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The cognitive and emotional effects of cognitive bias modification in interpretations in  
behaviorally inhibited youth

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**Abstract**

Cognitive bias modification (CBM) procedures follow from the view that interpretive biases play an important role in the development and maintenance of anxiety. As such, understanding the link between interpretive biases and anxiety in youth at risk for anxiety (e.g., behaviorally inhibited children) could elucidate the mechanisms involved in the development of pediatric anxiety. However, to date, the majority of CBM-I work only studies adult populations. The present article presents the results of a CBM study examining effects of positive interpretive bias modification on mood, stress vulnerability, and threat-related attention bias in a group of behaviorally inhibited children ( $n = 45$ ). Despite successful modification of interpretive bias in the at-risk youth, minimal effects on stress vulnerability or threat-related attention bias were found. The current findings highlight the need for continued research on cognitive biases in anxiety.

*Keywords:* Anxiety; Attention Bias to Threat; Behavioral Inhibition; Cognitive Bias Modification; Negative Interpretative Bias.

## Introduction

Anxious individuals are more likely than non-anxious individuals to interpret ambiguous information as threatening. While this negative interpretative bias could reflect the down-stream effects of anxiety, recent work suggests that interpretive biases influence the expression and experience of anxiety (e.g., Mathews & Macleod, 2002; Williams, Watts, MacLeod, & Mathews, 1997). This claim is bolstered by research employing experimental approaches to instantiate an interpretative bias, a training approach termed “cognitive bias modification in interpretation” (CBM-I). Because CBM-I experimentally modifies how ambiguous emotional information is interpreted, findings from CBM-I studies suggest that: 1) induction of a negative interpretive bias in non-anxious individuals increases anxiety; and 2) reduction of negative interpretive bias or induction of positive interpretive bias reduces anxiety (Beard, 2011; Macleod & Mathews, 2012). Importantly, CBM-I work suggests that an individual’s interpretive bias can affect their trait and state anxiety (e.g., Amir & Bomyea, 2010; Beard & Amir, 2008; Hirsch, et al., 2009; Hoppitt, Mathews, Yiend, & Mackintosh, 2010a), emotional vulnerability during stressful events (Mackintosh, Mathews, Yiend, Ridgeway, & Cook, 2006; Wilson et al. 2006), and even the anticipation of future anxiety (Hirsch, Mathews, & Clark, 2007; Murphy, et al., 2007).

To date, most CBM-I studies are conducted in adult populations. Only a handful of CBM-I studies have been conducted with children, and even fewer have been conducted with at-risk or clinically anxious samples (e.g., Fu, Du, Au, & Lau, 2013; Vassilopoulos, Banerjee, & Prantzalou, 2009). Thus the influence of bias manipulation on anxiety vulnerability in children remains largely untested. CBM-I work is needed to understand the link between interpretive bias and anxiety in children, when anxiety vulnerabilities first manifest (Pine, 1997). To examine if the same causal relations between interpretive biases and anxiety vulnerability found in adults exist in children, the current study employed

a positive CBM-I procedure. Specifically, the study examined if a reduction in negative interpretive bias is linked to decreased anxiety vulnerability in children high in behavioral inhibition (BI), a temperament style associated with social reticence and an increased risk for anxiety disorders. Negative interpretive biases are one factor thought to help account for individual differences in anxiety vulnerability in behaviorally inhibited children (Dodd, Hudson, Morris, & Wise, 2012; White, Helfinstein, & Fox, 2010). Thus, the current study examines whether decreasing threat-related interpretations in a group of behaviorally inhibited youth is linked to decreases in subsequent anxiety vulnerability.

Research examining the possible downstream cognitive and emotional effects of CBM-I may prove particularly useful in understanding the link between interpretive biases and anxiety. That is, changing negative interpretive bias may influence subsequent threat-related processing biases and further influence anxiety vulnerability. Prior work suggests that interpretive biases contribute to anxiety through cascading effects on attention (Amir et al., 2010; White, Suway, Pine, Bar-Haim, & Fox, 2011). Amir et al. (2010) showed that positive CBM-I influences individual's attention allocation to threatening information, whereas White et al. (2011) showed that training individuals to attend toward threatening information (a cognitive bias also associated with anxiety) influences subsequent threat-related interpretive biases. The acquisition of a bias at one processing stage (e.g. interpretation) may permeate multiple other stages of information processing (Daleiden & Vasey, 1997), generating threat-related biases at other information-processing stages (e.g., attention). Given that both interpretive biases and attention biases to threat are associated with increased anxiety vulnerability (Eldar, Ricon, & Bar-Haim, 2008; MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002), understanding their causal relation may help clarify the mechanisms involved in the development of anxiety disorders in youth.

