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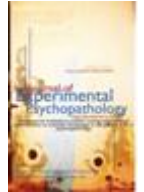
The Causal Role of Attentional Bias in a Cognitive Component of Depression

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Abstract

Cognitive theories have, for years, postulated the causal role of attentional biases in depression and low self-esteem. However, this assumption has been based predominantly on correlational findings. With the advent of attentional bias modification techniques (Mathews & MacLeod, 2002), it became possible to modify attentional bias experimentally. The purpose of this study was to ascertain whether negative attentional biases are trainable and causally linked to changes in important characteristics of depression, namely self-esteem. Participants completed negative attentional training and a stress induction task. Consistent with the diathesis-stress model, a combination of negative attentional biases and stress resulted in changes in self-esteem, which was used as an indicator of depression. The effects on self-esteem were specific to the type of stimuli used. These findings have important implications for our understanding of self-esteem, cognitive models of depression, and for the future of cognitive bias modification research in self-esteem and depression.

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Introduction

Cognitive theories of depression postulate that cognitive biases play a causal role in the onset and maintenance of the disorder (Beck & Dozois, 2014; Teasdale, 1988). In particular, these models explore how these biases maintain cognitive features such as low self-esteem or self-worth. Although much of the empirical work has focused on the role of memory biases, researchers have also examined negative attentional biases. A negative attentional bias is a tendency to disproportionally allocate attention towards negative information over neutral or positive information. Negative attentional biases have been observed in a number of different psychological disorders, including depression and anxiety (Mathews & MacLeod, 2005). Although presumed to be causal, few studies have explored the causal relationships among depression, self-esteem, and negative attentional biases.

The advent of techniques that can manipulate attentional allocation has afforded researchers the opportunity to test the causality of this association. In the area of anxiety, for example, researchers have shown that it possible to train both positive and negative attentional biases, and that training negative biases can result in an increased susceptibility to anxiety symptoms (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002; Mathews & MacLeod, 2002). In addition, the training of positive or reduction of negative attentional biases have been shown to reduce levels of anxiety and depression (Amir, Beard, Burns, & Bomyea, 2009; Amir, Weber, Beard, Bomyea, & Taylor, 2008; Baert, De Raedt, Schacht, & Koster, 2010; Kruijt, Putman, & Van der Does, 2013; Schmidt, Richey, Buckner, & Timpano, 2009; See, MacLeod, & Bridle, 2009; Wells & Beevers, 2010) and increase self-esteem (Dandeneau & Baldwin, 2004; Dandeneau, Baldwin, Baccus, Sakellaropoulo, & Pruessner, 2007). Recently researchers have explored inducing negative attentional biases to further demonstrate the causal link between attentional biases and depression (Beshai, Prentice, Dobson, & Nicpon, 2014; Fox, Zoughkou, Ridgewell, & Garner, 2011). The primary objective of this study was to further explore the causal relationship between negative attentional biases and changes in a depression-related index, self-esteem.

The empirical investigation of the causal role of attention in depression raises both ethical and methodological quandaries. First, it would not be ethical to induce a depressive episode which would necessitate repeated training sessions over a fairly lengthy period of time. Prolonged negative attentional training, even if effective, would not be advisable. Second, in addition to its cognitive features, the diagnosis of depression is based on physiological and behavioral symptoms (e.g., appetite, sleep, and weight). These symptoms do not vary over the course of minutes

(the standard induction of attentional biases) and thus would not be sensitive to a within session measurement of change. Indeed, most scales designed to measure symptoms of depression require the participant to reflect over time periods of a week or longer. Although visual analogue scales have often been used to measure depression in such cases, they are not as highly correlated with depression as is the construct of self-esteem (Ahearn, 1997; Heatherton & Polivy, 1991).

