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Malleability of Attentional Bias for Positive Emotional Information and Anxiety Vulnerability

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Abstract

Recent research supports a causal link between attentional bias for negative emotional information and anxiety vulnerability (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002). However, little is known about the role of *positive* emotional processing in modulating anxiety reactivity to stress. In the current study we used an attentional training paradigm designed to experimentally manipulate the processing of positive emotional cues. Participants were randomly assigned to complete a computerized probe detection task designed to induce selective processing of positive stimuli or to a sham condition. Following training, participants were exposed to a laboratory stressor (i.e., videotaped speech), and state anxiety and positive affect in response to the stressor were assessed. Results revealed that individual variability in the capacity to develop an attentional bias for positive information following training predicted subsequent emotional responses to the stressor. Moreover, individual differences in social anxiety, but not depression, moderated the effects of the attentional manipulation, such that, higher levels of social anxiety were associated with diminished attentional allocation toward positive cues. The current findings point to the potential value of considering the role of positive emotional processing in anxiety vulnerability.

Keywords

Anxiety vulnerability; attention; positive; individual differences; social anxiety; information processing

Cognitive theories of emotional disorders propose that anxiety vulnerability arises in part from the operation of selective processing biases that automatically favor negative emotional information (e.g., Mathews & MacLeod, 2005; Williams, Watts, MacLeod, & Mathews, 1997). According to these accounts, people differ in their tendency to preferentially allocate attention toward negative emotional cues under conditions of heightened stress, which in turn, confers differential susceptibility to anxiety. In support of these theories, recent experimental evidence suggests that individual differences in the readiness to develop an attentional bias for negative information, under experimental conditions that actively promote its acquisition, predicts the subsequent elevation of anxiety in response to laboratory-induced (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002) and

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naturally occurring stress (Clarke, MacLeod, & Shirazee, 2008). Little consideration, however, has been afforded to the role of *positive* attentional processing in cognitive theories of anxiety vulnerability. Accordingly, the goal of the current study was to examine the link between individual variability in the capacity to selectively allocate attention toward positive emotional information and emotional reactivity to an experimental stressor.

Recent experimental investigations support a direct link between attentional bias for negative information and anxiety vulnerability. In a seminal study, MacLeod et al. (2002) used a variant of the traditional probe detection task (MacLeod, Mathews, & Tata, 1986) designed to induce selective processing of either threatening or neutral cues by requiring participants to respond to a visual probe that consistently appeared following words of negative or neutral valence. Although participants were not explicitly instructed to direct their attention to a particular cue, the experimental contingency embedded in the paradigm was designed to lead to the development of a biased attentional response to the target stimuli. Consistent with their assigned training contingency, the experimental groups developed differentially biased attentional responses to negative emotional stimuli. Moreover, the group of participants trained toward negative emotional information displayed the greatest increase in anxiety and depression in response to an experimental stressor (i.e., attempting to solve insoluble anagrams). Subsequent extensions of this work in healthy (See, MacLeod, & Bridle, 2009), high anxious (Amir, Weber, Beard, Bomyea, & Taylor, 2008), and clinically anxious populations (Amir, Beard, Burns, & Bomyea, 2009; Amir et al., 2009; Schmidt, Richey, Buckner, & Timpano, 2009) have demonstrated that the experimental manipulation of attention *away* from negative stimuli leads to attenuated anxiety vulnerability as well as reductions in symptoms of anxiety. Considered together, accumulating evidence supports the experimental malleability of attentional bias for negative emotional information as well as its causal role in mediating anxiety reactivity to stress.

A notable feature of prior attentional malleability studies is that participants varied widely in the degree to which the experimental procedures evoked selective attentional allocation toward the target stimuli. This finding suggests that individuals may differ in their readiness to preferentially process emotional information of a particular valence when the development of such a bias is rendered temporarily adaptive (Clarke et al., 2008). Moreover, this individual variability may predict subsequent emotional reactivity in response to stress. For example, in a sample of healthy undergraduate students beginning their first year of university, Clarke et al. (2008) found that individual differences in the ease with which an attentional bias toward negative emotional cues could be evoked by an experimental attention training procedure predicted the degree to which trait anxiety became elevated by the end of the semester. These findings suggest that attentional modification procedures may be particularly sensitive to revealing individual differences in one's readiness to selectively process emotional information hypothesized to be important in regulating emotional reactivity to stress.

Although cognitive theories of anxiety propose a link between attentional bias for negative stimuli and susceptibility to elevated states of anxiety, they are largely silent regarding the role of *positive* emotional processing in the attention-anxiety vulnerability relationship. These deficiencies are notable given that research increasingly points to the existence of two relatively distinct systems that regulate positive and negative emotional functioning (e.g., Davidson, Jackson, & Kalin, 2000; Diener & Emmons, 1985; Gable & Berkman, 2008). Thus, knowing how individuals process negative emotional information may tell us little about the way in which they process positive emotional information.

