

Attentional bias training in girls at risk for depression

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Background: This study examined, for the first time, whether attentional biases can be modified in adolescents at risk for depression. **Methods:** The final sample consisted of 41 girls at familial risk for depression, who were randomly assigned to receive six sessions (864 trials) of real or sham attention bias training [Real attentional bias training (ABT) vs. Sham ABT]. Participants who received Real ABT completed a modified dot-probe task designed to train attention toward positive and away from negative facial expressions; in contrast, girls who received Sham ABT completed the standard dot-probe task. Attentional biases, self-reported mood, and psychophysiological responses to stress were measured at pre- and post-training assessments. **Results:** As expected, girls who received Real ABT, but not those who received Sham ABT, exhibited significant increases from pre- to post-training in their attention toward happy faces and away from sad faces. Moreover, adolescents who received Real ABT were buffered against the negative outcomes experienced by adolescents who received Sham ABT. Specifically, only adolescents who received Sham ABT experienced an increase in negative mood and a pre- to post-training increase in heart rate in anticipation of the stressor. **Conclusions:** The current findings provide the first experimental evidence that attentional biases can be modified in youth at risk for depression and further suggest that ABT modulates the heightened response to stress that is otherwise experienced by high-risk adolescents. **Keywords:** Attention bias modification; depression; adolescents.

Introduction

Adolescence is a critical period of vulnerability for the development of Major Depressive Disorder (MDD). The prevalence of MDD substantially increases during adolescence (Hankin & Abramson, 2001), and adolescent depression often places individuals at risk for recurrent MDD during adulthood (Costello, Mustillo, Erkanli, Keeler, & Angold, 2003). Children of depressed mothers are at particularly high risk for developing MDD during this period (e.g. Gotlib & Goodman, 1999). In fact, they are three to five times more likely to develop a depressive episode during adolescence than are children without a family history of depression (Williamson, Birmaher, Axelson, Ryan, & Dahl, 2004). Maternal depression is also associated with an earlier age of onset and a more severe course of depression in offspring (for a review, see Gotlib, Joormann, Minor, & Cooney, 2006). Given these findings, it is important to identify mechanisms that underlie the increased risk for depression in young children of depressed mothers.

Cognitive models of depression have been instrumental in helping us understand MDD. Cognitive theories (Beck, 1967; Teasdale, 1988) maintain that individuals who are experiencing depression and who are at risk for the disorder exhibit attentional biases, evidenced by preferentially attending toward negative stimuli and away from positive stimuli in their environment. In fact, the onset of depressive episodes has been posited to be due, in part, to these cognitive biases. Consistent with cognitive theories

of depression, research has documented that depressed and high-risk individuals attend toward negative and away from positive material (e.g. Joormann & Gotlib, 2007). Importantly, attentional biases are also observed in depressed children and adolescents (see Jacobs, Reinecke, Gollan, & Kane, 2008, for a review), as well as in youth at familial risk for the disorder (Owens et al., 2015), particularly following the induction of a negative mood (Joormann, Talbot, & Gotlib, 2007; Kujawa et al., 2011). For example, Joormann et al. (2007) found that, after being placed in a negative mood state, daughters of depressed mothers selectively attended to negative facial expressions, whereas daughters of never-depressed control mothers selectively attended to positive facial expressions. Importantly, cognitive biases have also been found to influence the course of depressive symptoms (Rude, Wenzlaff, Gibbs, Vane, & Whitney, 2002). In fact, Beevers and Carver (2003) documented that attentional biases toward negative information predicted an increase in depressive symptoms during times of stress.