To attend to ethical issues and procedural constraints, self-esteem was chosen as an indicator of the cognitive characteristics of depression. The experience of low self-worth is diagnostically related to the condition. Self-esteem is also highly correlated with measures of depression (Kazdin, French, Unis, Esveldt-Dawson, & Sherick, 1983; Tennen & Herzberger, 1987), conceptually linked to self-schemas (e.g., a negative self-image that characterizes depression) and causally linked to depression (Sowislo & Orth, 2012). For example, self-esteem correlates highly (r = -.71) with the Beck Depression Inventory –II (BDI-II). In fact, the magnitude of the correlation between self-esteem and depression is similar to the intercorrelation among indices of depression themselves [(e.g., BDI-II & Hamilton Rating Scale for Depression; r = .68 (Beck, Steer, & Brown, 1996) ; BDI-II & PHQ-9, r = .67 (Adewuya, Ola, & Afolabi, 2006)].

Although a heterogeneous cluster of physiological, behavioral and cognitive symptoms characterizes depression, a negative view of self is one of its most representative, subjective features. Individuals with depression often experience low self-esteem and feelings of inadequacy. Research has also indicated that individuals with depression and low self-esteem demonstrate a number of similar cognitive biases. Cognitive models of depression suggest that these biases play a causal role in the onset or maintenance of depression (e.g., Dozois & Beck, 2008; Ingram, Miranda, & Segal, 1998). In addition, these cognitive biases are theorized to perpetuate the cognitive symptoms of depression – in particular, low evaluation of self-worth, i.e. self-esteem.

Negative attentional biases have been related to both depression and low self-esteem. Several studies have demonstrated that individuals suffering from depression have difficulty disengaging from dysphoric or negative self-relevant content (Goeleven, De Raedt, Baert, & Koster, 2006; Gotlib et al. 2004b; Joormann & Gotlib, 2007). Similarly, Dandeneau and Baldwin (2004) demonstrated the link between attentional bias and low self-esteem using the Emotional Stroop task. Individuals with low self-esteem had more difficulty naming the color of rejection words than did individuals with higher self-esteem.

Attentional biases are present in teens who are genetically and environmentally at risk for developing depression (Dearing & Gotlib, 2009) and their presence, in combination with life stress, prospectively predicts dysphoria among college students (Beevers & Carver, 2003). This research suggests that cognitive biases may represent vulnerability factors, statistically increasing an individual's likelihood of experiencing the relevant disorder. Although intriguing, such studies merely demonstrate that correlations exist between attentional biases and depression, anxiety, and self-esteem; without direct manipulation of these purported causal mechanisms, it is impossible to rule out third party factors. Due to this methodological limitation, a new line of research has been developed known as attentional bias modification (ABM). In ABM, tasks that were originally used to *measure* attentional biases are modified and used to *train* individuals to amend their attentional tendencies and attend to particular stimuli characteristics.

MacLeod et al. (2002) refined this technique by manipulating the commonly used dot probe task to train attentional biases consistent with those seen in anxiety. Consistent with a diathesis-stress model, trained biases did not impact anxiety directly but did so when combined with a stressor. Specifically, following a stress induction, the negative training group demonstrated a larger increase in anxiety than did the positive training group. Such results suggest that attentional biases may act as a vulnerability factor and, when combined with stress, impact emotional arousal. Beshai et al. (2014) trained negative attentional biases (consistent with those seen in depression) in undergraduate students and compared these individuals to a no training control condition. Unlike the MacLeod et al. (2002) study the authors did not include a stress task and this may be why (although able to train a negative attentional bias) the training task did not impact depression indicators (visual analogue mood scale and cognitive triad inventory).

No research has yet demonstrated that increasing negative attentional biases can impact depressive symptoms or self-esteem. This is an important empirical question and one that speaks to the "front end" of causality. Such research would add significantly to the literature, which has established a causal relationship between the reduction in negative attentional biases and depression. Although important, if research only established a causal link between *reduced*

attentional biases and *reduced* depression, the question would remain as to whether *increased* attentional biases cause depression. For instance, the fact that one takes aspirin to reduce a headache (a demonstrable causal relation) does not mean that headaches are due to the lack of aspirin. Thus, the objective of this study was to examine this aspect of causality.

This study measured changes in self-esteem directly after attentional training and again following an additional stressor task (an anagram task). Consistent with the diathesis-stress model, which predicts that depressive episodes arise when vulnerability is combined with stressful life events, changes in self-esteem were predicted only following the combination of attentional training and stress, not with bias modification alone. Attentional training in and of itself was also not expected to influence participants' mood state.

