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Modifying interpretations among individuals high in anxiety sensitivity

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Abstract

To examine the causal relationship between cognitive biases and anxiety, a bias modification paradigm was used to reduce negative interpretation biases in participants with high anxiety sensitivity (AS). Participants (*N*=75) were assigned to a Positive training condition or to one of two Control conditions (Neutral or No training). During training, participants imagined themselves in ambiguous scenarios related to AS. Positive training required participants to resolve the scenarios' ambiguity positively and was hypothesized to result in more positive and less negative subsequent interpretations related to AS, fewer self-reported AS symptoms, and less emotional vulnerability on AS stressors (compared to the Control conditions). As expected, Positive training shifted interpretations of novel scenarios and self-reported AS symptoms in the anticipated direction. Evidence was mixed for the effect of Positive training on emotional vulnerability (small effect for less fear, but not for avoidance). Findings support the causal premise underlying cognitive models of anxiety.

Keywords

cognitive bias modification; information processing; interpretation; anxiety sensitivity

General cognitive models of anxiety posit that a series of cognitive biases maintain, and possibly cause, anxiety disorders (e.g., Beck & Clark, 1997; Beck, Emery, & Greenberg, 1985; Williams, Watts, MacLeod, & Mathews, 1997). If these biases are causally related to anxiety disorders, it is theoretically expected that reducing the biases will lead to a decrease in anxiety symptoms. The current study tests this causal premise by examining whether it is possible to modify interpretation biases among individuals high in anxiety sensitivity, and then examining the effects on subsequent interpretations, self-reported anxiety sensitivity symptoms, and fear and avoidance during interoceptive exposures (tasks that elicit unusual bodily sensations).

Anxiety sensitivity (AS) refers to a fear of symptoms related to anxiety (e.g., bodily sensations, such as sweating or heart racing), stemming from beliefs that these sensations have negative physical, psychological, or social consequences (Reiss, 1991; Reiss & McNally, 1985). Critically, elevated AS is a vulnerability marker for anxiety pathology (Rapee, Brown, Antony, & Barlow, 1992; Taylor, Koch, & McNally, 1992), and it appears to be especially important to the development of panic disorder (Ehlers, 1995; Hayward, Killen, Kraemer, & Taylor, 2000; Reiss, 1991). For instance, Maller and Reiss (1992) found that high (versus low) levels of AS were associated with a five times greater risk of developing a future anxiety disorder. Moreover, AS appears to be associated with reductions in pathological anxiety. In fact, Smits,

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Powers, Cho, and Telch (2004) found that changes in AS fully mediated changes in global impairment related to panic following cognitive behavioral therapy (CBT) for panic disorder. Further, numerous studies have demonstrated that successful CBT for panic disorder results in lower levels of AS (see review by Otto & Reilly-Harrington, 1999). AS is thus connected to both vulnerability for future anxiety pathology and treatment outcomes.

Given the apparent link between change in AS and anxiety disorder onset and reduction, the value of being able to quickly modify AS seems high. Theoretically, this would help demonstrate that AS has a functional (versus merely correlational) relationship with anxiety, and clinically, this may point to additional approaches to prevent and treat anxiety difficulties.

Cognitive bias modification: Shifting interpretations

Modifying interpretation biases may be a useful target to reduce high AS, because AS is characterized by a bias to favor threatening interpretations of ambiguous information (e.g., Richards, Austin, & Alvarenga, 2001; Teachman, 2005). For instance, people with high AS are likely to interpret a racing heart as a precursor to a heart attack, rather than the normal effect of a brisk walk. The current study extends these correlational investigations by attempting to directly modify interpretation biases in a sample with elevated AS.

Most research on cognitive bias modification (CBM) has focused on attentional bias training using a dot probe paradigm, in which participants see a neutral or a threat-relevant cue and subsequently detect the presence of a probe (e.g., MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002; Vasey, Hazen, & Schmidt, 2002). Results have demonstrated that it is possible to modify attentional biases, which in turn may reduce emotional vulnerability (MacLeod et al., 2002) and even pathological anxiety symptoms (Amir, Beard, Burns, & Bomyea, 2009; Amir, Weber, Beard, Bomyea, & Taylor, 2008).