Given evidence that attentional biases predict an increase in depressive symptoms, it is not surprising that investigators have begun to examine whether attentional biases can be changed. In the majority of these attentional bias training (ABT) studies, researchers use a modified version of the dot-probe task to train more positive and/or less negative attentional biases. In the typical dot-probe task, participants view pairs of facial expressions consisting of one neutral expression and one emotional expression. Immediately after the offset of these picture pairs, a dot appears in the location of one of

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the pictures and participants are asked to indicate whether the dot appears on the right or the left side of the screen. In the typical dot-probe task, the dot appears with equal probability behind the neutral and emotional face. In the modified dot-probe task used for training, however, the dot appears with higher probability (typically between 80% and 100%) behind the emotional face when the emotional face is positive or behind the neutral face when the emotional face is negative. With practice, participants learn these contingencies and are more likely to attend toward positive stimuli and away from negative stimuli even after the contingencies have been removed (Hallion & Ruscio, 2011).

Thus far, research on ABT and depression has focused on depressed or dysphoric adults. Although some researchers have failed to find beneficial effects of ABT, the results have, for the most part, been promising. For example, Wells and Beevers (2010) found that four sessions of ABT led to reduced attention toward negative stimuli and increased attention toward neutral stimuli in mildly to moderately depressed college students. Similarly, Yang, Ding, Dai, Peng, and Zhang (2015) documented that attentional biases toward negative stimuli decreased after eight sessions of ABT in college students with mild to severe symptoms of depression. In contrast, however, Kruijt, Putman, and Van der Does (2013) failed to find changes in attentional bias as a result of ABT. It is important to note, however, that these investigators used a visual-search paradigm instead of a modified dot-probe task to train attentional biases, which may have led to their null effects. Interestingly, Baert, De Raedt, Schacht, and Koster (2010) reported that the effects of ABT depend on the severity of depression: ABT benefited adults with mild depressive symptoms, but not those with severe depressive symptoms or with diagnosed MDD. Given these findings concerning the relation between ABT and depressive severity, it is particularly important that we examine the effects of implementing ABT prior to the initial onset of depression. Given recent evidence demonstrating that depressed youth benefit from ABT (Yang, Zhang, Ding, & Xiao, 2016), it is likely that ABT will also benefit youth at risk for the disorder. At this point, however, researchers have not yet examined whether attentional biases can be altered in youth at risk for developing depression.

In addition to this question, we also do not yet understand the mechanisms through which ABT yields beneficial effects; elucidating these mechanisms is a critical direction for future research. In this context, Browning, Holmes, Charles, Cowen, and Harmer (2012) examined mechanisms that might underlie the effects of training attentional biases toward positive stimuli in formerly depressed adults. They found that compared with participants who received Sham ABT, participants who received Real ABT had a smaller rise in morning cortisol, the primary stress hormone. Thus, ABT may achieve its

beneficial effects by reducing responsivity to stress. Consistent with this possibility, Hallion and Ruscio (2011) recently concluded on the basis of their meta-analysis that the benefits of ABT are apparent only after participants experience a stressor. Similarly, Baert, Casier, and De Raedt (2012) reported that adults who received ABT demonstrated more adaptive psychophysiological responses to a laboratory stressor than did individuals who received placebo training.

This study was designed to examine whether youth at maternal risk for depression could be trained to attend toward positive and away from negative stimuli and to explore the mechanisms underlying the effects of this training. Young girls at maternal risk for depression were randomly assigned to receive six sessions of either Real or Sham ABT in a parallel trial design. We focused on girls in this study because women are twice as likely as men to be depressed (e.g. Kessler, McGonagle, Swartz, Blazer, & Nelson, 1993), and this gender difference emerges during adolescence (Cyranowski, Frank, Young, & Shear, 2000). We used a version of the dot-probe task to train these high-risk girls to attend toward positive stimuli and away from negative stimuli. More specifically, girls who received Real ABT completed a version of the dot-probe task in which the dot appeared behind the positive face on 100% of positive trials and behind the neutral face on 100% of negative trials. We used the standard (i.e. noncontingent) version of the dot-probe task to assess the intensity of attentional biases before and after training. Consistent with theoretical expectations (Monroe & Simons, 1991; Segal & Ingram, 1994) and recent research (Joormann et al., 2007; Kujawa et al., 2011), girls were placed in a negative mood state before completing the dot-probe task at pre- and post-training sessions. In addition, to explore the mechanisms through which ABT might yield beneficial effects, we assessed psychophysiological reactivity to a laboratory stressor during pre- and post-training sessions. Based on cognitive models of depression, we expected to observe training-related changes in attention, mood, and physiological responses to stress. This is the first study to directly manipulate mechanisms that may underlie the transmission of risk for MDD from mother to daughter, and thus, the first time that ABT for depression has been conducted with children or adolescents at risk for the disorder. Therefore, findings from this study have the potential to make an important contribution to our understanding of vulnerability to depression in high-risk youth.