Method

Participants

Participants either received course credit (55 participants) or $15 financial compensation (53 participants) for their participation. Eligible participants were fluent in English and scored below 20 (indicating "minimal" or "mild" symptoms)[1] on the BDI-II. In total, 108 participants were recruited for this study (63 female, 45 male). Participants ranged in age from 17-63 years (M = 21.43 SD = 6.19). Fifty-four participants were assigned to each of the control and the training conditions.

Beck Depression Inventory – II (BDI-II).

The BDI-II is a 21-item measure that assesses presence and degree of depressive symptoms consistent with the description of major depressive disorder (Beck et al., 1996). This instrument has strong empirical support for its use in clinical (Beck et al., 1996) and non-clinical (Dozois, Dobson, & Ahnberg, 1998) populations.

Positive and Negative Affect Scale (PANAS).

The PANAS (Watson, Clark, & Tellegen, 1988) contains two 10-item subscales that measure positive and negative affect. Watson et al. (1988) investigated the reliability of the PANAS in an undergraduate sample where it demonstrated strong reliability and moderate (.56-.74) correlations with depression indices.

State Self-Esteem Scale (SSES).

The SSES is a 20-item modified Likert-type scale designed to measure state self-esteem (Heatherton & Polivy, 1991). The SSES was designed particularly to detect changes in different domains of self-esteem (performance, social, and appearance) following experimental manipulations. The SSES has been well validated both as a global state self-esteem measure and as a measure of domain specific self-esteem. Heatherton and Polivy demonstrated high internal consistency (α = .92) in the SESS. The SSES correlates highly with the Rosenberg Self-Esteem Scale (r = .72) and with the Beck Depression Inventory (r = - .71).

Name Letter Task (NLT).

The Name Letter Task (Nuttin & Lens, 1985; Nuttin Jr, 1987) was initially selected to add a secondary measure of implicit self-esteem; however, it was excluded from further analyses because it did not correlate with either the BDI-II or the SSES in this sample (McDermott & Dozois, 2012). Other researchers have similarly noted the low or non-existent relationship between the NLT and explicit self-esteem (Buhrmester, Blanton, & Swann, 2011) and the poor relationship between implicit self-esteem and depression (de Jong, Sportel, de Hullu, & Nauta, 2012). Thus, the NLT was excluded as it did not appear to adequately measure the intended variable (self-esteem).

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[1] Participants with low BDI-II scores were selected to reduce the risk that individuals with significant symptoms of depression would be placed into the negative training condition and potentially exacerbate their mood state.

Facial Stimuli.

Stimuli selection was also an important consideration to ensure content-specificity. Dysphoric and neutral facial images were chosen based on previous empirical work (Gotlib et al., 2004a; Wells & Beevers, 2010). The facial stimuli used for this task consisted of 24 monochromatic, facial images (see Figure 1). Half of the images featured a Caucasian face and half a Hispanic face; in addition, half of the faces were female and half male. Each of the 12 models was depicted twice: once with a dysphoric expression and once with a neutral expression. These images were all adopted from the Montreal Set of Facial displays of Emotion (Beaupre & Hess, 2005).

Figure 1. Example of facial stimuli used in the dot-probe task.

Dot-probe task.

The dot-probe task was presented to participants using a Pentium D, Bolen computer and displayed on a 17-inch monitor. The facial stimuli were approximately 9 x 10 cm and were placed approximately 12 cm apart. The dot-probe task consisted of 6 blocks each lasting approximately five-minutes in duration. Each block was separated by an optional two-minute break. In total this task took approximately 35 min, and 576 trials were presented.

Each trial began with a fixation cross in the center of the screen, presented for 1000 ms. The cross was replaced by two facial images, positioned on the right and left sides of the screen, presented for 1500 ms. We hypothesized that changes in self-esteem (our cognitive index of depression) were more likely to occur by using training conditions that were consistent with the biases observed in depression (i.e., longer exposure intervals and thematically consistent stimuli). One face always displayed a dysphoric expression and the other displayed a neutral expression. After the

facial images, a probe appeared on the left or right side of the screen. The probe was comprised of either one or two asterisks, and participants identified the number of asterisks present. In the attentional training condition, 80% of all probes were located in the same spatial location as the dysphoric stimuli.[2] In the remaining 20% of trials the probes appeared in the same location as the neutral face. In the control condition the probes were equally likely to appear behind the neutral faces and dysphoric faces.