In the current study a CBM-I procedure (Lester, Field, & Muris, 2011a, 2011b; Muris, Huijding, Mayer, & Hameetman, 2008; Muris, Huijding, Mayer, Remmerswaal, & Vreden, 2009) was employed to induce a positive interpretive bias in youth high in BI. The active training condition was compared to a placebo control condition, and effects of interpretive bias modification on mood, emotional vulnerability to stress, and attention bias to threat were then examined.

## **Methods**

### ***Participants***

Participants were 45 behaviorally inhibited children (29 males) between the ages of 9 and 12 ( $M = 11.42$  years;  $SD = 1.2$ ). Participants were randomly assigned into one of two training conditions: Positive Training ( $n = 23$ ; 14 boys) or Placebo Control ( $n = 22$ ; 14 boys).

Behaviorally inhibited children were recruited from a larger pool of participants ( $N = 187$ ) based on their scores on the Behavioral Inhibition Questionnaire (BIQ; Bishop, Spence, & McDonald, 2003). Based on normative data as reported in a large developmental study that included 293 children aged 9 to 15 years (Broeren & Muris, 2010), a BIQ score reflecting the top tercile of the population (i.e., BIQ total scores above 97.5) was used as the BI criterion (i.e., “high BI cut off score”). Seventy-six children met the eligibility requirements and were invited to participate. Parents and children from 50 families agreed to participate, the first five of whom served as pilot subjects. Out of the remaining 26 children, 7 families declined to participate and 19 were non-responsive to study invitations.

### ***Procedures***

The general study procedures are illustrated in Figure 1. Participants were randomly assigned to one of two CBM-I conditions: a positive interpretative bias training condition or a placebo, control condition. Prior to administering the CBM-I procedures, all children were assessed on their baseline

interpretive and attention biases. After the CBM-I procedure, all participants were again assessed on their interpretive and attention biases and then completed a stress induction procedure (i.e., a speech task). Mood scales were administered at multiple points throughout the study to assess changes in mood as a function of the CBM-I and the stress induction procedures.

## ***Measures***

### *Interpretive Bias Modification and Assessments*

*The New School Task:* The New Job Task consisted of three phases: pre-training bias assessment, bias modification, and post-training bias assessment. This task is a modified version of the social interpretive bias modification task used in Lester et al., (2011b) which was adapted from the non-social “Space Odyssey” interpretive bias modification task successfully used by Muris and colleagues (Muris et al., 2008, 2009). This CBM-I procedure has been used across multiple studies to successfully modify interpretive biases (Lester, Field, & Muris, 2011a; Lester et al., 2011b; Muris, Huijding, Mayer, & Hameetman, 2008; Muris et al., 2009). In this computer task, participants were presented with a list of short ambiguous scenarios that described first-person interactions under the rubric of “starting at a new school”. All scenarios described situations pertaining to a school environment (i.e., interacting with new classmates, giving a presentation in front of the class). Thirty of the scenarios were taken from the social training condition in Lester et al. (2011) and the remaining scenarios were adopted and modified from other established child interpretive bias measures (Bögels & Zigterman, 2000; Muris, Merckelbach, & Damsma, 2000; Waters, Craske, Bergman, & Treanor, 2008) or created in the Child Development Laboratory at the University of Maryland. The laboratory portion of the New School Task was programmed in E-Prime 2 and administered on a laptop computer. Prior to beginning the task, the experimenter thoroughly reviewed the instructions with the child.

Each trial included a scenario that described an ambiguous situation, followed by two option sentences describing how the scenario may have ended (Option A and Option B); one option always reflected a threat-related (negative) ending and the other always reflected a benign or positive ending. All scenarios used in the task were different (i.e., no scenario was presented to the participant more than once). Prior to the start of the task, participants were instructed to imagine that they had started a new school and were in the situation described. The participants were told that one of the ending options that would be presented was true, reflecting how the scenario ended in real life, and the other option was false, not reflecting the *real* outcome of the situation. For all trials, participants were instructed to choose the ending option (Option A or Option B) that best reflected how they thought the scenario would end in real life. Participants chose an option by selecting a corresponding button on the computer. The negative ending option appeared as Option A on half of the trials. The task was programmed in E-Prime 2 and administered on a desktop computer. Participant responses were collected via a button-box.