Methods

Participants

Participants were 42 unrelated girls between the ages of 10 and 14 years with no current or past Axis I disorder whose mothers

had experienced recurrent episodes of depression. None of the girls reported major medical complications, head trauma, learning disorders, or history of taking psychotropic medication, and all were fluent in English. Participants were recruited from the greater San Francisco/Palo Alto community through local media; we screened approximately 500 individuals for initial inclusion and exclusion criteria with a telephone interview before inviting 96 to Stanford University for further assessments. Of those, 42 were eligible for participation, and all but one participant returned for the posttraining session; thus, data from 41 girls were used in the analyses.

Trained interviewers assessed participants' diagnostic status by administering the Schedule for Affective Disorders and Schizophrenia (K-SADS-PL; Kaufman et al., 1997) to both the girls and their mothers (about their daughters). To be eligible to participate in the study, we required that girls not meet criteria for a past or current Axis I disorder according to both the parent and child report. A different interviewer administered the Structured Clinical Interview for DSM (SCID; First, Spitzer, Gibbon, & Williams, 2002) to the mothers to assess the presence of current and past psychopathology. To assess interrater reliability, an independent rater listened to 30% of the 96 SCID and K-SADS-PL interviews (i.e. 30% of the 42 eligible participants and 30% of the 54 ineligible participants). Group membership was confirmed reliably in all cases.

Mood induction

Because researchers have documented that cognitive biases can remain dormant until they are activated by a negative mood induction (Segal & Ingram, 1994), participants were placed in a negative mood state by watching one of two randomly assigned, 6-min film clips (*Champ*, Zeffirelli, 1979; *Dead Poets Society*, Weir, 1998). The film that was not watched at pretraining was watched at posttraining. While viewing the clip and for 2 min after, participants were instructed to 'imagine being in the situation' and to 'imagine the feelings you would experience in the situation'. This set of instructions has been found to be most effective in inducing a negative mood state (Westermann, Stahl, & Hesse, 1996).

Girls rated their mood (Mood Ratings) on a 5-point visual scale ranging from -2 (a very sad face) to 2 (a very happy face) before and after the negative mood induction. The first mood rating served as a baseline assessment of mood at the start of the pre- and post-training assessments. The second mood assessment allowed us to examine the effectiveness of the mood induction. This mood manipulation check has been used successfully in previous research (e.g. Joormann et al., 2007).

Dot-probe task

A set of 12 actors, each displaying happy, sad, and neutral expressions, was selected from the MacArthur Network Face Stimuli Set. We selected an equal number of male and female actors. Each of the 12 happy and 12 sad expressions was paired with the neutral expression of the same actor, creating 24 picture pairs. Each pair was seen four times, resulting in 96 trials, which were presented in a fully randomized order for each participant. Every trial started with a 1,000 ms display of a white fixation cross in the middle of the screen. Next, a picture pair was presented for 1,500 ms with the same actor displaying a neutral and an emotional expression. The emotional expression appeared on the right and left with equal probability. Finally, a small gray dot was presented to the left or the right of the screen, in the location where one of the pictures had been. The dot remained on the screen until participants indicated its location. Importantly, in the pre-training and post-training assessments, the dot appeared with equal probability behind the emotional and neutral expressions.

