Study 1 also permitted testing of the hypothesis that the influence of individual differences on post-intervention responding to stress would be affected by the type of stimuli (visual or linguistic) presented. The finding that psychoticism was the individual difference variable that exerted an effect over participants' responses when primed with visual representations of threat, while individual differences in neuroticism and in psychoticism determined participants' responding to attentional training with linguistic stimuli raises the question of whether the role of individual differences in this effect is dependent on the way in which the attentional bias intervention is delivered and the nature of the stimuli presented. It seems likely that the personality variable that exerts most influence on participants' responses to the intervention will depend on the type of task employed (i.e., dot-probe task or face-in-the-crowd task) and the type of stimuli used (linguistic stimuli or visual stimuli).

The design of the present study shares some similarities with that of Eldar et al. (2008) in which the authors delivered attentional bias training to 20 children with normal levels of anxiety using a dot-probe task with facial images from the NimStim set of facial images (as employed in Study 2), followed by a three-minute post-intervention stress task that required completion of difficult puzzles while being video-recorded. The findings showed that children trained to attend to angry faces exhibited increased anxiety to stress induction while children in the anti-negative intervention exhibited no change in anxiety from pre- to post-stress measurements. This study's experimental design sets it apart

from much of the previous research in permitting the conclusion that children's increased anxiety was attributable to the negative attentional bias intervention (i.e., it permits conclusions relating to cause and effect). The use of analog mood scales to assess anxiety responding to the stress task however, gives rise to the issue of self-report measurement of anxiety discussed previously. The authors also obtained an index of behavioural stress during the stress induction task which constitutes a positive step in terms of easing the existing reliance on self-report indices of anxiety and providing a more objective measure. However, behavioural indices of anxiety may be confounded by factors such as inter-rater reliability and participants' mood state prior to the intervention, and therefore stand inferior to physiological indices of anxiety. The authors also neglected consideration of individual differences in the children's temperaments. The absence of a measure of personality assumes that all individuals within each experimental group will respond in the same way to the intervention despite the fact that, as shown in Studies 1 and 2, this is not the case. Eldar et al.'s study is also limited by its small sample size of 20 participants making it difficult to generalize from these findings to the population in general and draw definitive conclusions.

A more recent study by Heeren et al. (2012) examined self-report, behavioural and physiological measures of anxiety (skin conductance reactivity; SCR) to a stress task following an attention training protocol, consisting of the dot-probe task with happy and angry face pairs, that was delivered on each of four consecutive days. The authors assigned 60 individuals with social anxiety disorder to either the "attend positive", "attend threat", or control group. The findings showed that participants trained towards positive stimuli reported

significantly less anxiety at follow-up than those trained towards threat and those in the control group. In addition, participants in the attend positive group showed a significant decrease in behavioural anxiety and SCR to the stress task from baseline to post-training as compared to participants trained towards threat (who showed a significant increase in behavioural anxiety and no change in SCR) and participants in the control group (who showed no change in either behavioural anxiety or SCR). The results of this study are promising as they demonstrate findings for self-report social anxiety, behavioural anxiety and a physiological measure of anxiety. Similar to Eldar et al. (2008), this study is limited by the failure to consider the role of individual differences in participants' responding to the intervention.

The experimental design of the present study constitutes a replication of that employed in Study 1 but with the exception that the dot-probe task employed in this study presented pairs of facial stimuli (instead of linguistic stimuli) to manipulate attentional bias for threat-related information. As in Study 2, the use of the Finometer hemodynamic cardiovascular monitor in this study represents an advance on the methodology of Study 1 in which the cardiovascular parameters assessed were limited to SBP, DBP, and HR. This study sought to investigate whether participants' responding to a dot-probe task with visual stimuli would be more greatly influenced by individual differences in trait neuroticism or trait psychoticism. Based on the findings of Study 2 in which participants' responding to the post-intervention stress task was shown to be determined by their levels of psychoticism, it was hypothesized that a similar finding would emerge in this study as participants were once again being primed either towards or away from photorealistic facial expressions of threat. As was

also examined in Studies 1 and 2, it was also hypothesized that the attentional bias intervention would bring about significant changes in participants' physiological responding to an ensuing stress task.

Method

Participants

The participants were 80 female undergraduate psychology students ranging in age from 17 to 32 years (mean age = 20.26 years; $SD = 2.94$) with BMI ranging from 18 to 37.5 kg/m² ($M = 24.01$, $SD = 3.85$). Gender served as an inclusion criterion with male participants being excluded from the study due to the highly imbalanced gender distribution in the undergraduate psychology population and due to research findings of gender differences in blood pressure (i.e., men tend to have higher resting blood pressure than do women; Turner, 1994). Participants reported no history of hypertension or heart disease. Participation was voluntary and participants were granted course credit for their time. Participants were randomly allocated to one of two experimental groups: anti-negative training group (39 participants) and negative training group (41 participants). This sample size is comparable to those of previous studies concerned with attentional bias (e.g., MacLeod et al., 2002) and was therefore considered to be appropriate for the present investigation. Smokers ($n = 13$) were included in this sample as were oral contraceptive users ($n = 10$; 1 of whom was also a smoker).

Experimental Tasks

Dot-probe task. The dot-probe task presented in this study was an exact replication of that described in Chapter 2 (p. 53) with the exception that the word stimuli were replaced with photorealistic facial stimuli. A total of 32 facial images (comprising 16 different individuals each posing an angry facial expression and a happy facial expression; i.e., 16 facial stimuli pairs) were employed in the dot-probe task and these images were taken from the NimStim set of facial expressions (Tottenham et al., 2009), described in Chapter 3 (p. 89, **Face-in-the-crowd intervention**). The 16 facial stimuli pairs were divided into two equal subsets each consisting of four male and four female facial stimuli pairs. Each participant was presented with one subset for the attentional training trials and the other subset for the attentional test trials and the order of their presentation for each participant was determined at random.

In total, the dot-probe task consisted of 384 trials presented in the following order: 48 pre-training test trials, 288 training trials and 48 post-training trials. For the 48 pre-training trials, each of the eight facial stimuli pairs in the subset appeared six times with the probe appearing in the location of the angry facial expression on 24 trials and that of the happy facial expression on 24 trials. For the attentional training trials each face pair in the subset appeared 36 times (8 face pairs \times 36 times each = 288 trials). The order in which the face pairs appeared was determined at random but each face pair in the subset had to have appeared once before the subset was repeated, each had to have appeared a second time before being presented a third time and so on. Probe location was contingent on the participant's training group with the probe always replacing the angry face for those in the negative training group and always replacing the

emotionally positive face for those in the anti-negative training group. The post-training trials followed the same procedure as the pre-training trials using the same subset as was used for the attentional training trials (i.e., the subset not used for the pre-training trials).