*The New School Task: Bias Modification Phase.* The bias modification consisted of 50 trials. Participants were informed that in this phase of the task they would find out if their choices were *right* or *wrong*. Following a response, feedback appeared on the screen (i.e., “Correct” accompanied by a green check mark or “Wrong” accompanied by a red X). Participants in the positive training condition received feedback that the positive ending was the correct ending on 90% of the scenarios; the remaining 10% of trials were “catch” trials, such that the positive ending option was *incorrect*. These trials were presented in a fixed order across training trials. In the placebo training condition, participants received feedback that the positive ending was correct for 50% of scenarios.

*The New School Task: Pre- and Post-Modification Assessment Phase.* The assessment phase of the New School Task was administered before and after the modification phase. Each assessment phase consisted of 10 trials. The assessment phase differed from the modification phase in that participants



responded to three different questions per trial [scenario] in order to get a robust estimate of the children's interpretive bias. After the ambiguous scenario was presented, the question, "*how do you think this situation will end?*" appeared on the screen, paired with three choices: "in a good way", "in a bad way", or "in a neutral/in-between way". To score interpretations on this question, all the "good" and "neutral" responses were summed and subtracted from the "in a bad way" responses. After children responded to the first question, children were presented with two ending options and asked to pick the option that best reflected how they thought the scenario ended in real life. One option always reflected a negative ending and the other always reflected a benign or positive ending. Total positive endorsed ending options were subtracted from total negative endorsements to create a bias score. After children selected an ending option the final question appeared on the screen: "*how distressed would you feel in this situation?*" Participants responded using a 4-point scale ranging from 1 "not at all" to 4 "a lot". Distress ratings across all ten scenarios were averaged to create a total distress score at each assessment point.

Interpretative bias scores from all three types of questions were significantly correlated at both baseline ( $r$ s ranging from .50 to .56,  $p$ s  $\leq$  .001) and post-training assessments, ( $r$ s ranging from .36 to .54,  $p$ s  $\leq$  .02). For variable reduction and to create a robust interpretative bias score, all three scores were standardized and averaged to create a composite score. A composite score was computed at each assessment time to reflect a total negative interpretive bias (Chronbach's  $\alpha$ s ranged from .72 to .83). Larger, more positive scores represent a larger negative interpretive bias and lower scores reflect greater non-threat interpretations.

#### *Attention Bias Assessment*

*The dot-probe task.* A modified dot-probe paradigm was used to examine attention bias toward threat. The current version of the task was provided by Tel-Aviv University/National Institute of Mental

Health Attention Bias Modification Treatment <http://www.tau.ac.il/~yair1/ABMT.html>. Each trial began with a fixation cross presented in the center of the screen for 500 ms, followed by a faces display for 500 ms. Each face display consisted of the simultaneous presentation of an individual's threat (i.e., angry) and neutral facial expressions or two neutral expressions. The two facial expressions were presented vertically. After the face display presentation, a probe (“<”, “>”) appeared and remained on the screen until participant response. Facial expressions consisted of ten different actors (5 male, 5 female) from the NimStim stimulus set (Tottenham et al., 2009). Each assessment phase consisted of 120 trials, with 80 of the trials containing a threat-neutral face display and 40 containing a neutral-neutral display. At each assessment, if a participant's accuracy rate was below 70% on the first 10 trials a warning would appear and the task ended. In this event, instructions were repeated and the task was restarted. The task was programmed in E-Prime 2 and administered on a laptop computer.

Standard dot-probe cleaning procedures were used (e.g., Abend, Pine, Fox, & Bar-Haim, 2014; Eldar, Ricon, & Bar-Haim, 2008). Dot-probe trials with incorrect responses and reaction times (RTs) less than 200 ms or greater than 2000 ms after target presentation were excluded from further analyses. Additionally, RTs above and below two standard deviations of the mean RT for pre and post assessments for each subject in a specific experimental condition (threat congruent, threat incongruent, neutral-neutral) were excluded from the mean reaction time calculations. To calculate attention bias scores, mean RTs of congruent trials were subtracted from mean RTs of incongruent trials, such that higher scores on the bias index reflect an attention bias toward threat and negative scores reflect an attention bias away from threat and toward neutral. One participant was excluded from analyses due to poor accuracy (i.e., an accuracy rate below 65%). Mean accuracy at pre-training was 96% ( $SD = 3.7\%$ ) and mean post-training accuracy was 97% ( $SD = 5.3\%$ ).