Anagram Stimuli.

Stimuli used for the anagram task were derived from related unpublished work (Ouimet, 2007). The stimuli consisted of 40 different letter strings. Of these 40 letter strings, 20 could not be rearranged to create real words in the English language. An example of an unsolvable string was "ITWHEG". The other 20 letter strings were solvable but extremely difficult, as rated by a fourth-year, undergraduate student. For example the letter string, "TAHEREN" could be rearranged to spell the word "HEARTEN".

Anagram Task.

The Anagram task was modeled after Mathews and MacLeod (2002). Participants read computer-displayed instructions, which indicated that the purpose of this task was to assess the relationship between performance on the dot-probe task and their ability to solve anagrams. To increase the level of stress involved, participants were informed that the ability to solve anagrams was a good indicator of intelligence. Participants were instructed that they would rearrange a string of letters to form a word while being videotaped and that their footage could be displayed to their peers as an example of good (if they scored in the top 10 percent) or poor (if they scored in the bottom 10 percent) performance. During the task, participants attempted to solve anagrams for three minutes. After this time had elapsed, a screen display appeared informing participants that their performance was unusually poor and that their video recording had been selected to demonstrate poor performance.

Procedure

Participants provided informed, written consent and then completed a paper and pencil version of the PANAS and a computerized version of the BDI-II. Individuals who scored below 20 on the BDI-II were randomly assigned to the negative training or the control condition. Participants scoring 20 or above, were directed into another experiment not addressed here.

After participants completed the dot-probe task, they were given a packet of questionnaires that contained the PANAS, NLT, and SSES. Participants were always given these questionnaires in the same order. Participants began the anagram task following the administration of the questionnaires. Once participants had finished the anagram task, and read their feedback, they were given a final package of questionnaires, which included the NLT and SESS. Participants were asked verbally if they knew the purpose of the experiment and the experimenter recorded accurate or close guesses.[3] Participants were then debriefed, provided new consent (due to the use of deception) and were thanked for their participation. In total, this experiment took approximately an hour.

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[2] In a standard presentation of the dot-probe task, the probe is located 50% of the time behind either the neutral or the negative stimuli, which serves to measure the degree of bias. In contrast, in our training group, the probe was located 80% of the time behind the negative stimulus. This ratio served to optimally balance attentional training while not permitting participants to consciously detect the pattern of stimulus presentation.

[3] No participant accurately guessed the purpose of the dot-probe task. After debriefing, two participants spontaneously disclosed that they believed they were in the training condition; however, when this was explored they were both found to have been in the control condition.

Results

Participant Characteristics.

One hundred and eight participants were in this study, with 54 in each condition. There was an equal number of paid participants in each condition, $\chi^2(1,108) = .07$, $p = .79$. In the training condition there were 22 males and 32 females with a mean age 22.54 ($SD = 7.84$) and a range from 17 to 63 years. In the control condition there were 23 males and 31 females with a mean age of 20.20 ($SD = 3.23$) and a range from 17 to 30 years. The mean initial BDI-II score was numerically higher for the control group ($M = 8.41$, $SD = 7.74$ vs. $M = 8.00$, $SD = 7.70$) but this difference was not statistically significant, $t(106) = -0.46$, $p = .64$.

Attentional Bias Training.

Each participant's mean reaction time to stimuli located behind neutral and negative faces was calculated, excluding all error trials. Participants in the training condition on average took 560 ms ($SD = 80$ms) to respond to the probe when it was behind the neutral face and 548ms ($SD = 71$ms) when it was behind the negative face. In contrast, participants in the control group responded in 570ms ($SD = 93$ms) when the probe was located behind the neutral faces and 572ms ($SD = 92$ms) when it was behind negative faces. In order to assess if attentional training had occurred, a 2 condition (negative, control) by 2 stimulus type (dysphoric, neutral) mixed ANOVA was conducted. The interaction between stimulus type and condition was statistically significant, $F(1, 106) = 3.5$, $p < .001$. This finding indicates that the training group was more likely to attend to dysphoric faces over neutral faces compared to the control group. Follow-up, paired t-tests demonstrated that participants in the training condition were significantly faster at responding to dysphoric images, $t(53) = 3.621$, $p < .001$, but no such difference appeared in the control condition, $t(53) = -1.91$, $p = .28$.