There are at least two lines of empirical evidence that point to a link between positive emotional information and anxiety vulnerability. First, research suggests that individual variability in the capacity to experience positive emotions confers differential resiliency to stressful life events (for reviews see Folkman & Moskowitz, 2000; Fredrickson, 2001). For example, research has shown that positive emotions help to speed physiological recovery following exposure to threat-provoking situations (Tugade & Fredrickson, 2004) and buffer people against increases in negative affect following naturally occurring crises (Fredrickson, Tugade, Waugh, & Larkin, 2003). Thus, positive emotions may serve to down-regulate or “undo” negative emotions in response to stress (Fredrickson, 2001). Although these studies inform us about how the *experience* of positive emotions influences stress reactivity, they provide little insight into the cognitive mechanisms involved in the *processing* of positive emotional information and anxiety vulnerability.

A second line of research suggests that the tendency to preferentially allocate attention toward positive cues in one’s environment may also play a role in attenuating negative emotional reactivity to stress. For example, Joormann, Talbot, and Gotlib (2007) found that following a negative mood induction, adolescent girls identified as low-risk for the later development of psychopathology displayed attentional shifts toward positive emotional cues, a tendency not exhibited by their high-risk counterparts. Moreover, one recent study found that undergraduate participants who received instructions to direct their attention toward positive cues during a modified probe detection task reported significantly less frustration in response to a stressful anagram task compared to participants not given instructions to modulate their attention (Johnson, 2009). Considered together, these findings suggest that allocating attention toward positive stimuli may promote adaptive emotion regulation under conditions of heightened stress (see also Gotlib, McLachlan, & Katz, 1998; Lee & Telch, 2008). However, the majority of previous studies have used correlational research designs and are therefore limited in establishing a direct link between positive attentional processing and emotional vulnerability.

To our knowledge, only one study has experimentally manipulated attentional deployment toward positive stimuli using a cognitive bias modification procedure and examined subsequent reactivity to stress. Adapting the attentional training paradigm described above (e.g., MacLeod et al., 2002), Wadlinger and Isaacowitz (2008) trained healthy undergraduate participants to selectively attend to either positive or neutral information. Participants then saw a series of negative images. Visual fixation time to the negative images was used as a proxy for emotional reactivity. Participants who were trained to allocate their attention toward positive stimuli spent significantly less time attending to negative images after, but not before training, relative to the attend-neutral group. The authors suggested that the positive attentional training facilitated effective emotion regulation by promoting gaze aversion from negative emotional stimuli. Although these findings are consistent with the role of positive attentional processing in modulating stress reactivity, this study did not implement a direct assessment of participants’ emotional reactions to the stressor and did not measure the effect of the manipulation on change in attention toward positive stimuli.

Accordingly, the primary goal of the current study was to examine the link between individual differences in the experimental malleability of attention toward positive emotional information and emotional reactivity to stress. Consistent with previous research (e.g., Clarke et al., 2008), we administered an assessment of attentional bias for positive information before and after the experimental manipulation. We also used tightly controlled laboratory methods to provoke stress and measured change in subjective anxiety as well as positive emotions in response to the stressor. We hypothesized that greater attentional shifts toward positive stimuli as a result of the attentional training manipulation would be associated with attenuated anxiety reactivity to the stressor. Moreover, given previous

research suggesting a link between attentional bias for positive stimuli and positive emotions (e.g., Tamir & Robinson, 2007), we expected that larger attentional shifts toward positive stimuli would be associated with a greater preservation of positive emotions from before to after the stressor.

A second issue regarding the interpretation of extant research is that previous studies have relied on using control conditions that actively trained attention in the opposite direction from the target emotional stimuli (i.e., away from negative stimuli, MacLeod et al., 2002; or away from positive stimuli, Wadlinger & Issacowitz, 2008). Such methodological designs obscure the unique effects of manipulating attentional allocation for the target emotional cues. Thus, our second goal was to employ a control condition where there was no contingency between the location of the positive stimuli and the location of the probe (Amir et al., 2008). As this experimental condition offers no advantage to develop a preferential attentional response either toward or away from the target emotional stimuli under investigation, we would not expect to see a meaningful relationship between change in attentional bias for positive stimuli and emotional responses to the stressor.

Although individuals vary in their responses to experimental procedures designed to evoke selective processing of emotional information, little consideration has been given to factors that may account for these individual differences. As an initial step toward addressing that issue, our third aim was to examine the effect of two individual difference variables hypothesized to influence attentional processing of positive information, namely level of social anxiety and depression. Social anxiety and depression are both characterized by low positive affect (Brown, Chorpita, & Barlow, 1998; Hughes et al., 2006; Naragon-Gainey, Watson, & Markon, 2009) as well as biased processing of positive emotional information (e.g., Alden, Taylor, Mellings, & Laposa, 2008; Levens & Gotlib, 2009; Yoon, Joormann, & Gotlib, 2009). Most relevant to the present study, several studies using probe detection tasks have found that social anxiety is associated with a tendency to direct attention *away* from positive emotional cues (e.g., Chen, Ehlers, Clark, & Mansell, 2002; Mansell, Clark, Ehlers, & Chen, 1999; Pishyar, Harris, & Menzies, 2004; see also Perowne & Mansell, 2002; Veljaca & Rapee, 1998), a bias that appears to reverse after reduction in social anxiety symptoms following treatment (Pishyar, Harris, & Menzies, 2008). In a similar vein, depressed individuals have been shown to lack the selective positive attentional bias shown to characterize healthy controls (e.g., Gotlib et al., 1988; Joormann & Gotlib, 2007). Considered together, these findings suggest that social anxiety and depression may be associated with a disrupted ability to access and adequately process positive emotional information. Thus, we hypothesized that the effects of the attentional training procedure on change in attention bias for positive stimuli would be moderated by individual differences in level of social anxiety and depression.