#### *Emotional Vulnerability Assessment*

*Speech Stress Task.* For the stress induction procedure, participants gave a speech on the topic: “*why we [the experimenter] should vote for you [the participant] to become class president*”. Participants were informed they would give their speech in front of two laboratory experimenters and told that their speech should last five minutes. In actuality, participants were informed the speech task was finished after two minutes. Participants were given two minutes to prepare their speech after which the experimenters entered the room and the speech began. The experimenters remained neutral during the speech and provided a standard set of prompts if the participant fell silent before the two minutes were finished. After the speech children completed a questionnaire to evaluate their speech performance. Using a scale ranging from 1 “not at all” to 10 “very”, participants reported on how happy they felt about their performance and how upset they were about their performance. Ratings on the happy and upset item evaluations were significantly correlated ( $r = -.62$ ), so the happy scale was reverse scored and the standardized upset and happy scales were summed to create an index of negative self-evaluation.

#### *Questionnaire and Self-report measures*

*Behavioral Inhibition Questionnaire* (BIQ; Bishop et al., 2003; Broeren & Muris, 2010). The BIQ is a 30-item parent-report questionnaire used to assess temperamental BI in children. Items relate to social novelty, situational novelty and physical challenges. Item examples are: “Is very quiet around new (adult) guests to our home”; “Is very friendly with children he or she has just met”; “Takes many days to adjust to new situations (e.g., school)”; “Is clingy when we visit the homes of people we don't know well”. Parents endorse each item for their child using Likert scale ranging from 1 “hardly ever” to 7 “almost always”. Scores were summed to create a total BIQ score.

*Screen for Child Anxiety and Related Emotional Disorders* (SCARED; Birmaher et al., 1997, 1999). The SCARED is a 41-item parent-report questionnaire designed to assess childhood anxiety symptoms in terms of the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV). Item

examples are, “My child feels nervous with people he/she doesn’t know well” (Social Phobia) and “My child is a worrier” (General Anxiety Disorder). Parents endorse each item for their child using a 3-point scale: 0 “never true”, 1 “somewhat or sometimes true”, and 2 “very true or often true”. Scores were summed to create a total anxiety score.

*Mood Scales.* To assess change in mood over the course of the experiment, a total of four sets of mood scales were administered at different points across the experiment (see Figure 1). Scales used to the following labels: “*happy, great*”, “*nervous, worried*”, “*sad, depressed*”, and “*angry, frustrated*”. Under each mood label, there was a line was divided into 30 equal partitions. Participants were asked to circle the mark on the scale that most accurately reflected their current mood state. Scores ranged from 1-30, where higher scores reflect a more anxious or depressed mood. At each assessment point, the sad, nervous, and angry mood ratings were averaged together to create a negative affect score. The happy mood ratings represented the positive affect score at each time point. The first set of mood scales was missing from one participant.

### *Statistical Analyses*

Prior to hypothesis testing, correlations among dependent measures were examined. Next, effects of training on interpretive bias, attention biases, and mood were examined using separate ANCOVAs controlling for pre-training interpretive bias, attention bias, or mood, with Training Condition (Positive Training, Placebo Control) as a between subjects factor. An ANCOVA approach was used to test for effect of training as it offers a robust test of post-training differences as a function of training, controlling for any baseline differences that may exist (Overall & Ashby, 1991). To assess emotional vulnerability to stress in the current experiment, negative and positive affect ratings were subjected to separate repeated measures ANCOVA with Time (Pre-Stress Induction, Post-Speech Preparation, Post-Speech) as a within subjects repeated factor and Training Condition (Positive Training, Placebo Control)

as a between subjects factor, controlling for the affect rating directly after the training procedure. Children's SCARED total scores entered as a covariate to control for possible anxiety differences. Greenhouse-Geisser statistics are reported when assumptions of sphericity were violated. To correct for non-normality, interpretative bias and attention bias scores were square-root transformed, and negative affect scores were log-transformed.