Psychosocial stressor and heart rate measurement

The stress protocol began with a 5-min rest period (baseline) during which participants sat quietly. Participants were then informed about the upcoming stressor. Specifically, they were read one of two story prompts and were instructed to finish the story in as dramatic, exciting, and interesting a way as possible. The prompt that was not given at pretraining was given at posttraining. Participants were given 5 min to prepare their story (anticipation) and then were given 5 min to tell their story (story) to a panel of judges who were blinded to training condition. Participants were informed that the judges would be evaluating how exciting and interesting the story was compared to stories told by other girls who had participated in the experiment. Immediately after telling their story, participants completed an unexpected 5-min serial subtraction task (math). They were instructed to count backwards from 400 to 0 by sevens. If they made a mistake, the experimenter instructed them to start again at 400. Finally, girls watched a relaxing nature video for 15 min (recovery 1, recovery 2, and recovery 3).

Heart rate was recorded continuously at a sampling rate of 1 kHz using the Biopac MP150 system and AcqKnowledge software package (Biopac Systems, Goleta, CA). We positioned three disposable electrodes in a modified lead II configuration and recorded girls' heart rate using the ECG amplifier module. Heart rate was scored in 300-s intervals using ANSLAB (Wilhelm, Grossman, & Roth, 1999). The ECG signal was inspected for artifacts and missing R-peaks based on improbable interbeat intervals (IBIs); whenever possible, missing R-peaks were added manually. If an R-peak was not discernable, up to two consecutive beats were inserted based on the IBI. If more than two R-peaks were missing and the missing section(s) summed to <60 s, we marked the section(s) as an artifact. If missing data summed to more than 60 s, the entire 300-s segment was excluded.

Self-report measures

Participants completed questionnaires assessing demographic and clinical characteristics. Depressive symptomatology was assessed with the Children's Depression Inventory - Short Form (CDI-S; Kovacs, 1984). The CDI-S has been used widely in studies of clinical and nonclinical children and adolescents.

Attentional bias training

Simple randomization was used to assign eligible participants to receive either Real or Sham ABT based on a randomly generated number; odd numbers were assigned to receive Real ABT and even numbers were assigned to receive Sham ABT with the stipulation that cell sizes did not differ by more than three participants at any point. After excluding the participant (Real ABT) who did not complete the posttraining assessment, 19 girls received Real ABT and 22 received Sham ABT. Girls who received Real ABT completed a modified version of the dot-probe task that was designed to increase participants' attention toward happy facial expressions and away from sad facial expressions. This task was identical to the dot-probe task completed at pre- and post-training, except that the dot appeared behind the emotional expression on 100% of the happy trials and behind the neutral expression on 100% of the sad trials. In contrast, girls who received Sham ABT completed the same version of the dot-probe task that was completed at pre- and post-training. In this version of the task, the dot appeared behind the emotional expression on 50% of the happy trials and 50% of the sad trials.

Procedure

This study was approved by the Stanford University IRB. Participants were scheduled for their pretraining assessment

within 1 week of their diagnostic evaluation. After providing informed consent, participants completed a measure of mood and then were exposed to a negative mood induction, followed by a second mood assessment. Immediately afterward, participants completed the typical, (i.e. noncontingent) dot-probe task to assess attentional biases followed by the laboratory stress task. At the end of the pretraining session, girls were randomly assigned to receive six sessions of Real or Sham ABT. Participants completed the first training session in the laboratory at the end of the pretraining assessment, and they completed the next five daily training sessions at home using a preprogrammed laptop computer. Girls returned to the laboratory approximately 1 week after the pretraining session to complete the posttraining assessment. Participants completed the same activities at posttraining that they completed at pretraining.

Results

Participant characteristics

Demographic and clinical characteristics of the participants are presented in Table 1. Girls who received Real ABT did not differ significantly from girls who received Sham ABT with respect to age, $t(39) = 0.13$, $p = .895$, ethnicity, $\chi^2(5, N = 41) = 9.68$, $p = .085$, number of training sessions completed, $t(38) = 0.88$, $p = .383$, CDI-S scores, $t(38) = 0.63$, $p = .533$, their mothers' age, $t(37) = 0.05$, $p = .960$, or their mothers' marital status, $\chi^2(3, N = 39) = 2.95$, $p = .400$.