At the beginning of each trial the words “NEXT TRIAL” appeared in the centre of the computer screen for 500 ms and served as a fixation point. This was immediately followed by the presentation of the happy and angry facial images pair with the images appearing at equal distances to the left and right of the fixation point. The position of the angry facial image was randomized so that it appeared in either the left or right screen location with equal probability on any trial. The facial images remained on screen for 500 ms and were immediately followed with the presentation of a probe. The probe was either a single dot (105 pixels) or two adjacent dots (each dot 105 pixels), determined at random. With a random 50% probability the probe was either a single dot or a double dot. Participants were instructed to press the left mouse key if the probe was a single dot and the right mouse key if the probe was two adjacent dots. On each trial participants had 1,500 ms to make a response and a time bar at the bottom of the screen indicated the amount of time remaining for that trial. This time limit, which is not a feature of the MacLeod et al (2002) dot-probe task, was included in order to standardize task completion times and therefore control for any possible effects of task completion times on subsequent cardiovascular reactivity indices. Participants were informed that only their first response would be recorded on each trial and that the task would only proceed to the next trial once the time allowed for the current trial had elapsed. For trials on which a response was not detected, an incorrect response was recorded and the task proceeded to

the next trial. No feedback was provided. Response times and accuracy of response were recorded for each trial.

Speech performance task. The speech performance stress task employed in this study was identical to that described in Chapter 2 (p. 56).

Cardiovascular Measures

Beat-to-beat cardiovascular measures were recorded using a Finometer hemodynamic cardiovascular monitor, the specifications and validity of which are described in Chapter 3 (p. 90, **Cardiovascular Measures**). Participants were seated at a desk with a personal computer and some writing space throughout the procedure. As in Chapter 3, the researcher was present in the laboratory for the duration of the experiment but was separated from the participant by an opaque screen. This served to minimize social contact between the researcher and the participant while also ensuring that participants adhered to instructions regarding the procedure.

Psychometric Measures

Revised Eysenck Personality Questionnaire. The EPQ-R described in Chapter 2 (p. 57, **Psychometric Measures**) was administered to measure both neuroticism and psychoticism. The neuroticism scale demonstrated good internal consistency in the present study (Cronbach's $\alpha = .81$) as did extraversion

(Cronbach's $\alpha = .80$). Cronbach's alpha for psychoticism was .61. Trait anxiety and state anxiety were assessed using the State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983) also described in Chapter 2 (p. 57, **Psychometric Measures**). In the present sample, internal consistency was excellent for the trait scale (Cronbach's $\alpha = .88$) and for the state scale administered pre-intervention (Cronbach's $\alpha = .88$) and post-intervention (Cronbach's $\alpha = .92$).

Procedure

Testing took place in a quiet hemodynamic laboratory at the participants' university. Participants were given an information sheet outlining the procedure and informed consent was obtained. Each participant's height and weight was measured and inputted into the Finometer. The participant was seated and the blood pressure cuffs were attached to their non-dominant middle finger and arm. Participants completed a demographic questionnaire and the STAI state scale (Spielberger et al., 1983) and then relaxed for the remainder of a 10-minute acclimatization period. Magazines were provided to facilitate relaxation and the establishment of cardiovascular baselines. Formal baseline measures were initiated and assessed over a 10-minute "vanilla" baseline period (Jennings et al., 1992). Following this, participants were presented with onscreen instructions for completion of the dot-probe task and instructed to commence the task when they had read and were satisfied that they understood, the instructions provided. The computer task took approximately 21 minutes to complete and was followed by a 3-minute resting period. Instructions for completing the speech task were delivered verbally during the final minute of this resting period. On completion

of the speech task the Finometer was stopped and disconnected and the STAI state scale was administered. Participants were then given a take-home questionnaire pack containing further psychometric measures to complete in their own time, and return to the experimenter at their earliest convenience.

Results

Overview of Analyses

Mean levels of each cardiovascular parameter SBP, DBP, HR, CO, TPR, and SV were calculated for each phase of the experiment, namely, baseline, task, post-intervention (rest) and stress task. As in Study 2, baseline levels were calculated as the average over minutes 3 (to allow time for the participant to habituate to the Finometer) to minute 9 (as instructions for the intervention were being delivered by the experimenter during the final minute of baseline). Post-intervention levels were calculated as the mean of minutes 1 and 2 of this phase with the final minute of the phase (minute 3) being omitted as instructions for the stress task were delivered during that period. Finally, stress task levels were calculated as the arithmetic mean of all readings recorded during that phase. Internal reliability consistency for each measure was excellent ($\alpha > .96$ for each SBP mean, $\alpha > .98$ for each DBP mean, $\alpha > .95$ for each HR mean, $\alpha > .97$ for CO mean, $\alpha > .95$ for each TPR mean, and $\alpha > .98$ for each SV mean). In order to test the hypothesis that attentional bias manipulation would induce different patterns of anxiety-related blood pressure responses to stress, while also taking account of individual difference variables, a $2 \times 3 \times 1$ mixed factorial analysis of covariance (ANCOVA) was carried out for each cardiovascular variable. The

between-subjects factor was group with two levels (negative training group and anti-negative training group) and the within-subjects factor was time with three levels (baseline, post-intervention, and stress). Neuroticism was included as a covariate in the first instance and identical ANCOVAs were then carried out for each cardiovascular variable with psychoticism included as the covariate in order to establish whether or not these variables affected the patterns of anxiety induced blood pressure responses.

Demographics

Data from 10 participants were excluded due to technical difficulties with the cardiovascular monitoring equipment ($n = 5$), baseline blood pressure readings that were not in the normotensive range ($n = 3$), and outliers in terms of BMI ($n = 2$).

The number of correct responses made by each participant (on pre-training, training, and post-training trials combined) on the dot-probe task intervention as a percentage of the total number of trials (i.e., accuracy score) was calculated. The mean accuracy score for participants overall was 86% ($SD = 28\%$). Participants who correctly completed less than 60% of trials ($n = 7$) were excluded from the final analyses of the study on the basis that they had completed too few correct trials for the intervention to have been effective in inducing an attentional bias. This resulted in a final sample of 63 participants (33 participants in the negative training group and 30 participants in the anti-negative training group).