Mood.

The PANAS was administered both before and after the dot-probe task to establish that the attentional training alone did not influence mood. Means and standard deviations are presented in Table 1. To investigate changes in mood, two separate, 2 (condition) by 2 (time) mixed ANOVAs were conducted on the positive and negative scales of the PANAS. Interactions between condition and time (pre and post attentional task) were not significant for either the positive, $F(1,104) = .662$, $p = .418$, or negative, $F(1,104) = .178$, p $= .674$, scales. Thus, the training condition of the dot-probe task did not appear to independently cause any change in self-reported mood.

Self-Esteem.

The SSES was administered before and after the anagram stress task to demonstrate that there were no group differences in self-esteem before the stress task and that the combination of attentional training and stress caused larger decreases in self-esteem than did stress alone. Exploring the results of the SSES subscales also afforded exploration of what components of self-esteem were most affected (social, performance, or appearance).

A 2 (condition) by 2 (time) split-plot ANOVA was used to explore the overall SSES results (see Table 1 for means and standard deviations). The main effect of condition was not significant, $F(1,106) = .295$, $p = .59$. To demonstrate that there were no pre-existing group differences before the stress task, an independent t-test comparing the two conditions was conducted. The two conditions were not statistically different on self-esteem at the end of the attentional training task, $t(106) = 1.41$, $p = .90$.

There was a main effect of time on self-esteem, with participants showing lower self-esteem after the stressor, $F(1,106) = 25.88$, $p < .05$. This main effect was, however, qualified by a statistically significant interaction between condition and time, $F(1,106) = 4.78$, $p < .05$. Follow-up tests revealed that both the training, $t(53) = 5.14$, $< .001$, and control, $t(53) = 2.05$, $< .05$, conditions showed a significant reduction in self-esteem following the anagram tasks; however, this reduction was larger for the training condition, $t(106) = 2.19$, $p < .05$.

Table 1: Means and Standard deviations of Measures

		Training		Control	
		Mean	**SD**	**Mean**	**SD**
PANAS- Positive					
	Pre Dot-Probe	27.66	6.81	21.15	7.02
	Post Dot-Probe	28.15	6.12	22.83	7.99
PANAS- Negative					
	Pre Dot-Probe	12.85	2.80	12.45	2.46
	Post Dot-Probe	13.34	3.67	12.51	3.12
SESS Total					
	Pre Stress Task	72.93	10.55	69.94	11.39
	Post Stress Task	67.07	14.01	67.61	13.40
SSES Performance					
	Pre Stress Task	26.56	4.69	25.65	4.49
	Post Stress Task	22.87	5.54	23.19	4.49
SSES Social					
	Pre Stress Task	26.00	5.11	24.07	5.33
	Post Stress Task	24.46	6.22	24.30	5.79
SSES Appearance					
	Pre Stress Task	20.37	3.99	20.22	4.37
	Post Stress Task	19.74	4.48	20.12	4.27

Note. PANAS = Positive and Negative Affect Scale and SSES = State Self-Esteem Scale.

Self-Esteem Subscales.

The SSES subscales (i.e., social, appearance, performance) were also analyzed independently using a series of 2 (condition) by 2 (time) mixed designs to explore the components of self-esteem most affected by the attentional training and anagram stress task. Only the performance self-esteem subscale showed a significant main effect of time ($F(1,106) = 44.10$, $p < .001$) as neither the social ($F(1,106) = 3.67$, $p = .058$) nor appearance scales ($F(1,106) = 2.73$, $p = .10$) did. Follow-up analysis revealed that both the training ($t(53) = 5.63$, $p < .001$) and the control ($t(53) = 3.76$, $p < .001$) conditions showed a significant reduction in performance self-esteem. Only social self-esteem scale revealed a significant interaction of condition and time, $F(1,106) = 6.57$, $p < .05$, in contrast, to appearance, $F(1,106) = 1.51$, $p = .22$, and performance self-esteem, $F(1,106) = 1.74$, $p = .19$, which failed to reached statistical significance. Follow-up testing of the social self-esteem subscale revealed that the training condition had a significant reduction in social self-esteem following the anagram task ($t(53) = 3.17$, $p < .01$) whereas the control condition did not ($t(53) = 0.45$, $p < .648$). These results suggest that social self-esteem was significantly affected by the combination of attentional training and stress. Thus, although the combination of stress and negative attentional training was necessary to cause changes in social self-esteem the anagram task alone affected performance self-esteem in both conditions.