Mood manipulation check

Mood ratings are presented in Table 1. A Training Condition (Real ABT, Sham ABT) by Mood Timing (prefilm, postfilm) by Training Time (pretraining, posttraining) repeated-measures analysis of variance (ANOVA) conducted on self-reported mood yielded a significant main effect of Mood Timing, $F(1, 39) = 78.08$, $p < .001$, $\eta^2 = .67$, and a significant interaction of Mood Timing and Training Time, $F(1, 39) = 16.89$, $p < .001$, $\eta^2 = .30$; no other main or interaction effects were significant, $F_s < 1.3$, $ps > .05$. As expected, participants' negative mood increased from before to after the film at both

the pretraining, $t_{\text{paired}}(40) = 10.06$, $p < .001$, and the posttraining assessments, $t_{\text{paired}}(40) = 5.15$, $p < .001$. The increase in negative mood, however, was greater at the pretraining than at the posttraining assessment, $t_{\text{paired}}(40) = -4.19$, $p < .001$. Participants who received Real versus Sham ABT did not differ in their mood change from prefilm to postfilm at pretraining or posttraining, $t_s(39) < 1$, $ps > .05$, indicating that the negative mood induction was equally effective across ABT conditions. Interestingly, participants' baseline (i.e. prefilm) negative mood increased from the pretraining to the posttraining assessment, $t_{\text{paired}}(40) = 3.11$, $p = .003$. Importantly, this pre- to post-training increase in baseline negative mood was significant only for participants who received Sham ABT, $t_{\text{paired}}(21) = 2.59$, $p = .017$. Although participants who received Real ABT also exhibited increases in negative mood, this change was not statistically significant, $t_{\text{paired}}(18) = 1.91$, $p = .072$. Participants who received Real versus Sham ABT did not differ significantly from each other with respect to change in baseline mood from pre- to posttraining, $p > .05$. No other comparisons were significant, $ps > .05$.

Attentional biases

Consistent with previous research (e.g. Joormann et al., 2007), we restricted our analyses to accurate trials on which participants' reaction times (RTs) were >100 and $<1,000$ ms. Errors occurred on fewer than 1% of the trials. Excluding trials with extreme RTs resulted in the deletion of $<1\%$ of the data. Girls who received Real ABT did not differ from girls who received Sham ABT with respect to error rates, $t_s(40) < 1.08$, $ps > .05$, or the number of trials that were excluded due to extreme RTs, $t_s(40) < 1.79$, $ps > .05$.

Average RTs were computed for each emotion type and probe location. Consistent with prior attentional bias research (cf. Mogg, Bradley, & Williams, 1995), we calculated attentional bias scores for each emotional expression. Attentional bias scores reflect the

Table 1 Participant characteristics

Variable	Sham ($N = 22$)	Real ($N = 19$)	Range
Baseline age, M (SD)	11.68 (1.17)	11.74 (1.49)	10 to 14
Caucasian, %	54.55	57.89	–
Number trainings completed, M (SD)	5.33 (1.07)	5.58 (0.61)	3 to 6
Baseline CDI, M (SD)	1.68 (1.80)	1.35 (1.18)	0 to 6
Mothers' age, M (SD)	44.10 (7.95)	44.00 (3.53)	27 to 54
Mothers' marital status, % married	60.00	73.68	–
Mood ratings pretraining			
Before film clip (baseline)	1.18 (0.59)	1.16 (0.69)	0 to 2
After film clip	–0.09 (0.61)	–0.11 (0.88)	–2 to 1
Mood ratings posttraining			
Before film clip (baseline)	0.82 (0.73)	0.74 (0.73)	–1 to 2
After film clip	0.18 (0.73)	0.00 (0.82)	–2 to 2

CDI, Children's Depression Inventory – Short Form.

attention-capturing quality of emotional faces. Positive values of this bias indicate attention toward the emotional face relative to a matched neutral face; negative values indicate attention away from the emotional face relative to the neutral face.