Descriptive Statistics

With the exception of a significant between-group difference in baseline HR ($F(1, 62) = 4.68, p = .034$), one way ANOVAs showed that there were no between-group differences in baseline cardiovascular measures or psychometric measures. The between-groups difference in baseline HR was such that participants in the negative training group had lower baseline HR ($M = 74.44, SD = 10.40$) than participants in the anti-negative training group ($M = 79.75, SD = 8.92$). Mean (and standard deviations) psychometric measures are presented in Table 7 and cardiovascular measures are presented in Table 8.

Table 7

Mean (and standard deviation) psychometric measures for each experimental group

Measure	Negative training group		Anti-negative training group	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
State anxiety ^a	1.74	.38	1.72	.45
State anxiety ^b	1.86	.45	1.84	.55
Trait anxiety	2.20	.45	2.14	.46
Neuroticism	.59	.18	.62	.21
Psychoticism	.22	.10	.18	.09

Note. ^a Baseline; ^b Stress

Table 8

Mean (and standard deviation) cardiovascular measures across the experiment for each experimental group

Measure	Negative training group						Anti-negative training group					
	Baseline		Post-intervention		Stress		Baseline		Post-intervention		Stress	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
SBP (mmHg)	117.87	10.67	124.76	9.79	137.00	11.01	119.34	11.66	127.80	15.33	141.63	16.97
DBP (mmHg)	73.54	6.64	78.03	8.36	86.84	7.67	73.05	8.51	78.14	9.64	88.02	10.89
HR (bpm)	74.44	10.40	75.35	10.36	80.58	10.01	79.75	8.92	79.42	8.82	85.69	8.82
CO (lpm)	5.09	.93	5.21	.97	5.81	1.21	5.36	.95	5.46	1.25	5.95	1.28
TPR (pru)	1.14	.24	1.20	.34	1.22	.34	1.07	.19	1.17	.38	1.18	.25
SV (units)	68.40	11.42	69.56	10.14	71.19	12.40	68.12	13.29	69.48	15.54	70.58	16.24

Cardiovascular Response Patterns and Neuroticism

The 2 (group; negative training and anti-negative training) \times 3 (time; baseline, post-intervention, and stress) \times 1 (neuroticism) mixed factorial ANCOVAs carried out for each cardiovascular variable revealed significant main effects of time for SBP, $F(1.73, 98.81) = 16.08, p < .01, \text{partial } \eta^2 = .22$, DBP, $F(2, 114) = 18.67, p < .01, \text{partial } \eta^2 = .25$, HR, $F(1.73, 98.65) = 12.35, p < .01, \text{partial } \eta^2 = .18$, TPR $F(2, 114) = 4.46, p = .014, \text{partial } \eta^2 = .07$, and SV $F(2, 114) = 4.02, p = .020, \text{partial } \eta^2 = .07$. In the case of CO mean HR responding at the baseline was included in the ANCOVA as a covariate to control for the significant between-groups difference in baseline HR as reported above. There were no significant main or interaction effects for CO. There was a significant time \times neuroticism interaction at the quadratic level for TPR $F(1, 57) = 5.04, p = .029, \text{partial } \eta^2 = .03$, and SV $F(1, 57) = 4.63, p = .036, \text{partial } \eta^2 = .08$. The time \times neuroticism interaction for TPR is illustrated in Figure 5, in which participants were subdivided into high and low neuroticism groups based on a median-split of neuroticism. Post-hoc *t*-tests showed that there was a significant difference in TPR responding to the stress task $t(59) = -2.009, p = .049$ such that participants with high neuroticism showed greater TPR responding to the stress task ($M = 1.29, SD = .30$) than participants with low neuroticism ($M = 1.13, SD = .29$).

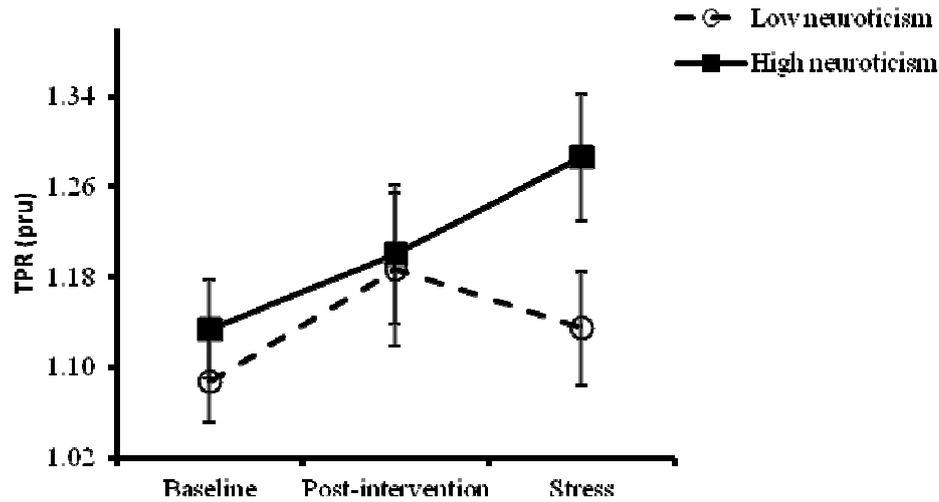


Figure 5. Time \times neuroticism interaction for TPR. Error bars denote standard errors of the mean

Cardiovascular Response Patterns and Psychoticism

The 2 (group; negative training and anti-negative training) \times 3 (time; baseline, post-intervention, and stress) \times 1 (psychoticism) mixed factorial ANCOVAs carried out for each cardiovascular variable revealed significant main effects of time for SBP, $F(1.75, 99.52) = 34.20, p < .01, \text{partial } \eta^2 = .38$, DBP, $F(2, 114) = 44.29, p < .01, \text{partial } \eta^2 = .437$, HR, $F(1.66, 94.60) = 6.02, p = .006, \text{partial } \eta^2 = .10$, and CO $F(1.69, 91.03) = 4.11, p = .03, \text{partial } \eta^2 = .07$. There was no significant main effect of time for TPR or SV. For CO, there was a significant time \times psychoticism interaction at the quadratic level $F(1, 54) = 9.65, p = .003, \text{partial } \eta^2 = .15$. Post-hoc t -tests showed that the level of CO responding at the post-intervention time point for participants low in psychoticism ($M = 5.62, SD = .97$) was significantly greater $t(59) = 2.38, p = .020$, than for participants high in psychoticism ($M = 4.96, SD = 1.21$). This interaction is illustrated in Figure 6 in

which participants were subdivided into high and low psychoticism based on a median split of psychoticism scores.