Prior to analyses, interpretive and attention bias scores on pre- and post-training blocks were examined for significant outliers. For each variable, outlier status was defined as a  $z$  score of  $\pm 3.13$  (which is appropriate for sample sizes between 40-50; Barnett & Lewis, 1994). No outliers were detected.

In addition to the aforementioned frequentist models of the data, for each model Bayes Factors were estimated for the effects that test the substantive hypothesis of interest. Rather than asking whether or not effects are significant, Bayes Factors ( $BF_{10}$ ) quantifies the ratio of the probability of the data under the alternative hypothesis relative to the null. A value of 1, therefore, means that the observed data are equally probable under the null and alternative hypotheses, values above 1 suggest that the data are more probable under the alternative hypotheses relative to the null and values below 1 suggest that the data are more probable under the null hypotheses relative to the alternative. For example,  $BF > 3$  suggests the data are three times more probable under the alternative hypothesis than the null, and the reciprocal ( $BF < 1/3$ ) suggests the data are three times more probable under the null hypothesis than the alternative. Bayes factors have the considerable advantage over null hypothesis significance tests that they provide information about the probability of the data under the null hypothesis (relative to the alternative). In contrast, significance tests provide no evidence at all about the status of the null hypothesis (Dienes, 2014).

Bayes Factor were estimated using the *lmBF()* or *anovaBF()* functions in the BayesFactor (Morey & Rouder, 2014) package in R (R Core Team, 2014). This function uses a default Jeffries prior (Rouder, Morey, Speckman, & Province, 2012). This default prior models prior beliefs in the effect size using a Cauchy distribution centered on 0 and with a default scale factor of 0.707. In doing so, our prior belief is that there is a 50% probability that the effect size ( $d$ ) lies between  $-0.707$  to  $0.707$ . This default value represents a fairly open-minded belief that effects could range from fairly large and positive in the predicted direction to equally large in the opposite direction.

The two statistical approaches (significance testing and Bayes Factors) provided in the current manuscript represent two alternative approaches to understand the data, but can be used in parallel to interpret the current results. The significance testing can offer a guide as to whether a result represents a statistical difference and fits with the most commonly used statistical approach. The Bayes factor, on the other hand, provides comparative information of the data's likelihood under both the null and alternative hypotheses.

## ***Results***

Means and standard deviations appear in Tables 1 and 2. Participants in the two training conditions did not differ in age,  $t(43) = 0.95, p = .35$ , sex,  $\chi^2(1) = 0.37, p = .85$ , or BIQ scores,  $t(43) = 0.15, p = .88$ . All baseline study variables were examined to check for possible sex (via independent samples  $t$ -tests) and age (via correlation analyses) differences. Age was significantly negatively correlated to positive affect ratings,  $r(44) = -.42, p = .01$ , and attention bias,  $r(45) = -.33, p = .03$ . There were no significant sex differences on any of the variables.

### *Inter-correlations Between Study Variables at Baseline*

Correlations are presented in Table 3. At baseline, interpretive and attention bias to threat were negatively correlated; larger negative interpretive bias scores were related to larger attention biases *away* from threat. No other baseline measures were significantly correlated.

#### *Training Effects on Interpretative Bias*

*New School Task Assessment Phase.* Results of the interpretive composite scores revealed a significant main effect of Training Condition,  $F(1,40) = 8.35, p < .01$ , partial  $\eta^2 = .17$ ,  $BF_{10} = 5.14$  ( $\pm 0.94\%$ ), indicating that the data are 5.14 times more probable under the alternative hypothesis compared to the null. Behaviorally inhibited children in the positive training condition showed lower negative interpretive biases at the post-training assessment compared behaviorally inhibited children in the placebo training condition.

#### *Training Effects on Attention Bias to Threat*

*Dot-Probe.* Analyses of the Attention Bias Scores revealed the effect of Training Condition was not significant,  $F(1,40) = 1.24, p = .27$ , partial  $\eta^2 = .03$ ,  $BF_{10} = 0.40$  ( $\pm 1.26\%$ ), indicating that the data are  $1/0.4 = 2.5$  times more probable under the null hypothesis compared to the alternative. The training procedure did not have a significant effect on children's attention bias to threat.