Figure 1 depicts attentional bias scores at the pre- and post-training assessments for participants who received Real and Sham ABT. To test the effects of Real versus Sham ABT on attention to happy and sad facial expressions, we conducted a three-way Training Condition (Real ABT, Sham ABT) by Face Emotion (happy, sad) by Training Time (pretraining, posttraining) repeated-measures ANOVA on attentional bias scores. This ANOVA yielded a significant main effect of Face Emotion, $F(1, 39) = 5.50, p = .024, \eta^2 = .124$, and a significant interaction of Face Emotion and Training Time, $F(1, 39) = 7.86, p = .008, \eta^2 = .168$, which were qualified by the predicted significant three-way interaction of Training Condition, Face Emotion, and Training Time, $F(1, 39) = 4.19, p = .047, \eta^2 = .097$. All other main and interaction effects were not significant, $F_s(1, 39) < 3.43, p_s > .05$. Follow-up tests for girls who received Real ABT yielded a significant main effect of Face Emotion, $F(1, 18) = 5.96, p = .025, \eta^2 = .249$, and a significant interaction of Face Emotion and Training Time, $F(1, 18) = 10.42, p = .005, \eta^2 = .367$. Specifically, as predicted, high-risk girls who received Real ABT exhibited decreased attention toward sad faces from pre- to posttraining, $t_{\text{paired}}(18) = -3.51, p = .002$, and increased attention toward happy faces from pre- to posttraining, $t_{\text{paired}}(18) = 2.32, p = .032$. In contrast, there were no significant main effects or interactions for girls who received Sham ABT, $F(1, 21) < 1, p_s > .05$.

Responses to stress

Psychophysiological data concerning reactivity to a laboratory stressor were obtained reliably pre- and post-ABT in a subset of the participants (13 Real ABT girls and 14 Sham ABT girls). Missing

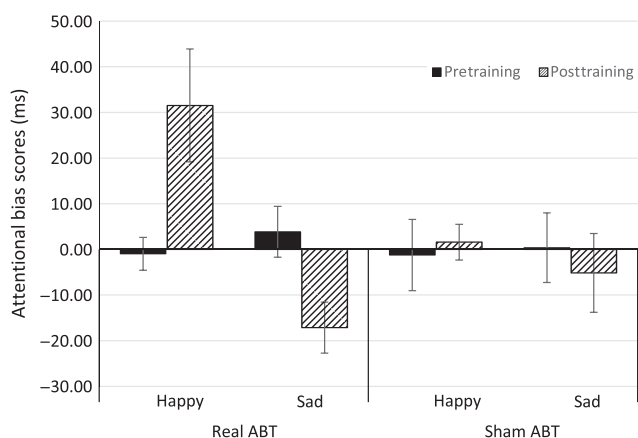


Figure 1 Attentional bias scores (in ms) at pre- and post-training assessments for participants who received Real and Sham attentional bias training (ABT). Error bars indicate $\pm 1 SE$

psychophysiological data were due to participants refusing to participate in the laboratory stressor ($n = 5$) or unreliable acquisition of heart rate data at the pre- or post-training assessment ($n = 15$), resulting in unusable ECG data. Participants for whom we did and did not have reliable data assessing their physiological reactivity to stress did not differ in age, severity of depressive symptoms, or number of training sessions completed, $t_s(38) < 1, p_s > .05$.