Method

Participants

Participants were 77 individuals (30 men, 47 women) drawn from a pool of undergraduate students at a large university (mean age = 19.17, $SD = 2.73$). Students were offered course credit for their participation.

Materials and Tasks

Baseline Self-report Measures—To examine the effects of social anxiety and depression on participants' response to the attentional training procedure, participants completed the Liebowitz Social Anxiety Scale–Self-report version (LSAS-SR; Liebowitz, 1987) and Beck Depression Inventory II (BDI-II; Beck, Steer, & Brown, 1996). The LSAS-

SR consists of 24 social situations, and individuals are asked to rate both their level of *Fear* and *Avoidance* for each situation on a 4-point scale ranging from 'none/never' to 'severe/usually'. Items are summed to create a total score reflecting social anxiety severity. The LSAS-SR displays strong psychometric properties that converge with the interviewer-administered LSAS (Fresco et al., 2001). The BDI-II is a 21-item self-report inventory that assesses severity of depression during the past two weeks. The BDI-II is widely used in psychopathology research and demonstrates excellent psychometric properties (e.g., Beck et al., 1996; Dozois, Dobson, & Ahnberg, 1998). Internal consistency was adequate in the current sample (Cronbach's $\alpha = .93$ and $.85$ for the LSAS-SR and BDI-II, respectively).

Emotional Reactivity Assessment—The Spielberger State-Trait Anxiety Inventory – State subscale (STAI-S; Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) was used as the primary outcome measure to assess change in participant anxiety following exposure to the social stressor (speech task). The STAI-S comprises 20 items and participants were asked to rate the items according to how they *currently feel*. Each item is rated on a 4-point Likert-type scale ranging from *not at all* to *very much so*. Higher scores reflect higher levels of anxiety. The STAI-S has strong psychometric properties (Spielberger et al., 1983). Participants rated their anxiety prior to and immediately following the speech task in order to evaluate the effects of the experimental manipulation on participants' subjective feelings of anxiety and discomfort following exposure to the social stressor. Internal consistency of this scale was adequate in this sample (Cronbach's $\alpha = .93$, $.92$ for pre- and post-stressor ratings, respectively).

Given research suggesting that positive emotions are important in modulating stress reactivity (Folkman & Moskowitz, 2000; Fredrickson, 2001), we also assessed changes in positive affect (PA) from before to after the stressor. PA was measured using five items (pleased, friendly, satisfied, happy, enthusiastic) used in previous research on positive emotional functioning in social anxiety (Kashdan & Steger, 2006; see also Deiner & Emmons, 1985). Items were rated on a five-point Likert-type scale with anchors of *very slightly or not at all* to *extremely*, and were summed to create a total PA score (Cronbach's $\alpha = .93$, $.92$ for pre- and post-stressor ratings, respectively). Higher scores reflected greater subjective PA.

Stimuli for Probe Detection Tasks—The emotional stimuli used in the attention bias assessment and training procedures comprised social-evaluative words of positive valence taken from previous information processing studies in social anxiety (Dozois & Frewen, 2006). We created two sets of 12 word-pairs (sets A and B). Each pair comprised one positive word (e.g., likeable) and one neutral word (e.g., couch) matched in frequency and length. Neutral words were selected to represent a common category (i.e., household items).

The word sets were allocated to the assessment and training blocks following procedures used in previous research (e.g., Clarke et al., 2008). Participants in each condition were randomly assigned to receive a particular word set during the pre-assessment (e.g., set A) and were tested following the training block using stimuli from the other word set (e.g., set B). The training block employed the stimulus set used during the pre-assessment block. Thus, the stimuli used during each assessment block had never been previously encountered during the experimental task, thereby allowing us to test for generalizability of the training to a new set of materials.

Attention Bias Assessment Task—To examine the malleability of attentional allocation toward positive emotional information, participants completed a probe detection task (MacLeod et al., 1986) before and after the experimental training procedure. Each trial began with a fixation cross presented in the center of the computer screen for 500ms. The

cross was then replaced by a positive-neutral word pair presented in the center of the screen for 500ms, one word 3cm above the other. The words then disappeared and a probe (i.e., the letter “E” or “F”) appeared immediately in the location of one of the two words. Participants were instructed to press a mouse key corresponding to whether the letter was an E or an F. The letter probe remained on the screen until the participants responded. Response latencies to identify the probe were recorded from the onset of the presentation of the letter probe to the button press. After the participant responded, a blank screen appeared for 500ms before the next trial began with a fixation cross. Participants were presented with 96 trials—each consisting of a positive-neutral word pair—comprising all combinations of Probe Type (E or F), Probe Location (Top or Bottom), and Positive Word Location (Top or Bottom): 2 (Probe Type) $\times$ 2 (Probe Location) $\times$ 2 (Positive Word Location) $\times$ 12 Positive-Neutral Word Pairs. Trials were presented in a new random order to each participant. The first 10 trials were considered practice trials and were therefore excluded from the attention bias assessment blocks. Participants were seated approximately 30cm from the computer screen. Stimuli were presented in 12-point Arial font in black on a grey background. The computer program was written in Delphi (Embarcadero, Inc.) for this experiment.