Modifying interpretation biases in non-anxious samples also appears effective (e.g., Grey & Mathews, 2000; Hertel, Mathews, Peterson, & Kinter, 2003). In a series of experiments, Mathews and Mackintosh (2000) showed that it is possible to induce both negative and positive interpretation biases in an unselected community sample. In their training paradigm, participants read and imagined themselves in a series of emotionally ambiguous scenarios. To induce a positive bias, participants read scenarios that ended in a non-threatening way. To induce a negative bias, participants read the identical scenarios but with a threatening ending. The authors found that training resulted in training-congruent interpretations when participants were presented with novel ambiguous scenarios. Several studies have replicated the Mathews and Mackintosh study with non-anxious populations and found similar results (Mackintosh, Mathews, Yiend, Ridgeway, & Cook, 2006; Salemink, van den Hout, & Kindt, 2007a, 2007b; Yiend, Mackintosh, & Mathews, 2005). Moreover, the effect of training on interpreting novel scenarios has been shown to endure for at least 24 hours (Yiend et al., 2005), and to persist despite changes in environmental context (Mackintosh et al., 2006).

The small number of studies that has used interpretive CBM programs with anxious populations have been promising, though there is limited evidence for reduction of clinically significant symptoms. For instance, Murphy, Hirsch, Mathews, Smith, and Clark (2007) used a modification of the Mathews and Mackintosh (2000) paradigm in which the training scenarios were presented aurally to a sample high in social anxiety symptoms. The authors found that Positive training led to more positive interpretations, relative to the Control condition (which included scenarios that had a neutral, valence-irrelevant ending), and that participants in the Positive training condition *predicted* that they would be significantly less anxious in future social situations, but there was no assessment of an actual social interaction in the study. Teachman and Addison (2008) modified the Mathews and Mackintosh training scenarios to use with a high spider fear sample. Positive training led to faster resolution of positive (versus negative) word fragments and more positive interpretations of novel spider scenarios. Although the training did not have a strong effect on subsequent fear and avoidance related to a live spider, in the Positive training condition (but not the full sample), faster resolution of positive word fragments was correlated with less avoidance and fear of the live spider. Hirsch, Hayes, and Mathews (2009) used both an aural modification of the Mathews and Mackintosh paradigm and a homograph-based interpretation training task with a sample with high levels of worry. In the homograph-based interpretation training task, participants repeatedly practiced retrieving benign meanings of threat-related homographs (such as sack; which could be interpreted in a benign manner as a bag for potatoes or in a threatening manner as being dismissed from a job). The authors found that the combined interpretation training approaches led to less negative thought intrusions and less fear during a breathing task when compared to a control condition. In addition, Mathews, Ridgeway, Cook and Yiend (2007) found that the Mathews and Mackintosh training paradigm, repeated over the course of four sessions, not only reduced subsequent negative interpretation biases, but also successfully reduced trait anxiety in a sample of high trait-anxious volunteers.

Notably, previous studies using the Mathews and Mackintosh (2000) paradigm have produced conflicting results regarding whether the training affects state anxiety immediately (e.g., Salemink et al., 2007b) or only when participants are presented with a subsequent emotional stressor (i.e., training did not have an immediate effect on state anxiety: e.g., Mathews et al., 2007; Salemink et al., 2007a; Teachman & Addison, 2008). Importantly, results have been more reliable for effects on subsequent stressors, which is the critical outcome to indicate changes in emotional vulnerability. For example, Wilson, MacLeod, Mathews, and Rutherford (2006) found that Positive interpretation training resulted in less anxiety following a video stressor. Interpretation training is thus expected to affect subsequent levels of emotional vulnerability, but may not immediately alter mood (suggesting the training is more likely specific to interpretation biases, as opposed to an affect manipulation).