To examine the effects of Real versus Sham ABT on reactivity to a psychosocial stressor, we conducted a three-way Training Condition (Real ABT, Sham ABT) by Stressor Phase [baseline, anticipation, during the stressor (two assessments), and following the stressor (three assessments)] by Training Time (pretraining, posttraining) repeated-measures ANOVA on heart rate in response to the stressor. This ANOVA yielded a main effect of Stressor Phase, $F(6, 150) = 66.33, p < .001, \eta^2 = .726$, reflecting the expected increase in heart rate in response to the stressor and decrease in heart rate following the offset of the stressor. There was also a significant interaction of Training Condition and Stressor Phase, $F(6, 150) = 2.77, p = .014, \eta^2 = .100$, which was qualified by the significant three-way interaction of Training Condition, Stressor Phase, and Training Time, $F(6, 150) = 2.46, p = .027, \eta^2 = .090$. No other main effects or interactions were significant, $F_s < 1.73, p_s > .05, \eta^2 < .07$. A follow-up two-way ANOVA for girls who received Sham ABT yielded a significant main effect of Stressor Phase, $F(6, 78) = 28.04, p < .001, \eta^2 = .683$, and a significant interaction of Stressor Phase and Training Time, $F(6, 78) = 5.61, p < .001, \eta^2 = .301$. Girls who received Sham ABT exhibited higher heart rate in anticipation of the stressor, $t_{\text{paired}}(13) = -2.22, p = .045$, and during the stressor at the level of a trend, $t_{\text{paired}}(13) = -1.94, p = .075$, at posttraining than they did at pretraining. In contrast, girls who received Real ABT did not exhibit this increase in heart rate reactivity to stress at any point during their posttraining compared to their pretraining assessment, $t_{\text{paired}}(13) < 1.07, p_s > .30$. Figure 2

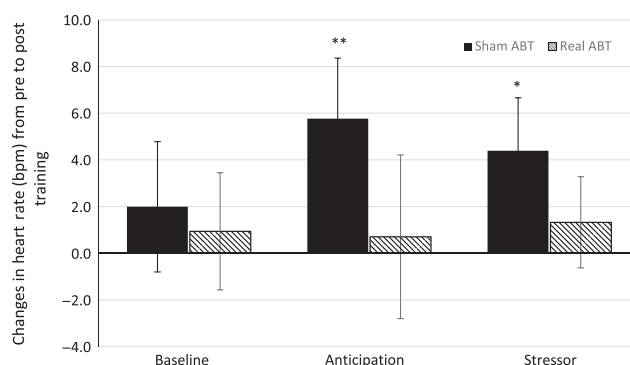


Figure 2 Changes from pre- to post-training in heart rate (beats per minute) in response to a laboratory stressor for girls who received Real versus Sham attentional bias training (ABT). Error bars indicate $\pm 1 SE$. ** $p < .05$, * $p = .075$

depicts changes in participants' heart rate from the pre- to the posttraining assessments for the baseline, anticipation, and stressor periods.

Discussion

This is the first study to examine whether youth at risk for MDD can be trained to attend toward positive and away from negative stimuli. Given the increased prevalence of depression during adolescence (Hankin & Abramson, 2001), the difficulty of treating adolescent depression once it occurs (March et al., 2004), and the long-term consequences of depression during adolescence (Costello et al., 2003), it is critical that we identify mechanisms that underlie the increased risk for depression during this developmental period. Findings from this study suggest that attentional biases can be altered in adolescents at risk for depression. Moreover, we examined the mechanisms underlying the effects of training and found that youth who received Real ABT were protected against the adverse emotional and physiological changes from pre- to posttraining that were exhibited by youth who received Sham ABT. Specifically, youth who received Sham ABT experienced a pre- to post-training increase in negative mood and a pre- to post-training increase in heart rate in anticipation of the stressor; in contrast, youth who received Real ABT were buffered against these negative outcomes.

As expected, participants who received Real ABT, but not those who received Sham ABT, exhibited significant increases from pre- to post-training in their attention toward happy faces and away from sad faces. Although researchers have demonstrated that attentional biases can be trained in depressed adults (e.g. Baert et al., 2010; Wells & Beevers, 2010), findings in the adult literature have been equivocal (see also Hallion & Ruscio, 2011). When these mixed results are considered in conjunction with evidence that ABT is more effective for adults with mild, but not severe, depressive symptoms (Baert et al., 2010) and that ABT is effective for depressed adolescents (Yang et al., 2016), it is possible that there are some populations for whom attentional biases are less entrenched and, therefore, more malleable. Consistent with this formulation, adolescence is a time of neural plasticity and reorganization, during which there may be a valuable window for intervention. This neural reorganization is particularly apparent for social behavior (Nelson, Leibenluft, McClure, & Pine, 2005); thus, our use of facial expressions of emotions as stimuli during ABT might be both salient and effective for this age group.