There was a significant main effect of psychoticism for SV, $F(1, 57) = 4.20, p = .045$, partial $\eta^2 = .07$ and for TPR, $F(1, 57) = 4.70, p = .034$, partial $\eta^2 = .08$. There were no other main or interaction effects for SV but for TPR there was a significant time \times psychoticism interaction at the quadratic level, $F(1, 57) = 5.03, p = .029$, partial $\eta^2 = .08$. Post-hoc t -tests showed that participants high in psychoticism had significantly greater TPR at the post-intervention time point than did participants low in psychoticism $t(37.99) = -2.162, p = .037$ (see Figure 6). The finding of significantly higher TPR responding combined with significantly lower CO responding at the post-intervention time point for participants with high psychoticism points to a vascular hemodynamic response profile following completion of the intervention for these participants.

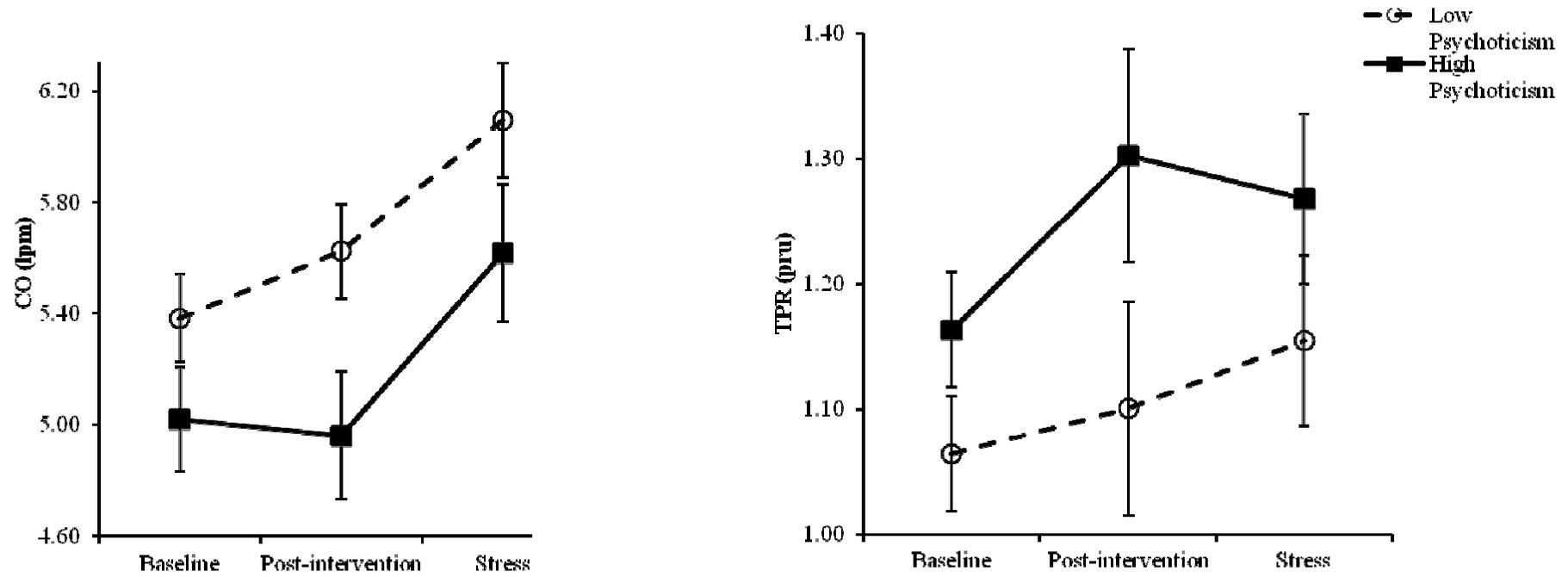


Figure 6. Time \times psychoticism interaction for CO (right) and TPR (left). Error bars denote standard errors of the mean

Self-report Anxiety

The 2 (training group; negative training group, anti-negative training group) \times 2 (time; state anxiety reported at baseline and again on completion of the stress task) \times 1 (neuroticism) mixed factorial ANCOVA carried out to assess the effect of training attention towards emotional faces showed a significant main effect for neuroticism, $F(1, 56) = 9.78, p = .003, \text{partial } \eta^2 = .15$, such that those with high neuroticism scores reported greater anxiety at baseline and post-intervention than those with low neuroticism scores. It also revealed a significant main effect of time, $F(1, 56) = 5.08, p = .028, \text{partial } \eta^2 = .08$, such that STAI scores reported on completion of the stress task were higher ($M = 1.85, SD = .50$) than those reported at baseline prior to commencement of the experiment ($M = 1.74, SD = .41$). This verified the effectiveness of the stress task. The equivalent $2 \times 2 \times 1$ ANCOVA carried out with psychoticism as the covariate showed no main or interaction effects.

Reaction Time

Only correct responses were included in the reaction time analysis. Median reaction times for each participant for pre-training test trials and for post-training trials were calculated. Based on these median reaction times, mean reaction times (and standard deviations) for each training group (negative and anti-negative) were calculated and are presented in Table 9.

Table 9

Mean and (standard deviation) reaction times in seconds for pre-training and post-training trials

	Negative training group		Anti-negative training group	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Pre-training trials				
Negative	.66	.08	.66	.10
Anti-negative	.67	.10	.65	.10
Post-training trials				
Negative	.60	.09	.60	.10
Anti-negative	.63	.10	.60	.08

As in Study 1, a 2 (time: pre-training, post-training) \times 2 (experimental group: negative training group, anti-negative training group) mixed factorial ANOVA was conducted to examine whether the dot-probe task had induced a between-group difference in reaction times to negative information. The ANOVA revealed a significant main effect of time, $F(1, 61) = 23.55, p < .01$, partial $\eta^2 = .28$, such that participants overall were faster to respond to post-training trials ($M = .60, SD = .10$) than to pre-training trials ($M = .66, SD = .09$). The time \times group interaction effect was not significant which indicates that on completion of the intervention participants trained towards negative stimuli were no faster in responding to negative post-training trials than were participants who were trained towards anti-negative stimuli. A similar ANOVA was also conducted for anti-negative trials to examine whether those exposed to the anti-

negative training intervention were faster to respond to neutral words presented post-training than those exposed to the negative training intervention. Again, there was a significant main effect for time $F(1,61) = 16.03, p < .01$, partial $\eta^2 = .21$, such that participants overall were faster to respond to post-training trials ($M = .61, SD = .09$) than to pre-training trials ($M = .66, SD = .10$). The time \times group interaction failed to reach significance. A one-way ANOVA with accuracy score as the dependent variable and training group as the between subjects factor showed no significant between-group difference in correct responses made.