#### *Training Effects on Mood and Emotional Vulnerability to Stress*

*Mood Changes.* Directly after the training procedure the two Training Conditions did not significantly differ on negative affect ratings,  $F(1,41) < 1$ ,  $BF_{10} = 0.24$  ( $\pm 4.14\%$ ), indicating that the data are  $1/0.24 = 4.17$  times more probable under the null hypothesis compared to the alternative. The two conditions significantly differed on reports of positive affect at trend,  $F(1,42) = 3.41, p = .07$ , partial  $\eta^2 = .08$ . Contrary to hypothesis, this trend level effect revealed that children in the Positive Training Condition tended to report lower levels of positive affect compared to the Placebo Control Condition.

However, the Bayes Factor,  $BF_{10} = 0.94$  ( $\pm 1.24\%$ ), indicated that the data are equally probable under the null and alternative hypotheses.

*Emotional Vulnerability to Stress.* Analyses of the negative affect scales revealed a significant main effect of Time,  $F(2,76) = 5.06$ ,  $p = .01$ , partial  $\eta^2 = .12$ ; all participants showed a linear increase in their negative affect across the stress task,  $F(1,38) = 7.91$ ,  $p = .01$ , partial  $\eta^2 = .17$ . There was no significant main effect of Training Condition,  $F(1,38) < 1$ . There was a trend level effect of Time  $\times$  Training Condition,  $F(2,76) = 2.54$ ,  $p = .09$ , partial  $\eta^2 = .06$ . However, the Bayes Factor,  $BF_{10} = 0.92$  ( $\pm 2.77\%$ ), indicated that the data are equally probable under the null and alternative hypotheses for this interaction term.

The analyses of positive affect scales also revealed a significant main effect of Time,  $F(2,76) = 3.96$ ,  $p = .02$ , partial  $\eta^2 = .09$ , indicating all participants showed a linear decrease in their positive affect across the stress task,  $F(1,38) = 5.62$ ,  $p = .02$ , partial  $\eta^2 = .13$ . There was no significant main effect of Training Condition,  $F(1,38) < 1$  and no Time  $\times$  Training Condition interaction,  $F(2,76) = 1.70$ ,  $p = .19$ , partial  $\eta^2 = .04$ ,  $BF_{10} = 0.27$  ( $\pm 6.99\%$ ), indicating that the data are  $1/0.27 = 3.7$  times more probable under the null hypothesis compared to the alternative for the time  $\times$  condition interaction.

Lastly, examination of participants negative self-evaluation score regarding their speech performance revealed that the Training Condition ( $M = 6.19$ ,  $SD = 2.23$ ) did not differ significantly from the Control Condition ( $M = 5.5$ ,  $SD = 2.72$ ),  $F < 1$ .

### ***Discussion***

The current experiment examined if negative interpretations could be experimentally reduced in children at risk for anxiety (i.e., high in behavioral inhibition) through a single session of CBM-I. Additionally, the effects of the CBM-I procedure on children's mood, emotional vulnerability to stress, and attention bias to threat were also examined. The results revealed that CBM-I successfully altered the



manner in which children endorsed negative and positive interpretations: compared to a placebo control condition, children in the positive training condition showed higher post-training positive interpretive bias scores on the New School Task. This finding is noteworthy in light of previous CBM-I work suggesting that threat-related biases may be more easily acquired than reduced in vulnerable populations (Muris et al., 2008; Taylor, Bomyea, & Amir, 2011).

Despite the change in interpretations on the New School Task, these effects failed to generalize to other measures of anxiety vulnerability: children who underwent the positive CBM-I procedure did not significantly differ from those receiving the control condition on mood, anxiety vulnerability to stress, or attention bias to threat. Moreover, Bayes Factors suggested that at best, the probability of the data under the null and alternative hypotheses was equal, but mostly more probable under the null.

The successful manipulation of interpretive biases without any influence on other anxiety-related emotional and cognitive processes (also see, Salemink et al., 2007; Salemink, ven den Hout, & Kindt, 2010) raises interesting questions regarding the role such biases have in the maintenance or cause of anxiety. Given the therapeutic potential CBM-I procedures for anxiety disorders, it will be important for future research to continue examining associations between interpretive biases and anxiety vulnerability, as well as identify the specific CBM-I methods that maximize the generalization of CBM-I. For example, training sessions separated by time, which allows for consolidation of what had been learned in the training session (Abend et al., 2014), may increase the effects of CBM-I on anxiety.