This study is also the first to use ABT to experimentally link attentional biases with mood in youth at risk for depression. Participants who received both Real and Sham ABT exhibited pre- to post-training increases in baseline negative mood;

however, the increase in negative mood was significant only for participants who received Sham ABT not for participants who received Real ABT. Although this finding should be interpreted with caution given that the higher-order interaction was not statistically significant, it is consistent with cognitive models of depression that contend biased attention toward negative and away from positive material contributes to the initial onset of depressive symptoms (e.g. Beck, 1967; Teasdale, 1988). Moreover, this finding suggests that biased attention toward happy stimuli and away from sad stimuli protects youth at risk for depression from the stress frequently experienced by adolescents (Spear, 2000).

In this study, we also explored mechanisms through which ABT might achieve its beneficial effects. The current findings support the formulation that ABT improves psychological well-being by altering responses to stress. At-risk youth who received Sham ABT exhibited an increase in anticipatory heart rate from pretraining to posttraining. In contrast, participants who received Real ABT appeared to be protected against experiencing this pre- to post-training increase in anticipatory heart rate. Overall, the majority of research with both rats and humans suggests that organisms habituate to subsequent stressors, which theorists posit is an adaptive means of coping with repeated stress. Interestingly, a study conducted by Pitman, Ottenweller, and Natelson (1988) might offer insight into when this adaptive habituation response goes awry. These investigators found that rats that had experienced chronic stress in the form of restraint showed a greater biological response in anticipation of the stressor on stress Days 2 and 3 than they did on stress Day 1 and than did nonrestrained control rats. Thus, chronic stress may hinder the adaptive habituation response. The fact that participants in this study, who are at risk for depression, exhibited an increase in anticipatory heart rate from pre- to post-training may reflect dysregulation of the stress response and may be, in part, what contributes to their higher risk for depression. That six sessions of Real ABT reduced participants' anticipatory stress response is noteworthy as it may protect them from the onset of future depressive episodes.

We should note several limitations of this study. First, we measured changes in attentional biases, psychophysiological reactivity to stress, and mood during the same relatively short-time interval. As such, we are unable to examine mediators of change. Moreover, given the relatively small sample size in this study, we do not have sufficient power to detect mediators or moderators of change. Future studies should recruit and follow a larger sample of participants over longer periods of time in order to gain a more comprehensive understanding of the relations among cognitive biases, responses to stress, and mood. Finally, we were able to collect reliable

psychophysiological data in only a subset of the sample. It is noteworthy that, despite this smaller sample size, we observed different physiological responses to stress between participants who received Real versus Sham ABT. Nonetheless, future research should examine training-related changes in psychophysiological reactivity to stress in a larger sample.

Despite these limitations, this study provides insight into the relations among attentional biases, physiological reactivity to stress, and negative mood in youth at risk for depression. This is the first study to directly manipulate a risk factor that may underlie the intergenerational transmission of risk for MDD from parent to child and, thus, increases our understanding of mechanisms involved in this process. Our findings also represent the first experimental evidence that manipulating attentional biases might protect against the maladaptive psychophysiological reactivity to stress and exacerbation of negative mood

that would otherwise be experienced by high-risk adolescents.

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Key points

- This is the first study to examine whether attentional biases can be modified in girls at risk for depression.
- Girls who received real attention bias training (Real ABT) exhibited significant increases in attention toward happy faces and away from sad faces from pre- to post-training; in contrast, girls who received Sham ABT did not.
- Whereas girls who received Sham ABT experienced an increase in baseline negative mood and in heart rate in anticipation of a stressor from pre- to post-training, girls who received Real ABT were protected against these negative changes.
- Findings indicate that attentional biases can be modified in girls at risk for depression and suggest that ABT yields beneficial effects by modulating physiological responses to stress.

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