Discussion

The results of the present study show that irrespective of their experimental training group, participants' physiological responding to the experimental protocol overall was determined by individual differences in personality. Participants with high neuroticism evidenced increased physiological responding to the stress task, as indicated by increased TPR, as compared to participants with low neuroticism. When the influence of individual differences in psychoticism on physiological responding to the experimental protocol were examined, the findings revealed that participants with high psychoticism evidenced elevated TPR on completion of the attentional bias intervention, accompanied by a corresponding decrease in CO. In sum, these findings indicate that for participants with high neuroticism, the stress phase of the experimental protocol elicited the greatest physiological arousal. For participants with high psychoticism, physiological reactivity was at its most heightened post-intervention prior to the completion of the stress task. High neuroticism and high

psychoticism were both associated with a vascular hemodynamic response profile.

Mean cardiovascular responses to the post-intervention stressor for those participants trained to direct their attention towards emotionally threatening facial images were not significantly different to those of participants in the anti-negative training group (i.e., the experimental manipulation of attentional bias did not result in between-group differences in anxiety responding to stress). Furthermore, the findings of Study 1 and of Study 2 of individual differences in anxiety responding to stress following the manipulation of attentional bias were not replicated in the present study. The finding that participants with high neuroticism showed increased TPR responding to the stress task, however, is consistent with the findings of Hughes et al. (2011) of attenuated CO responding to stress in participants with high neuroticism. Hughes et al. (2011) suggest that such a response is likely to indicate blunted reactivity to stress. Individuals with high neuroticism encounter sufficient stress in their daily lives as to minimize the salience of a laboratory stressor and result in their disengaging from the task.

The finding that participants with high psychoticism showed reduced CO and increased TPR responding (i.e., a vascular response) following completion of the attentional bias intervention, though not consistent with the findings of Study 2, is perhaps congruous with the type of response that might be expected from individuals with high psychoticism. The lack of empathy for others and poor regard for social norms that define individuals with high psychoticism would likely have influenced the response of participants to the attentional bias intervention. The experience of interpersonal conflict is likely to be more typical for individuals with high psychoticism and as a result exposure to emotionally

threatening and emotionally positive images in the attentional bias intervention appears to have evoked more physiological arousal and been received as more stressful than the stress task itself. Furthermore, as discussed previously, the fact that the stimuli used were photorealistic facial images likely elicited a more visceral, impulsive response than would be elicited by linguistic stimuli.

Although the findings of Study 2 of a significant time \times group \times psychoticism interaction were not replicated in the present study, a similarity can be drawn between the findings of the present study and of Study 2. Participants in Study 2 with high psychoticism who completed the negative attentional bias training showed a vascular response to stress. Participants overall in the present study (i.e., participants in both the negative training group and the anti-negative training group) with high psychoticism also showed a vascular hemodynamic response profile (but in this study the response was elicited by the intervention and not the stress task). The findings of Study 2 and Study 3 together thus point to a vascular hemodynamic response profile in individuals with high psychoticism when responding to tasks construed as stressful.

The present study shares the same key strengths of Studies 1 and 2: experimental manipulation of attentional bias to allow for investigation of causality; examination of objective indices of anxiety in the form of cardiovascular parameters; and investigation of how individual temperaments might influence the impact of the intervention. In addition, this study's use of photorealistic stimuli is an advance on the dot-probe task with linguistic stimuli employed in Study 1 and in much of the existing attentional bias research literature. As discussed previously, a large literature (e.g., Bar-Haim et al., 2007)

supports the use of facial expressions of threat over linguistic stimuli for the purpose of increasing external and ecological validity.

The attentional bias intervention employed in the present study incorporated elements from both Study 1 (the dot-probe task) and Study 2 (photorealistic facial stimuli). The failure to replicate the findings of Study 1 or Study 2 in the present study may be due to a number of factors. Firstly, the valence of the stimuli as a whole is less clear in the present study. The probe detection task uses fewer stimuli than the visual search task (a neutral-negative face-pair as compared to a matrix of nine individual faces) and may be less threatening as a result. Another notable difference between the two tasks employed is the extent to which participants are likely to have processed the threat stimuli. In the visual search task, participants are actively instructed to process the discrepant face (which for participants in the negative training group always displays a negative emotional expression) while for participants in the dot-probe task no such instruction is given, it is merely anticipated that the participant will process the threatening stimulus. Nonetheless, the threat communicated by a matrix of facial expressions is more instinctive and immediate and can thus be said to be eliciting the impulsivity associated with psychoticism. This explains why psychoticism was the individual difference variable of greatest influence in Study 2. Interestingly, Dandeneau et al. (2007) recommended the use of a post-intervention face memory task as a means of confirming that participants were indeed attending to the facial stimuli during training. This is an important consideration for future research. A related point that also warrants consideration is the possibility that participants performing the dot-probe task might have knowledge of the contingency involved between the

location of the dot and the valence of the stimulus. It is likely that some participants might have inferred that the purpose of the dot-probe task was to get them to look at particular stimuli. It is recommended that future researchers systematically track whether participants report this and exclude such participants from analyses.

Although there were no between-group differences in self-report anxiety responding to the stress task, the stress task employed, which was identical to that employed in Study 1, was effective overall in eliciting a stress response as evident from participants self-report levels of anxiety. This finding differs from that of Study 1, in which there was no overall effect for the stress task in the self-report indices of anxiety. As acknowledged in Study 1, however, the ability to assess changes in self-report anxiety from baseline to the stress phase was limited by the use of the State-Trait Anxiety Inventory *trait* form (Spielberger et al., 1983) to assess baseline levels of anxiety. It cannot be ruled out that the absence of an effect then in Study 1 is owing to this limitation in methodology. The finding of the present study is consistent with that of Study 2 in which the serial subtraction task successfully elicited a stress response in the sample overall but there were no between-group differences in the self-report indices of this response.

Examination of response time data showed no overall difference between-groups in responding to post-training trials. However, analysis of the negative and anti-negative training groups separately showed that participants were faster in making a response to the post-training trials than to the pre-training trials. This indicates that the training was having an effect overall in training participants to respond quickly to the appearance of the probe. Heeren et

al. (2012) reported no significant change from baseline to post-training in reaction times for threatening stimuli in those trained towards threat but reported a significant decrease in reaction times for threatening stimuli in those trained away from threat stimuli. As per Study 1, a smaller number of trials (50% fewer) were employed in the present study than were employed by MacLeod et al. (2002) on which the current dot-probe methodology was based. Statistically significant differences may have been more difficult to detect as a result. The experimental protocol of Heeren et al. (2012) consisted of a program of training delivered over four days which is likely to have elicited more significant differences in attentional bias from baseline to post-training. In addition, Yiend (2010) stated that psychopathology-related samples appear to show biased attention to negative stimuli at any level of intensity, whereas higher levels of intensity are required before selective attention is elicited in individuals in the general population.