Experimental Conditions

Attention Toward Positive (ATP)—The ATP consisted of the probe detection paradigm described above, modified to facilitate an attentional bias toward positive material. In this case, the probe always replaced the positive word (e.g., Wadlinger & Isaacowitz, 2008). As in the probe detection task described above, the neutral and positive words appeared equally often in the top and bottom positions. Participants completed 384 trials: 2 (Probe Type: E, F) $\times$ 2 (Positive Word Location: Top, Bottom) $\times$ 12 Positive-Neutral Word Pairs, repeated 8 times. Thus, although there was no specific instruction to direct attention toward the positive word, on all trials, the position of this type of word indicated the position of the probe.

Attention Control Condition (ACC)—The control condition was identical to the ATP procedure except that on each trial the probe appeared with equal frequency in the position of the positive and neutral words. Thus, there was no contingency between the position of either positive or neutral words and the position of the probes, and therefore there would have been no advantage to developing biased attentional responding (see Amir et al., 2008).

Social Stressor—To assess the effects of the training procedure on emotional reactivity to a stressor, participants completed an impromptu speech (see Amir et al., 2008 for details). The experimenter informed participants that their speech would be video recorded so that it could later be rated by a graduate student for its quality. Participants chose one topic for their speech selected from a list of 5 topics used in previous research (abortion, corporal punishment, seatbelt laws, nuclear power, and the American health system; Hofmann, Newman, Ehlers, & Roth, 1995). Following a two-minute preparation period, participants were instructed to stand in a designated area in front of a video camera to deliver the speech. The behavioral assessment ended after 5 minutes or when the participant stated that he or she wanted to stop.

Procedure

Upon arrival to the laboratory, participants provided informed written consent and completed the baseline measures (i.e., demographics questionnaire, LSAS-SR, and BDI-II). Participants were randomly assigned to either the Attention Toward Positive (ATP, $n = 43$) or the Attention Control Condition (ACC, $n = 34$). The experimenter and participants were blind to group assignment. Next, participants completed three blocks of the probe detection task – pre-training assessment, training (ATP or ACC), and post-training assessment. Instructions for these tasks were presented on the computer and were identical for both

conditions. After completing the computer task, participants completed the STAI-State and PA scale to obtain a pre-stressor index of affect. Next, participants completed the speech task (described above), and completed a post-stressor STAI-State and PA scale, after which they were debriefed and thanked for their participation. During debriefing, participants were asked about their hypotheses concerning the purpose of the study and whether they detected any patterns between the word stimuli and visual probes during the computer tasks. No participants correctly ascertained the true purpose of the study, nor the training contingency in the ATP.

Results

Preliminary Analyses and Data Preparation

Demographic and Clinical Characteristics—Table 1 presents demographic information and self-report symptom scores for participants in the ATP and ACC groups. Participants in the two conditions did not differ on any of the demographic or symptom measures, all $p > .10$.

Computation of the Positive Attentional Bias Index—Prior to the main analyses, response latency data from the attention bias assessment blocks were prepared in keeping with recommendations from Ratcliff (1993). First, trials with incorrect responses were removed (3.76%). Response latencies less than 100ms or greater than 2000ms were eliminated from analysis of the pre- and post-training assessment tasks (1.00% of trials with correct responses). Response latencies ± 2.5 SD from each participant's mean response latency were also eliminated from analysis of the pre- and post-training assessment tasks, respectively (2.71% of remaining trials).

To examine the degree to which the attentional training procedure facilitated attention toward positive emotional information, we first calculated an attentional bias score for the pre- and post-training assessment blocks (see MacLeod & Mathews, 1988; MacLeod et al., 2002): Participant's mean response latency to correctly identify probes appearing in the vicinity of the positive words was subtracted from their mean response latency to correctly identify probes in the vicinity of neutral words. Thus, a positive attentional bias score reflected speeded latencies for probes in the vicinity of positive words, indicating greater attentional bias toward positive information. In contrast, a negative bias score reflected a relative slowing to respond to probes following positive words relative to neutral words, thereby indicating an attentional avoidance of positive information. In keeping with previous research (Clarke et al., 2008; MacLeod et al., 2002), an index of the readiness to develop an attentional bias toward positive stimuli was computed by subtracting the pre-training bias score from the post-training bias score. Thus, higher scores reflected the degree to which participants shifted their attentional allocation toward positive information from before to after training. In keeping with the premise that people are differentially predisposed to acquire an attentional bias for positive information, participants displayed substantial variability in the degree to which the experimental manipulation elicited attentional shifts toward positive stimuli from before to after training (ATP: $M = -0.91$, $SD = 38.94$, range -59 to +116; ACC: $M = -11.76$, $SD = 46.20$, range -134 to +92).

Computation of the Emotional Reactivity Indices—We created two indices of emotional reactivity by subtracting pre-stressor ratings of state anxiety (STAI-S) and PA from post-stressor ratings of state anxiety and PA, respectively (Maris, 1998). Thus, higher scores reflected a greater increase in anxiety or PA in response to the speech. Participants in both conditions displayed substantial variability in their emotional response to the stressor (ATP: change in anxiety, $M = 5.67$, $SD = 6.28$, range -5 to +18; change in PA: $M = -0.88$,

$SD = 2.80$, range -7 to $+5$; ACC: change in anxiety: $M = 6.56$, $SD = 7.89$, range -14 to $+26$; change in PA: $M = -1.50$, $SD = 3.38$; range -7 to $+9$).