The current study expands on this promising early research by looking at a population that is at high risk for future anxiety problems – participants high in AS – to evaluate whether it is possible to reduce this risk factor through modifying interpretation biases. In addition, this study examines the effects of interpretation bias modification on actual fear and avoidance during tasks designed to elicit AS (as opposed to predicted future anxiety, as in the Murphy et al., 2007, study). A modified version of the CBM paradigm used by Mathews and Mackintosh (2000) was used in which participants learned to ascribe positive or negative interpretations to ambiguous scenarios related to AS. We included a Positive training condition, as well as two Control conditions: a Neutral training condition (to control for the effects of making interpretations in general), and a No training condition (to control for the effects of being exposed to stimuli related to AS). It was hypothesized that Positive training would lead to more positive and less negative interpretations for novel ambiguous scenarios and faster completion of positively valenced word fragments, relative to the two Control conditions (which were expected to have similar results to one another). It was also hypothesized that Positive training would lead to lower levels of self-reported AS symptoms, as well as less subsequent emotional vulnerability, as indicated by fear and avoidance during interoceptive exposures.

Methods

Participants

Participants were recruited from the university's psychology department participant pool based on their responses to the Anxiety Sensitivity Index (ASI; Reiss, Peterson, Gursky & McNally, 1986). Only students who scored 27.5 or greater on the ASI were invited to participate, matching a one standard deviation cutoff above prior ASI college student norms (Peterson &

Reiss, 1992). Seventy-five students (69.3% female, mean age = 18.93, SD = 1.00, range = 18-24) participated in the study. Sixty percent reported their ethnicity as Caucasian, 26.7% as Asian, 4% as African American, 1.3% as Native Hawaiian/Pacific Islander, 5.3% as multiple ethnicities, and 2.7% as "other".

Materials

Anxiety and mood symptoms—The Anxiety Sensitivity Index (ASI; Reiss et al., 1986) is a 16-item Likert-type questionnaire that measures a person's concern about or fear of anxiety-related symptoms (e.g., "It scares me when I become short of breath"). The ASI was used to recruit high AS participants and to examine whether training had an immediate impact on ASI scores. Scores in the current sample were similar to ASI scores found in clinical samples with panic disorder (Rapee et al., 1992), supporting the classification of this sample as a clinical analogue. Cronbach's alpha in the current sample for the ASI completed during the testing session was .84.

The Positive and Negative Affect Schedule-Fear Subscale (PANAS-FS; Watson & Clark, 1994) is a self-report measure of mood states based on adjective ratings. Only the 6-item fear subscale was administered in the present study in order to evaluate how training affected state fear throughout the study. The PANAS-FS was administered five times throughout the study. Cronbach's alpha across administrations ranged from .61-.90 with an average of .77.

Interpretation bias measure—The Brief Body Sensations Interpretation Questionnaire (BBSIQ; Clark et al., 1997) is a 14-item questionnaire in which participants are presented with ambiguous scenarios and three possible explanations to disambiguate the scenario. For each item, one explanation is always negative, while the other two are either positive or neutral. Half of the items deal with external threats, such as threatening social events, and the other half of the items are related to bodily sensations (only the Bodily Sensation items were examined in the present study given their tie to AS). An example Bodily Sensation item is, "You feel short of breath. Why?" and the three possible explanations are, "you are developing the flu," "you are about to suffocate or stop breathing," and "you are physically 'out of shape'". Participants rate likelihood of each explanation being true on a 0-8 Likert-type scale (an additional ranking response option was not included in the current study). Endorsement of negative interpretations of Bodily Sensation items was used as a measure of baseline interpretation bias. The measure was also administered at the end of the study to see if training would show immediate effects on interpretations of Bodily Sensation items. Note, this was a somewhat exploratory test given that is was unclear whether people would change their responses to the measure when they could likely recall the answers they had provided less than an hour earlier at the baseline assessment.

Behavioral avoidance tasks (BATs): Interoceptive exposures—Behavioral Avoidance Tasks (BATs) are used to measure avoidance and fear related to emotion provocations. In the current study, two BATs were used that produce harmless, but potentially anxiety-provoking, physical sensations. Avoidance was measured by the amount of time a person chose to participate in the task. Subjective fear was measured by the PANAS-FS, administered immediately following completion of each BAT (participants were asked to indicate how they felt when their anxiety was at its highest during each task). The two tasks used in this study have been used in previous studies examining anxiety reactions (e.g., Gordon & Teachman, 2008; Teachman, Smith-Janik, & Saporito, 2007), and were derived from the widely used Panic Control Treatment manual (Barlow & Craske, 1994). They were selected to determine if training affects subsequent emotional vulnerability to stressors related to AS.