As the present study employed an experimental design similar to that of Study 1 and Study 2 (i.e., a similar sample of participants, with a similar protocol and similar stress tasks), many of the limitations identified in Study 1 and Study 2 also apply to this study: specifically, carrying out the experiment in a contrived laboratory setting; the use of a female only sample; and the ability to generalize the findings of a healthy undergraduate population to the general population. In turn, the recommendations for future research arising from the present study echo those of Studies 1 and 2: the examination of this effect in a sample of males; the use of a sample of both men and women to allow for the comparison of gender differences; and the measurement of attentional bias in more naturalistic settings in which a greater variety of stress provoking stimuli and situations are present.

A further issue that remains unexamined thus far and which also warrants investigation in future research is whether the effects of attention training towards negative stimuli differ to those observed following simple exposure to negative stimuli. While a number of studies have incorporated a 'no training' condition in which the probe appears in the vicinity of the negative or neutral word with equal frequency (e.g., Amir et al., 2008; See, MacLeod, & Bridle, 2009), existing research studies have not examined whether mere exposure to negative stimuli in the absence of any training contingency has any effect on patterns of attention towards negative information and on subsequent anxiety responses to stress. This research question should form part of the agenda for future research.

Chapter 5

OVERALL DISCUSSION

Integrated Summary of Studies

The present research examined the impact of attentional bias intervention on anxiety responding to stress using physiological indices of anxiety and considered the influence of individual differences in personality on responding to such interventions and to a subsequently presented stress task. The results of studies 1 and 2 are consistent with previous research (e.g., Eldar et al., 2008; MacLeod et al., 2002) showing that the use of systematic contingencies to train attention towards threatening or negative stimuli brings about exacerbated anxiety responding when exposed to stress. The implementation of an attentional bias intervention in a controlled laboratory setting in each study made it possible to test hypotheses regarding the direction of causality between threat-related attentional bias and anxiety. Although there now exists a small but increasing number of studies which have tested the direction of causality, the majority of studies up to this point have taken a cross-sectional approach and focused on establishing the existence of an association between threat-related attentional bias and anxiety rather than on determining the nature of this effect in terms of which variable is causally affecting the other. This study makes an important contribution to the existing literature by introducing the measurement of physiological indices of anxiety to an area of research that up until now has been reliant on participant's own self-report indices of anxiety or, in a small number of cases, on the judgments of independent raters.

The findings reported overall demonstrate the importance of examining the influence of individual difference variables, and specifically neuroticism, and psychoticism, in any investigation of the relationship between biased attention for threat-related stimuli and anxiety responding to stress.

Overview of Study 1

The results of Study 1 show that the manipulation of attentional bias impacts on an individual's anxiety response to stress as measured physiologically, with the precise nature of this impact being determined by individual differences in personality. While it initially appeared that there were no between-group differences in participants' cardiovascular responding to the stress task following the attentional bias manipulation, the inclusion of neuroticism as a covariate in the analyses indicated that individual differences in this personality trait influenced participants' subsequent cardiovascular stress responses in different ways. The subsequent inclusion of psychoticism as a covariate also revealed individual differences in anxiety responding to stress. The experimental design of this study (i.e., implementation of an intervention in a controlled laboratory setting) permitted the testing of the hypothesis that attentional bias manipulation would causally affect subsequent anxiety responding to stress.

The finding that significant group differences in responding to the stress task became apparent only when individual differences in personality were investigated highlights the importance and the value of personality in elucidating important differences in how individuals respond to an attentional bias

intervention. For participants high in neuroticism, the training of attention towards threat disrupted their ability to cope with a subsequent stress task. In contrast, for participants with low neuroticism, it was the training of attention away from threat that brought about exaggerated stress responding. As neuroticism is characterized by a proneness towards negative affect and worry it is not surprising that individuals with high neuroticism that were primed with threatening linguistic stimuli during the intervention would show exacerbated anxiety responses to stress as it is likely that the intervention served to reinforce this characteristic pattern of focusing on more negative information in the environment.

Overview of Study 2

Study 2 employed a face-in-the-crowd task to investigate anxiety responses to stress in those trained to direct their attention towards or away from threatening facial expressions. The use of the face-in-the-crowd task served to overcome criticisms that have been made of linguistic stimuli in terms of ecological validity. Consistent with Study 1, the findings showed that the attentional bias manipulation had a causal influence on participants' anxiety responses to the stress task presented on completion of the intervention. As was also evident in Study 1, between-group differences in responding following the intervention only became apparent when individual differences in personality were taken into account. Similar to Study 1, the findings of Study 2 also showed that participants' responses were influenced by individual differences in psychoticism.

In the negative training group participants with low psychoticism showed more heightened blood pressure responding (both SBP and DBP) to the stressor while participants with high psychoticism showed increased TPR in response to the stressor, indicative of a vascular response profile. These findings showed that regardless of participants' level of psychoticism, being primed with threatening facial images disrupted participants' ability to cope with stress. For participants in the anti-negative training group who were primed with emotionally positive facial images, their ability to cope with the stressor was not affected by the intervention.

Overview of Study 3

Study 3 combined the methodology of Study 1 and Study 2 with the aim of establishing whether the findings of individual differences in anxiety responses to stress following completion of an attentional bias training protocol are brought about as a result of the stimuli employed (linguistic stimuli or photorealistic stimuli) or as a result of the experimental paradigm employed. The use of the dot-probe task represented a replication of the paradigm employed in Study 1. The photorealistic facial stimuli were the same as those employed in Study 2. In contrast to Studies 1 and 2 in which specific hypotheses were formulated regarding the types of effects that were likely to be observed, Study 3 adopted a more exploratory approach. The findings showed that individual differences in personality determined participants' responses to the experimental protocol overall. Participants with high neuroticism evidenced increased physiological arousal in response to the stress task while participants with high psychoticism exhibited elevated physiological responding post-intervention. In

each instance (i.e., for participants with high neuroticism and those with high psychoticism) their patterns of physiological responding were characteristic of a vascular hemodynamic response profile.