The influence that CBM-I has on subsequent anxiety-related cognitive and emotional processing may be fragile or narrow, making it difficult to detect transfer effects. Transfer effects may be dependent on the material (e.g., stimuli) used in the training paradigm, as well as the procedures used to assess emotional vulnerability. For example, CBM-I may not transfer to the processing of stimuli that differ from those used during training. In a series of CBM-I studies, Mackintosh and colleagues (2013) only

found significant training effects on stress reactivity when the content of the stimuli used in the CBM-I procedure matched the content used to assess emotional vulnerability. In CBM-I work targeting attention biases to threat, Browning and colleagues (2012) found that attention-bias training did not generalize across stimulus classes. Moreover, the attention-bias training effects on subsequent interpretive bias reported by White et al. (2011) were limited to anxiety specific, and not general negative, interpretations and Amir and colleagues (2008), who found that positive social interpretation training affected attention bias, used social stimuli to assess attention bias to threat. Modification of interpretations via different types of CBM-I procedures (e.g., Amir et al., 2010; Hayes, Hirsch, Krebs, & Mathews, 2010) could also yield different patterns of transfer effects than the type of CBM-I (Lester et al., 2011a, 2011b; Muris et al., 2008, 2009) employed in the current experiments. Finally, for training to generalize, multiple sessions may be required.

The current study contained several important limitations, the most significant of which related to the CBM-I procedure. As a function of feedback to the child's endorsement ("correct" or "incorrect"), children in the active training group simply may have learned a rule: "endorse the positive ending option", without fully processing the ambiguous nature of the scenario at hand. Thus, the task may have encouraged children to choose the positive ending without influencing the interpretation of ambiguity beyond the bounds of the task. Given that the interpretive bias assessments before and after training were assessed using a similar format to those in the training procedures, this possibility cannot be ruled out. Future CBM-I work in children work should employ multiple different methods to fully understand the causal links between interpretive bias and anxiety. Moreover, to fully understand if CBM-I procedures modify children's genuine interpretive bias, future CBM-I work should use training-procedure independent assessments of children's interpretive bias. However, it should be noted that a

similar paradigm to that used in the current study has been shown to modify interpretations on independent assessments of interpretive bias (e.g., Muris et al., 2009; Lester et al., 2011b).

The study also possessed other limitations. As noted above, effective CBM-I may require multiple sessions, but the current CBM-I procedure administered training across one session. Finally, as opposed to the more traditional laboratory-based observational assessment in early childhood, the current study used parental-reported BI to select a high behaviorally inhibited sample.

In summary, the current studies showed successful modification of interpretive biases in a group of young adults and vulnerable children; however the influence such bias modification had on subsequent anxiety related factors was limited. Before CBM-I methods can be used successfully in the clinic, there must exist a strong body of literature supporting their effectiveness. The current findings contribute to the growing body of research aiming to understand the role of negative interpretive bias in anxiety vulnerability; however, they also call on the need for continued research in this area, in both adult and developmental populations.

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**Table 1.**  
Means and Standard Deviations (SD) for Interpretive and Attention Biases

Variable	Positive Training Condition				Placebo Control Condition			
	Pre		Post		Pre		Post	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
New School Interpretive Bias	.13	.74	-.17	.73	-.14	.91	.18	.86
Attention Bias to Threat	12.67	32.65	9.35	38.34	3.03	45.22	-3.58	29.01



**Table 2.**  
Means and Standard Deviations (SD) for Mood Scale ratings

	Positive Training Condition								Placebo Control Condition							
	Post-Training		Pre-Stress Induction		Post-Speech Preparation		Post-Speech		Post-Training		Pre-Stress Induction		Post-Speech Preparation		Post-Speech	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Negative Affect	3.23	3.75	2.46	4.08	6.61	5.94	8.76	8.27	3.97	4.94	3.68	4.75	6.44	6.14	6.83	5.75
Positive Affect	17.98	7.75	18.52	8.36	13.61	9.68	14.41	9.32	21.86	7.23	22.45	7.51	19.13	9.13	16.29	10.35

**Table 3.**  
Correlation Matrix

Item	Item		
	1	2	3
1. New School Interpretive Bias			
2. Attention Bias to Threat	-.30 *		
3. Negative Mood Scale	.14	-.06	
4. Positive Mood Scale	-.01	-.30	-.13

\*  $p < .05$

**Figure 1.**

Outline of Experimental Procedures