Main Analyses

Do Individual Differences in the Readiness to Selectively Allocate Attention toward Positive Information Predict Subsequent Emotional Reactivity to Stress?—Prior to conducting the main analyses, we screened for multivariate outliers by examining leverage and Cook's distance values. This procedure did not identify any influential outliers. Consistent with previous experimental research on attention and anxiety vulnerability (Clarke et al., 2008; MacLeod et al., 2002), we computed Pearson's correlations to examine the relationship between change in attentional bias for positive cues and emotional reactivity to the stressor following exposure to the attentional training task. Results indicated that in the ATP group, change in attentional bias was negatively correlated with change in anxiety $r(43) = -.40$, $p = .007$, and positively correlated with change in positive affect, $r(43) = .40$, $p = .008$. Thus, a greater tendency to shift attention toward positive cues following training predicted attenuated anxiety reactivity and heightened positive emotional reactivity to the speech. See Figure 1.

To examine the possibility that the degree to which participants develop a positive attentional bias through repeatedly encountering positive emotional information during the probe detection task alone would be associated with emotional reactivity to the stressor, we examined these same relationships in the ACC group. Results revealed that change in attentional bias for positive stimuli was not significantly correlated with emotional reactivity to the stressor [change in anxiety: $r(34) = .16$, $p = .38$; change in PA: $r(34) = -.17$, $p = .35$]. See Figure 2. To examine whether the association between change in attentional bias for positive stimuli and emotional reactivity differed in the two conditions, we compared the correlation coefficients in the ATP and ACC groups using a Fisher's z transformation. Results revealed that the correlation coefficients differed significantly from one another for both change in anxiety, $z = -2.44$, $p = .014$ and change in PA, $z = 2.49$, $p = .013$.

Does Social Anxiety and/or Depression Moderate one's Readiness to Selectively Allocate Attention toward Positive Stimuli?—Hierarchical regression analyses were used to test the hypothesis that level of social anxiety and/or depression would moderate the effect of the attentional training procedure on malleability of attention toward positive stimuli. Treatment condition (ATP, ACC) and social anxiety (LSAS total score) or depression (BDI-II total score) served as predictors. Change in attentional bias for positive information from pre- to post-training served as the dependent variable. Prior to the analyses, continuous predictor variables included in interaction terms were centered and categorical variables were dummy coded following the recommendations of Aiken and West (1991). The two predictor variables, Condition and LSAS (or BDI-II), were entered separately in steps one and two of the regression equation, respectively. The Condition $\times$ LSAS (or Condition $\times$ BDI-II) interaction term was entered in step three of the regression analysis. Significant interactions were probed in two ways: First, we conducted a simple slope analyses within Condition (Aiken & West, 1991) in order to examine whether social anxiety and/or depression were associated with attention malleability following the experimental manipulation. Second, we conducted a regions of significance analysis using the Johnson-Neyman technique (Johnson & Neyman, 1936) to identify the specific values of the moderator at which the experimental groups significantly differed on change in attentional bias for positive information. This analysis was implemented using an SPSS macro developed by Hayes and Matthes (2009).

Table 2 presents the results of the hierarchical regression analysis. For the analysis involving LSAS, results revealed a significant Condition $\times$ LSAS interaction, $\Delta R^2 = .05$, $p = .04$, which indicated that level of social anxiety moderated the effect of the attentional training procedure on change in attentional bias for positive stimuli. To explicate the nature of the significant interaction, we examined the simple effects of social anxiety on change in attentional bias in individuals in the ATP versus ACC conditions (see Aiken & West, 1991). Results revealed that social anxiety was negatively associated with change in bias in the ATP group, $\beta = -.44$, $t = -2.45$, $p = .02$, suggesting that as level of social anxiety increased, shift in attentional allocation toward positive stimuli decreased following training. In contrast, the association between social anxiety symptoms and change in attention bias in the ACC group was not significant, $\beta = .04$, $t = .29$, $p = .78$. A regions of significance analysis identified 30.49 on the LSAS as a point of transition between a statistically significant and a statistically non-significant effect of the manipulation, $B = 24.00$ ($SE = 12.04$), [$t(73) = 1.99$, $p = .05$]. Specifically, this analysis revealed that for LSAS scores below 30.49 to the lowest value observed (LSAS = 5), the ATP group displayed a significantly larger increase in attentional bias for positive stimuli relative to the ACC group. However, at LSAS scores above 30.49 to the maximum observed value (LSAS = 87), the ATP and ACC groups did not differ significantly on change in attentional bias. See Figure 3.

The regression analysis involving depression as the hypothesized moderator revealed that the critical Condition $\times$ BDI-II interaction was not significant, $\Delta R^2 = .01$, $p = .41$. These findings indicated that level of depression did not influence participants' responses to the attentional training procedure, which suggests specificity of the present findings to social anxiety. See Table 2.