Overall Implications of the Findings

The findings of Study 1 and Study 2 that the causal effect of threat-related attentional bias on anxiety responding to stress is in fact discernible at the physiological level bear a number of important implications: (i) physiological indices of anxiety constitute an appropriate means of examining the relationship between threat-related attentional bias and anxiety responding to stress; (ii) effects occur in ways that cannot be detected by self-report measures alone and thus physiological measures should also be examined; (iii) physiological indices eliminate the subjective bias associated with self-report measures of anxiety; (iv) heightened anxiety responding to stress in those with an attentional bias for threatening information may disrupt normal patterns of physiological functioning thereby impairing health; and (v) effects may be occurring outside of conscious awareness and thus are likely to be pertinent in studies of automatic attentional processes where biasing is occurring outside of the individual's awareness.

As discussed in Chapter 1 (Introduction), a number of meta-analyses have reported that attentional bias for threat-related information is evident in both clinically anxious and non-clinical high anxious individuals but not in non-anxious samples (e.g., Bar-Haim et al., 2007). For each of the three studies reported in the present thesis, the sample employed consisted of non-clinical, undergraduate students whose anxiety scores did not fall within the category of

high trait anxiety scores. Nonetheless, analysis of the anxiety indices of participants who were exposed to the intervention that trained attention towards threat-related information showed that a threat-related attentional bias was successfully induced in those participants as evident from their differing patterns of responses to the stress task to which they were subsequently exposed. This demonstrates the importance of examining attentional bias for threat-related information not just in clinical samples but also in non-clinical samples in which individuals have varying levels of trait anxiety. The suggestion that attentional biases are evident in clinical but not in non-clinical samples is also misleading in that it suggests that there exists only those individuals who are anxious and those who are not when in fact anxiety is a dimension on which all individuals vary. Furthermore, the importance of considering individual differences in personality is also relevant to this point. It is apparent that only the most pronounced cases of attentional bias are evident when personality is not considered. Studies 1 and 2 (Chapters 2 and 3) demonstrate that attentional bias is indeed evident in non-clinical samples when individual differences in personality are taken into account.

When considered together, the overall findings of the three studies which showed that participants experienced varying levels of anxiety responding to stress following attentional bias manipulation, contingent on individual differences in personality, bear important implications. As outlined by Bar-Haim (2010), such findings provide support for the hypothesis that the modification of attentional bias for threat-related stimuli causally affects anxiety symptoms. In addition, the findings have important practical implications as they suggest that attention bias training may be employed, in an applied setting, to bring about a

reduction in attentional bias for threat, thus reducing the experience of anxiety for those with a clinical diagnosis of anxiety or with high trait anxiety. While attention training protocols on their own might not reduce anxiety, their use in conjunction with more traditional approaches such as cognitive behavioural therapy (CBT) may prove effective. Attention training protocols have the potential to be adapted to address specific anxieties by matching the stimuli used in training to those associated with the anxiety. Such a protocol could potentially be delivered online alongside a therapist-delivered CBT intervention aimed at shifting the focus of thoughts away from negative information.

Bar-Haim (2010) also highlighted the fact that computer based attention training protocols provide ease of delivery with little need for therapist contact as such programs could be delivered and completed online or via the installation of a software package. Post-treatment access to such training programs would also reduce the likelihood of relapse and help to maintain anxiety reductions achieved in training. MacLeod, Soong, Rutherford, and Campbell (2007) carried out two studies to examine the efficacy of an internet-delivered attentional bias manipulation software package firstly in the assessment of, and secondly in the training of an attentional bias either towards or away from threat-related information. Consistent with previous findings, and in support of the efficacy of internet delivered protocols, the authors reported that (i) participants with generalized anxiety disorder showed attentional vigilance for threat while participants in the control group showed no such vigilance for threat, thus establishing that such protocols possess the capacity to assess attentional bias, and (ii) in their second study, participants trained to attend to negative information showed a vigilance for threat stimuli on post-training assessment

trials thus verifying the capacity of the internet-delivered protocol to manipulate attentional bias.

The findings relating to the influence of individual differences in personality on responding to attentional bias manipulation also have important implications for the way in which attentional bias interventions are delivered. The findings reported in this thesis showed that although all participants were exposed to the same intervention, there were differences in how participants responded to the intervention depending on whether they were high or low in neuroticism (Studies 1 and 3) or psychoticism (Studies 1, 2, and 3). Responses then to the intervention will vary according to how emotionally stable or unstable, impulsive or measured a person is. This highlights the importance of tailoring interventions to suit the individual's temperament rather than adopting a "one size fits all" approach in which the intervention is aimed at the attentional bias specifically and not at the individual.

Future research may also want to investigate the possibility that the lower order structure of facets (i.e., sub-aspects of neuroticism) as assessed by the NEO-Personality Inventory Revised (NEO-PI-R; Costa & McCrae, 1992) which include anxiety, self-consciousness, depression, vulnerability, impulsiveness, and angry hostility, may shed more light on the nature of the relationship between individual differences in neuroticism and anxiety responding to stress following attentional bias manipulation. It is worth noting however, that such sub-aspects have lower construct validity than the main traits in the EPQ or NEO models. In a recent study examining the predictive value of personality factors and facets in subjective well-being, Marrero Quevado and Carballeira Abella (2011) reported

Cronbach's alphas ranging from .81 to .88 for the Big 5 factors and ranging from .33 to .79 for facets.

Limitations of the Present Research

The participants employed in each of the three studies reported above consisted of English speaking under-graduate students attending an Irish university. The physiological measurements of young, healthy, adults that were obtained from this sample would not be expected to differ greatly over time to the extent that they would not still be representative of a similar sample of young adults assessed at a future point in time or indeed, of a sample that has been assessed in the past. In addition, these measurements would not be expected to differ significantly to those that might be obtained from a similar sample of individuals in a different geographic location. Therefore, the physiological data gathered from this sample does not pose a problem to the ability to generalize from these findings. One possible limitation of the sample, however, relates to the fact that the participants were university students. This questions our ability to generalize from these findings to non-university attending individuals, those who are illiterate and those of low socio-economic status. It is not possible to state with certainty that these findings would apply to non-university attending individuals. Furthermore, it is arguable that the impact of the stress tasks and of the threat stimuli employed might be different depending on the cultural background of the participant. It is acknowledged that the results may not generalize perfectly across cultures given differences in taboos and other associations between symbols and threats.