In the Candle Blowing task, participants imagined that their finger was a candle that they must blow out repeatedly for up to 60 seconds. The participants blew out air rapidly at a tempo of 100 breaths per minute (standardized by a metronome). This activity is harmless, but it produces temporary sensations, such as sweating, hot flashes, dizziness, tingling, and numbness. In the Straw Breathing task, participants breathed through a thin straw for up to 60 seconds while holding their nostrils shut. While harmless, this task elicits temporary feelings of suffocation, lightheadedness, and dizziness.

Interpretation training—The training procedure was modified from a paradigm used by Mathews and Mackintosh (2000) in which subjects learned to ascribe positive or negative interpretations to ambiguous scenarios related to social threat. For the current study, participants read and imagined themselves in 64 scenarios related to AS. To insure that each scenario accurately reflected a concern related to AS, each scenario was designed to correspond to one of the items from the 36-item Anxiety Sensitivity Index-Revised (ASI-R; Taylor & Cox, 1998). For example, a scenario about laughing so hard that you cannot catch your breath was based off of the ASI-R item “It scares me when I become short of breath.” All scenarios were three sentences long and were designed to be emotionally ambiguous until participants read and completed a word fragment at the end of the scenario that resolved the ambiguity.

An example of a positive scenario is “You are jogging. Your heart starts to beat quickly. This is in_igorating.” Participants who saw this scenario would type the letter “v” to complete the word “invigorating,” assigning the scenario a positive interpretation. The corresponding negative scenario is “You are jogging. Your heart starts to beat quickly. This is dan_erous.” Participants who saw this scenario would type the letter “g” to complete the word “dangerous,” assigning the scenario a negative interpretation.

Participants in the Positive training condition completed the word fragments at the end of the scenarios so that all of the scenarios had a positively valenced meaning. Participants in the Neutral training condition completed half of the word fragments so that the scenarios had a positively valenced meaning and half so that the scenarios had a negatively valenced meaning. Participants in the No training condition did not complete any of the training scenarios. After completing each word fragment, participants answered a comprehension question that reinforced the correct emotional interpretation of the scenario. For the above example, the corresponding question for participants in the Positive training and Neutral training conditions was “Is your rapid heart beat healthy?” Participants in the Positive training condition would type “Y” indicating “yes” and participants in the Neutral training condition would type “N” indicating “no.” Participants were not allowed to proceed to the next trial until they correctly completed both the word fragment and comprehension question.

Along with the 64 training scenarios related to AS, participants also completed 24 filler scenarios that were not related to AS. The filler scenarios did not have any emotional content or ambiguity, and were dispersed throughout training to make the purpose of training less obvious.

Recognition scenarios: To evaluate effectiveness of the training procedure and to check whether the training influenced subsequent, novel interpretations, all participants (even those in the No training condition) read 20 ambiguous scenarios after the training was complete. Ten of the ambiguous scenarios were related to AS and the other ten were related to spiders and were included as an alternate threat category. The final word fragment and the subsequent comprehension question for these 20 scenarios did not clarify the scenarios’ emotional meaning, so the scenarios remained emotionally ambiguous. Each of the 20 ambiguous scenarios included a title relating to the main event in the scenario to help cue participants’ memory for the original scenario.

Five minutes after exposure to these 20 scenarios, participants were given a sheet that had the titles of the ten scenarios related to AS. Each title was followed by four responses that clarified the emotional meaning of the original scenario in different ways. One response was always a positive interpretation of the scenario related to AS, and one response was always a negative interpretation of the scenario related to AS. The other two responses were a positive and negative interpretation of the scenario that was unrelated to AS (termed "foils")[1]. Participants were asked to rate all four responses (on a scale of 1-4) for each scenario based on how similar in meaning they were to what they believed to be the meaning of the scenario they had originally read (with "1" being "very different in meaning" to "4" being "very similar in meaning") .