Given the influence of social anxiety on the attentional training procedure, we wanted to establish whether individual differences in attention malleability for positive information following training continued to be associated with emotional reactivity to the stressor after controlling for level of social anxiety. To address this issue, we computed partial correlations between change in attentional bias for positive stimuli and change in anxiety/PA while controlling for LSAS scores. These analyses revealed that change in attentional bias for positive information remained significantly correlated with change in anxiety, $r(43, df = 40) = -.33$, $p = .03$ and change in PA, $r(43, df = 40) = .31$, $p = .05$, when controlling for level of social anxiety. Thus, although social anxiety moderated attentional responses to the experimental training procedure, it did not account for the positive attention-emotional reactivity relationship.

Discussion

Previous research suggests a causal link between attentional bias for negative emotional information and susceptibility to heightened anxiety in response to stress (e.g., Amir et al., 2008; Clarke et al., 2008; MacLeod et al., 2002). The current study extended this research by examining the relationship between individual differences in the capacity to selectively allocate attention toward *positive* stimuli and subsequent emotional reactivity to stress. We found that participants who displayed the greatest shift in attentional allocation toward positive stimuli following the experimental attentional training procedure exhibited the *least* anxiety reactivity to the stressor. These findings suggest a direct link between attentional bias for positive emotional information and subjective emotional reactivity to stress. Moreover, we were able to identify an individual difference variable that accounted in part for variability in the readiness to develop an attentional bias for positive information under experimental conditions designed to encourage its acquisition. Within the group of participants trained to selectively attend toward positive emotional cues, greater level of

social anxiety was associated with diminished processing of positive information. These findings suggest that social anxiety may interfere with one's ability to take advantage in what, to non- socially anxious individuals, are stress-offsetting emotional cues.

People differ in their readiness to preferentially allocate attention toward (or away from) negative emotional stimuli under experimental conditions that promote the development of such an attentional bias (Clarke et al., 2008; MacLeod et al., 2002). Consistent with this research, participants in the current study displayed variability in the degree to which the training contingency evoked preferential processing of positive emotional information. The magnitude of change in attentional bias for positive information associated with the training procedure in the current study (-59 to +116) is comparable to the range reported in previous studies (e.g., - 75 to +115, Clarke et al., 2008). Extending previous findings, however, the current study found that greater shifts in attentional allocation toward *positive* stimuli were associated with attenuated anxiety reactivity to the stressor. These findings suggest that the “undoing” or down-regulatory effects of positive emotions under conditions of stress (Fredrickson, 2001) may also extend to basic attentional processing of positive information. In contrast, in the control condition where there was no contingency associated with the processing of positive cues, and therefore no advantage in terms of optimizing task performance to develop a preferential attentional response toward or away from positive stimuli, change in attentional bias for positive information did not reliably predict emotional reactivity to the stressor. We suspect that changes in attentional bias resulting from this condition likely represented noise, perhaps resulting from measurement error (Schmukle, 2005). These findings suggest that it was the development of a positive attentional bias in response to the experimental training contingency that rendered the acquisition of such a bias adaptive, rather than repeated exposure to positive emotional information per se, that predicted subsequent emotional reactivity.

How might the selective processing of positive stimuli evoked by the attentional training procedure have attenuated anxiety reactivity to the laboratory stressor? One possibility is that increases in attentional allocation toward positive emotional cues led to a corresponding decrease in the processing of negative emotional information in the context of the stressor, which in turn resulted in the observed emotional reactions. Consistent with this suggestion, research has shown that individuals trained to selectively orient their attention toward positive cues spent significantly less time viewing negative emotional components of visual images compared to control participants (Wadlinger & Isaacowitz, 2008). There is compelling evidence, however, for the independence of positive and negative emotional functioning (e.g., Davidson et al., 2000; Diener & Emmons, 1985; Gable & Berkman, 2008). Thus, it remains to be established whether modifying attentional allocation toward (or away from) emotional information of a particular valence (e.g., positive) results in corresponding changes in the deployment of attention toward emotional cues of a differing valence (e.g., negative). Research is needed to address that issue.

Another mechanism through which shifts in attention toward positive cues evoked by the training procedure may have attenuated anxiety reactivity is through the conservation of positive emotions throughout the duration of the stressor (e.g., Fredrickson, 2001; Tugade & Fredrickson, 2007). Positive emotions have been shown to facilitate recovery from negative emotional reactivity following exposure to stress (e.g., Tugade & Fredrickson, 2004) and therefore may have served to modulate or “undo” the negative emotional effects that resulted from the stress-provoking speech challenge. In support of that possibility, greater shifts in attention toward positive stimuli following training were associated with a lesser decrease in positive emotions from before to after the speech. However, given that state anxiety and positive affect were measured concurrently, it is not possible to determine whether the manipulation had a direct effect on both anxiety and positive affect, or whether

attenuated anxiety reactivity operated through enhanced positive emotions. Future research is needed to disentangle the overlapping versus unique contributions of positive and negative attentional processing and emotional reactivity to stress.

Despite the recognition that there is variability in the degree to which attentional training procedures evoke selective processing of the target stimuli (Clarke et al., 2008), individual difference factors that contribute to this variability have until now been afforded little consideration. Previous research on the experimental manipulation of attention and emotional vulnerability has been restricted to examining between-group comparisons in relatively homogenous samples of participants (e.g., high levels of social anxiety; Amir et al., 2008; midrange levels of anxiety; MacLeod et al., 2002). Although this approach optimizes the ability to ascertain the effects of the experimental manipulation on the dependent variables of interest through the reduction of individual error variance, it constrains variability of participant responses and therefore obscures the examination of variables that may impact responsiveness to the manipulation. Researchers have long argued for the integration of tightly controlled experimental designs with approaches that consider individual differences in response to the experimental procedures (Cronbach, 1957; Vogel & Awh, 2008). Consistent with this approach, the current study comprised individuals displaying a full range of the hypothesized moderators (i.e., social anxiety and depression), which allowed us to exploit individual variability in response to the attentional training procedures.