Discussion

The primary aim of this study was to ascertain whether a causal relationship could exist between negative attentional biases and changes in self-esteem, a characteristic of depression. Consistent with this objective, the specific and general effects of attentional bias on self-esteem were explored. In order to test the relationship between stress, negative attentional bias, and self-esteem it was important to induce an attentional bias that was consistent with the type of bias observed in depression. The results of this study demonstrate that it is possible to train a negative

attentional bias consistent with what has been observed in depression. Participants in the training condition attended more to the dysphoric stimuli and less to the neutral stimuli at 1500ms. These results imply that it is possible to modify attentional allocation.

After establishing that the training condition modified attentional allocation, it was important to establish whether this training caused changes in self-esteem (which served as an indirect indicator of depression). Congruent with the diathesis-stress model of depression, and the findings of MacLeod et al., (2002) and Beshai et al. (2014), it was hypothesized that the combination of negative attentional bias and stress would be necessary (rather than attentional training alone) to cause changes in self-esteem. However, there remained the possibility that attentional training would independently cause changes in mood. For example, viewing emotional faces can induce congruent moods in viewers (Wild, Erb, & Bartels, 2001). To ensure that the negative attentional training did not induce a congruent mood-state, changes in mood were assessed pre and post attentional training, using the PANAS. The interaction between condition and time (pre and post training task) was not significant, which suggests that attentional training had no direct effect on mood. Another possibility was that the training condition could cause a change in self-esteem in the absence of stress. However, additional analysis revealed no significant group differences in self-esteem following the dot-probe task but prior to the stress induction; thus, negative attentional training alone did not cause changes in depression-relevant indices. Although it is possible that self-esteem differences existed in the two conditions prior to the experiment and were equalized by the attentional training, two lines of evidence contradict this. First, participants were assigned to the condition by random assignment; thus, it is unlikely there would be a systematic bias in the two groups. Second, the findings of Beshai et al. (2014) and Mathew and MacLeod (2002) suggest that negative attentional training alone is insufficient to cause changes in anxiety and depression.

After establishing that attentional training alone would not cause changes in mood or self-esteem, we sought to establish whether the combination of training and stressor could influence self-esteem. The results demonstrated that individuals in the training condition experienced a greater decrease in self-esteem than did those in the control condition. The results on the SSES were consistent with what would be predicted from both the diathesis-stress model and cognitive models of depression (Eberhart & Hammen, 2010; Monroe & Simons, 1991). Changes in self-esteem appeared to be secondary to a combination of negative attentional training and a stressor.

Once it was established that self-esteem was influenced by attentional training in the context of a stressor, it was possible to explore what, if any, specific aspects of self-esteem were most affected. The SSES contains three domains: performance, social, and appearance. Analyses revealed that the social domain was the only domain significantly affected by the attentional training task. This finding was particularly interesting because the majority of change (i.e., the largest within-subject decrease) was seen in performance self-esteem but the difference between groups was most prominent in the social domain. In fact, on the social self-esteem scale only the training condition showed a significant reduction in self-esteem. It is understandable that the largest within-subject difference occurred in the performance domain because the stressor task focused on the participants' failure to complete a task that was ostensibly linked to their intelligence. It is interesting, however, that the largest between-group difference in self-esteem occurred in the social domain.

This difference in the social self-esteem domain may have been driven by the stimuli used in the training task (i.e., facial expressions). Not only are facial expressions used to communicate emotions or responses, they have also been linked to social information processing and communication. For example, individuals with social anxiety avoid attending to faces (Chen, Ehlers, Clark, & Mansell, 2002) and individuals with autism display abnormal processing of social information from faces (Adolphs, Sears, & Piven, 2001). Training attention towards negative facial expressions potentially caused participants to attend to negative interpersonal or social information during the stress task. For example, these participants may have been more aware of how others would disapprove of or judge their performance. Thus, after completing the stress task, participants were more sensitive or prone to identify the negative social connotations of their performance.