The psychometric measures employed in each of the studies reported consisted of measures that have been well-validated over time and that were shown to have satisfactory levels of construct validity in the present studies also. The use of psychometric measures necessitates that participants be able to read in order to complete the measure. Once again this questions the ability to generalize from these findings to a non-university attending sample with lower literacy levels. This being acknowledged, this is an issue that could be raised about any study which involves the completion of psychometric measures. Furthermore, Study 1 employed a dot-probe task with linguistic stimuli. Although participants were not instructed to do so, it was anticipated that they would read the stimuli appearing on screen and process their semantic meaning. The use of facial stimuli in Studies 2 and 3 offers one means by which to overcome this possible limitation as literacy levels are not likely to interfere with the ability to perceive facial representations of threat.

The majority of the literature concerned with the association of maladaptive stress responses with poor cardiovascular health outcomes has focused on those individuals who are at a high risk for experiencing cardiovascular disease or a related outcome so as to minimize the likelihood, and in cases where it is unavoidable, to reduce the severity of this occurrence. The question then arises as to why a sample of healthy young adults should be examined when they are at little risk of experiencing a cardiovascular event, and of what relevance are findings that relate to such samples? The importance of examining a sample of healthy young adults is reflected in the fact that shifts in blood pressure within a healthy population are indicative of future risk for poor cardiovascular outcomes and as such are a marker of future ill-health. The

identification of unhealthy cardiovascular profiles that contribute to the life-long development of cardiovascular disease is critical to developing ways to prevent such outcomes.

Each of the three studies reported in this thesis were conducted in a controlled laboratory setting. The laboratory setting is, admittedly, an artificial one. For this reason it is often argued that studies that are conducted in a contrived laboratory setting are limited in the extent to which the findings can be generalized to real-world settings in which a number of different factors can impinge on and are likely to be influencing an individual's behavior at any one time. It is for this very reason however that the use of a laboratory setting is also advantageous as it permits control over extraneous variables likely to influence the emotional, physiological and/ or behavioural responses being examined. The use of a controlled laboratory setting was necessary in this research in order to demonstrate the nature of the cause and effect relationship arising from the threat-related attentional bias that was implemented. For this reason, the laboratory setting can be considered an advantage, rather than a limitation, of the present research.

Future Research

Future research examining attentional bias towards threatening information in clinical samples should examine the influence of individual differences in personality on anxiety responses to stress using physiological indices of anxiety as employed in the studies reported in the present thesis. The examination of individual differences in personality may prove to be more

informative in a clinical population than in the non-clinical populations examined in the present thesis. Personality scores for participants examined in each of the three studies reported tended to lie around the middle of the continuum with little if any of the participants showing extremely low or high scores on any of the traits tested. It is to be expected that a clinical population would show greater variation and more extreme scores with this serving to further elucidate the impact of personality on responding to attentional bias intervention and subsequent stress. The present research did not include a follow-up meeting with participants in order to assess the longevity of the training effects observed. Such a consideration is warranted in future research.

Overall Conclusions

The numerous attempts to characterize and define anxiety reflect the fact that it is a commonly experienced emotional state. Anxiety can best be described as a complex, normal, innate response to stress which in evolutionary terms serves an adaptive function of protection from harm but which in its exaggerated form disrupts both psychological and physical health. The cognitive approach to anxiety considers as central, and indeed *causal*, the role of information processing in the experience of anxiety. The present research affirms the cogency of this approach and equally importantly, demonstrates that the experience of anxiety in the presence of stress can be attributed not only to the cognitive processing of information but also to underlying biological responses. This suggests that cognitive and biological factors are modifiable in unison in ways that help us to explain what anxiety is and how it might be tempered.

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APPENDIX A

CONSENT FORM



Participant Identification Number:

Title of Project: Anxiety and Stress responsivity

Name of Researcher: Niamh Higgins

I confirm that I have read the information sheet for the above study and have had the opportunity to ask questions.

I am satisfied that I understand the information provided and have had enough time to consider the information.

I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my legal rights being affected.

I agree to take part in the above study.

Name of Participant

Date

Signature

Researcher

Date

Signature

APPENDIX B

Dot-Probe Task Linguistic Stimuli**Subset A**

Negative	Neutral
Suffer	Parked
Wound	Dried
Attacks	Physics
Victims	Smelled
Tease	Aisle
Discouraged	Connections
Gloomy	Pastel
Tormented	Mythology
Panicky	Clarets
Insecure	Fetching
Horror	Wagons
Dead	Data
Afraid	Detail
Bitter	Handle
Evil	Hill
Fright	Sipped
Disease	Remarks
Worthless	Batteries
Rejected	Quantity
Bomb	Crew
Worst	Owned
Catastrophe	Approximate
Lethal	Racket

Ignored	Lighted
Tragic	Rector
Terror	Pupils
Trap	Tent
Hazard	Ballot
Hopeless	Feathers
Inadequate	Transition
Forlorn	Keyhole
Coffin	Edited
Strangled	Signature
Apprehension	Instrumental
Fear	Note
Trouble	Evening
Worry	Inner
Enemy	Check
Distress	Creature
Nausea	Confer
Tragedy	Request
Sad	Pat
Suffered	Recorded
Destroyed	Furniture
Damage	Campus
Harm	Pond
Inferior	Shearing
Sluggish	Textured

Subset B**Negative**

Grave

Cancer

Desperate

Danger

Defeat

Shot

Trauma

Kill

Worried

Powerless

Devastated

Angry

Threat

Severe

Sinister

Assault

Lost

Despised

Humiliated

Injury

Intimidated

Awful

Mourn

Scared

Conflict

Dull

Murder

Neutral

Filed

Saddle

Variables

League

Museum

Cars

Enjoin

Shop

Context

Multitude

Stagecoach

Curve

Varied

Recall

Integral

Bottles

Read

Tomatoes

Waterproof

Holder

Coefficient

Tract

Scans

Planet

Detailed

Flew

Junior

Agitation	Fireplace
Incurable	Reclaimed
Stress	Cities
Hostile	Rolling
Pain	Laws
Grieving	Hallmark
Sickly	Tokens
Cry	Via
Anxiety	Journal
Dying	Lists
Hurt	Core
Mutilated	Decanting
Suffocating	Constituent
Lonely	Jersey
Pathetic	Cleaners
Violent	Thereby
Hatred	Fitted
Midway	Dismal
Futile	Attire
Deathbed	Softener
Unhappy	Bridges

APPENDIX C

Words presented in the Speech Performance Task

Academic

Beginning

Building

Century

Degree

Doctor

Early

Evening

Expensive

Funny

Interview

Lecturer

Order

Poetry

Present

Private

Story

Student

Symptom

Water

Material

Important

Medicine

Music

Picture

Public

August

Bottle

APPENDIX D

Facial stimuli presented in the Face-in-the-crowd task

Emotionally positive stimuli



Emotionally threatening stimuli