We found that individual differences in social anxiety, but not depression, moderated the effects of the training procedure on change in attentional bias for positive information. Although a growing body of research indicates that social anxiety is characterized by deficits in positive social and emotional functioning (e.g., Brown, Chorpita, & Barlow, 1998; Hughes et al., 2006; Kashdan & Steger, 2006; see Kashdan, 2007 for review), little is known about the impact of social anxiety on procedures designed to encourage the processing of positive information. The current findings are consistent with earlier research demonstrating that social anxiety is associated with deficits in the processing of positive social emotional information relative to non-anxious individuals (e.g., Pishyar et al., 2004; Silva et al., 2006; Veljaca & Rapee, 1998). They go one step further, however, in illuminating the pernicious impact of social anxiety on the processing of positive emotional stimuli in that, under conditions explicitly designed to facilitate the development of an attentional bias toward positive cues, higher levels of social anxiety were associated with diminished attentional deployment toward positive information.

Our data indicated that only individuals with lower levels of social anxiety ($LSAS < 30$) were able to take advantage of the experimental training contingency by responding with significantly greater attentional shifts toward positive information relative to their control counterparts. It is notable that LSAS scores above 30 have also been shown to reliably discriminate non-anxious individuals from those meeting diagnostic criteria for social anxiety disorder (e.g., Rytwinski et al., 2009). Given previous research (e.g., Johnson, 2009; Wadlinger & Isaacowitz, 2008) and the present findings suggesting that the capacity to orient one's attention toward positive emotional cues may promote emotion regulation during times of stress, research is needed to identify procedures capable of facilitating the processing of positive emotional stimuli in socially anxious individuals. Promising future directions may include modifying parameters of the attentional training paradigm, for example, the type of stimuli (e.g., words vs. emotional faces), the number of trials or training sessions (Amir et al., 2009), or augmenting the task with cognitive bias modification procedures that target a different domain of positive information processing (e.g., interpretation bias modification; Holmes, Lang, & Shah, 2009).

Future studies should also examine *why* levels of social anxiety would be associated with a reduced tendency to develop an attentional bias toward positive cues following exposure to an experimental contingency designed to promote its acquisition. One possible account of the current findings concerns the organization of positive information in memory. Research in healthy individuals suggests that the relative efficiency of positive information processing occurs because of the higher density or interconnectedness of positive evaluative information in associative memory (cf. negative information, Unkelbach, Fiedler, Bayer, Stegmüller, & Danner, 2008). Therefore, the activation of one positive concept spreads more rapidly to other similar positive concepts making that information more readily accessible. In contrast, individuals prone to heightened levels of social anxiety have been shown to display *less* interconnectedness among positive social-evaluative information relative to non-anxious and anxious controls (Dozois & Frewen, 2006). As a result, individuals displaying greater levels of social anxiety may have been less cognitively ready to capitalize on the experimental contingency intended to facilitate the processing of positive social evaluative cues.

Another possibility is that whereas the positive emotional cues encountered during training activated related positive cognitive associations (e.g., thought and memories) in low anxious participants, those same cues may have triggered more negative cognitive representations of the self in participants with higher levels of social anxiety (Ouimet, Gawronski, & Dozois, 2009; see also Wood, Perunovic, & Lee, 2009). Consistent with this hypothesis, research suggests that social anxiety is associated with a tendency to display negative cognitive and emotional reactions to positive social information (e.g., Alden et al., 2008; Wallace & Alden, 1997; Weeks, Rodebaugh, Heimberg, & Norton, 2008). Moreover, there is some evidence to suggest that although socially anxious individuals do not differ from non-anxious individuals in rating the valence of positive social information, they do differ in their implicit or automatic cognitive responses (Heuer, Rinck, & Becker, 2007) as well as predicted emotional or behavioral reactions (Alden, Mellings, & Laposa, 2004; Campbell et al., 2009) to that same stimuli. Thus, even when socially anxious individuals identify emotional information as positive in valence, they display distinct cognitive-emotional responses to those same stimuli compared to healthy controls. Further research is needed to examine this and other putative mechanisms underlying the patterns of deficient attentional processing associated with social anxiety found in the current study.

Biased processing of positive emotional information is not unique to social anxiety, but has also been shown to be characteristic of depression (e.g., Joormann & Gotlib, 2007; Levens & Gotlib, 2009). Accordingly, we set out to examine whether symptoms of depression similarly moderated the effects of the attentional training procedure of change in attentional bias for positive stimuli. Results revealed that current levels of depression did not influence the effects of the manipulation on attention malleability for positive stimuli. These findings provide preliminary support pointing to a unique relationship between social anxiety and the readiness to preferentially attend toward positive stimuli. It should be noted, however, that attentional biases associated with depression are more consistently revealed under experimental conditions that allow for greater elaborative processing of emotional stimuli (e.g., stimulus presentation durations > 1000ms; see Mogg & Bradley, 2005). Thus, the relatively brief (500ms) stimulus presentation length used in the current study may have been less sensitive to revealing attentional biases that are more characteristic of depression. Future research is needed to clarify this issue.