These findings support a causal link between attentional biases and self-esteem. Also, based on the assumption that self-esteem is a valid indicator of depression, this study also suggests indirectly that there may be a causal link between negative attentional biases and depression, at least with respect to its cognitive features. This link is

theoretically important, as it is a key ingredient in making the causal link between depression characteristics and negative attentional biases.

In summary, these findings provide additional support for the diathesis-stress model of depression. As noted earlier, no effects on self-esteem or mood were found immediately after the attentional training task; however, this difference appeared after the stress induction. This diathesis-stress model proposes that a combination of vulnerability and stress are necessary for the onset of a depressive episode. Although, a depressive episode was (intentionally) not induced, the findings did suggest that a combination of negative bias (vulnerability) and anagram task (stressor) caused changes in cognitive characteristics of depression (i.e., self-esteem).

If attentional biases are causally related to depression, a logical next step would be to explore the use of attentional training in prevention and to continue to explore its use in treatment. Findings from Wells and Beevers (2010) suggest that attentional training can reduce depressive symptoms in participants high in depression symptoms. However, Baert et al. (2010) only found that attentional bias modification was effective at reducing symptoms in individuals experiencing mild to moderate depressive symptoms whereas it aggravated symptoms in participants experiencing more severe symptoms. More recently, Kruijt, Putman, and Van der Does (2013) were unable to demonstrate changes in depressive symptoms with their attentional training experiments. Given the variability in results, further investigation is needed to delineate what role attention modification plays in depression and establish what factors make attentional bias modification effective for symptom reduction. The evidence from the current study suggests that negative attentional bias increases susceptibility to stressors; thus, it is possible that positive training in a high-risk group could result in greater resilience to stress. This idea has been tested in research with telemarketers. Dandeneau et al. (2007), for example, demonstrated that positive attentional training reduced the amount of stress participants reported. Indeed, if attentional training can reduce stress reactivity, it may serve as a preventative measure, decreasing the possibility of a later onset of an emotional disorder.

Although this study provides an innovative test of the impact of attention on depression-related phenomena, it is not without its limitations. One significant limitation to this study is that there was no direct exploration of whether the stressor task was necessary to cause the observed changes in self-esteem or whether time alone would have led to these changes. Without directly involving a no-stress condition it is impossible to control for the effect of time. It is possible therefore that a stressor task was not necessary and that it simply took time for the negative attentional training to have an impact on self-esteem. Although this is a notable limitation, a pilot study we conducted suggests that this is not the case. In this study participants completed a similar attentional training task and then completed a filler, 10-minute task. No changes in mood or self-esteem were observed over the same period as was tested in the current study. Such findings suggest that the stressor task is indeed necessary to cause changes in self-esteem although this is an issue open for further exploration.

Another notable limitation is that there was no direct measure of changes in depressive symptomatology in the study. Although self-esteem measures correlate highly with depression measures, and the two are theoretically linked, changes in depressive symptoms were not measured directly. Measuring changes in indices of worthlessness and helplessness may be valuable additions to future research. Another limitation of this study was that it was conducted in a laboratory setting over the course of an hour; single-session training in a lab environment may not be ideal to replicate naturally occurring biases. While recognizing the ethical issues involved in such a design, the administration of such a trial in naturalistic environments, with a range of stimuli over time, may allow for the training of a more established, realistic, and generalized bias.

In this study participants were trained to modify their attentional biases in a pattern consistent with that observed in depression. This study also revealed that attentional training, in conjunction with stress, could cause changes in self-esteem, a measure statistically and conceptually related to depression. These findings add to previous research (e.g., Baert et al., 2010; Wells & Beevers, 2010) and provide some of the first "front end" causal evidence for the relationship between attentional biases and depression. Future research is needed to permit a clearer understanding of the role that attentional biases play in depression and how attentional training may be useful in the prevention and treatment of this debilitating disorder.

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