Several caveats should be noted when drawing conclusions from the current study. First, the present sample comprised undergraduate students and generalizability to community and clinical samples is needed. Second, social anxiety was assessed using a self-report measure. Although the LSAS-SR has been shown to correlate highly with the interviewer-

administered LSAS (Fresco et al., 2001), a clinical interview may provide a more objective assessment of social anxiety symptoms. The stimuli used during the attention assessment and training procedures were selected to reflect social-evaluative content (Dozois & Frewan, 2006). However, it remains to be established whether the current results are specific to socially relevant positive information or whether they reflect a more pervasive biased processing of positive emotional information in general (i.e., non-social positive information). Further, the current materials represented semantic content, and it remains to be established whether the effects would generalize to more ecologically valid social stimuli (e.g., emotional faces, Amir et al., 2008).

Another limitation is that the primary dependent measures of emotional reactivity relied on subjective emotional responses. Future research is needed to examine the effects of positive attentional training using more objective measures of emotional reactivity (e.g., cardiovascular recovery). It should also be noted that because the two experimental conditions differed in the contingency between the location of the word stimuli and the location of the probe, the ATP condition may have afforded greater processing fluency given that the location of the probe was always predictable. Given research suggesting that the ease of perceptual processing can influence affective evaluations (Reber, Schwarz, & Winkielman, 2004), future research should examine the effects of alternative control conditions that better account for processing fluency. One final caveat concerns the use of only negative emotion trait measures (i.e., social anxiety and depression) to explain individual differences in participants' response to the attentional training procedure. Given that positive and negative emotional functioning are subserved by at least partially distinct systems (Davidson et al., 2000), future research should also include positive emotion trait scales (e.g., behavioral approach sensitivity, optimism) to explore the contribution of these additional sources of individual variability in predicting response to positive attentional training manipulations.

In summary, the current findings demonstrated that individual differences in the capacity to selectively process positive emotional cues, under experimental conditions that facilitated the development of such biased attentional processing, conferred differential emotional resiliency in the context of a laboratory stressor. These findings extend contemporary accounts of biased information processing in anxiety vulnerability (Mathews & MacLeod, 2005) and suggest that the down-regulating effects of positive emotional experiences on negative emotions (Fredrickson, 2001) may also extend to basic attentional processing of positive information. Moreover, this is the first study to illuminate an individual difference variable that accounts in part for the variability observed in the experimental malleability of attentional allocation in the presence of positive emotional information. The current findings add to a growing empirical literature documenting that social anxiety is associated with aberrant responsiveness to positive social emotional information and point to the potential value of expanding cognitive theories to consider the role of positive emotional processing in anxiety vulnerability.

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Figure 1.

Relationship between change in attentional allocation toward positive stimuli and emotional reactivity to the social stressor in the ATP group. Panels (a) and (b) illustrate this relationship for change in state anxiety and positive affect, respectively.

Figure 2. Relationship between change in attentional allocation toward positive stimuli and emotional reactivity to the social stressor in the ACC group. Panels (a) and (b) illustrate this relationship for change in state anxiety and positive affect, respectively.

Figure 3. Simple regression slopes of condition (ATP, ACC) predicting change in attentional allocation for positive stimuli at levels of social anxiety (LSAS).

Table 1

Means and Standard Deviations for Demographic and Symptom Measures

Variable	ATP	ACC
Age	19.05 (1.38)	19.32 (3.84)
Years of Education	13.47 (.88)	13.09 (1.08)
Gender (% female)	58%	65%
LSAS-SR	43.09 (17.09)	49.97 (24.03)
BDI-II	9.37 (6.72)	10.06 (6.08)

Note. Standard deviations in parentheses. ATP = Attention Toward Positive; ACC = Attention Control Condition; LSAS = Liebowitz Social Anxiety Scale – Self report; BDI-II = Beck Depression Inventory II. Participants in the two conditions did not differ on any of the demographic or symptom measures, all $p > .10$.

Hierarchical Regression Analyses of Experimental Condition (ATP, ACC) and Individual Differences in (a) Social Anxiety and (b) Depression Predicting Change in Attentional Allocation for Positive Information.

Table 2

Moderator	(a) Social Anxiety (LSAS)				(b) Depression (BDI-II)			
	B	SE B	β	ΔR^2	B	SE B	β	ΔR^2
Step 1				.02				.02
Condition	-10.85	9.71	-.13		-10.85	9.71	-.13	
Step 2				.02				.00
Condition	-8.76	9.80	-.10		-11.15	9.76	-.13	
Moderator	-0.31	0.24	.15		0.44	0.76	.07	
Step 3				.05*				.01
Condition	-7.50	9.59	-.10		-11.14	9.78	-.13	
Moderator	-0.91	0.37	-.44*		-0.07	0.98	-.01	
Condition $\times$ Moderator	1.00	0.48	.38*		1.29	1.56	.12	

Note. ATP = Attention Toward Positive; ACC = Attention Control Condition; LSAS = Liebowitz Social Anxiety Scale; BDI-II = Beck Depression Inventory II

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