An example of a recognition scenario, titled "The Roller Coaster" is "You are riding a roller coaster. It continues to speed up, causing butterflies in your stomach. As the ride goes down a steep hill, you begin to ye_l." Participants would then type the letter "l" to complete the word "yell". The corresponding comprehension question is "Are you riding on a roller coaster?" The four response options to "The Roller Coaster" recognition scenario include: 1) "as the ride goes down a steep hill, you smile because of the fun sensation of feeling butterflies in your stomach" (positive interpretation related to AS), 2) "as the ride goes down a steep hill, you scream because the butterflies in your stomach make you feel out of control" (negative interpretation related to AS), 3) "as the ride goes down a steep hill, you smile at your friend's thrilled expression" (positive foil interpretation), and 4) "as the ride goes down a steep hill, you are annoyed by the loud people sitting behind you" (negative foil interpretation).

It was hypothesized that participants in the Positive training condition would interpret the ambiguous scenarios more positively, as evident by higher ratings for the AS-relevant positive interpretation responses and lower ratings for the AS-relevant negative interpretation responses. The foil responses were included to determine if the training procedure led to more positive interpretations specific to AS or to more positive interpretations in general.

Funnel debriefing—To determine if participants were aware of the purpose of training or the primary hypotheses (which could lead to demand effects), all participants were asked three questions at the end of the study before they were fully debriefed. Specifically, participants were asked if they had any comments about the study, if they had any guesses about the point or hypotheses of the study, and why they thought they were asked to read the scenarios.

Procedure—Participants were told that the study was investigating how people react to various computer tasks, and were unaware of why they were recruited for the study (i.e., based on their ASI score). Following informed consent, they filled out a short demographic questionnaire, and then completed the BBSIQ and the PANAS-FS to get a baseline measure of interpretation bias and current fear level. Participants were then sequentially assigned to the Positive (N = 25), Neutral (N = 25), or No training (N = 25) condition. The different groups were balanced for gender. All participants, regardless of training condition, completed five practice scenarios that were unrelated to AS and contained no emotional content or ambiguity to insure that they understood how to complete the word fragments and answer the comprehension questions. Following the practice scenarios, participants in the Positive and Neutral training conditions completed the ambiguous scenarios training procedure (including training and filler scenarios). For every 13 trials, participants read eight training scenarios and three filler scenarios (there were also two additional "probe" scenarios in each set of 13 that are not reported here[2]). The trials were selected randomly from the pool of training scenarios and filler scenarios. Participants in the No training condition completed a task that assessed their implicit AS associations, but which was not expected to influence their interpretation

[1]Due to experimenter error, 11 participants received a recognition response sheet that was missing the negative foil option for one of the scenarios.

biases.[3] This training-irrelevant task was selected to expose them to content related to AS so that content exposure and time between assessments was constant across conditions.

All participants then completed the word fragment component of the 20 scenarios that would be used later for the recognition test. As soon as the recognition scenarios were completed, a timer was set for five minutes during which participants first completed the PANAS-FS again to determine if training affected their fear ratings, and then, as a distractor task, participants worked on a puzzle. After five minutes, participants then completed the recognition ratings for the previously presented recognition scenarios. Next, participants completed the straw breathing and candle blowing BATs (PANAS-FS was completed after each BAT). Participants then completed the BBSIQ again to see if the training led to changes in interpretation biases, followed by the ASI[4], and then a final PANAS-FS to make sure that participants were not experiencing any residual fear at the end of the study. Finally, participants completed the funnel debriefing to check for knowledge of the hypotheses and were fully debriefed.

Results

Descriptive statistics

Chi-square tests to evaluate equivalence of the three training groups revealed that the training conditions did not differ by gender ($\chi^2 = .13$, $p = .94$) or ethnicity ($\chi^2 = 7.63$, $p = .67$). Further, analysis of variance (ANOVA) tests revealed that there were no significant differences between the training conditions in age ($F_{(2,72)} = .324$, $p = .72$, $\eta_p^2 = .01$), state fear as measured by the PANAS-FS ($F_{(2,72)} = .77$, $p = .47$, $\eta_p^2 = .02$), or baseline AS as measured by the ASI ($F_{(2,72)} = .13$, $p = .88$, $\eta_p^2 = .004$). There was also no significant difference in baseline interpretation bias as measured by the BBSIQ's Bodily Sensation items ($F_{(2,72)} = 2.59$, $p = .08$, $\eta_p^2 = .07$), though given the medium effect size and interest in measuring training effects above and beyond the impact of baseline biases, this variable was used as a covariate in all analyses for training effects. See Table 1 for pre- and post-training descriptive statistics separated by training condition.

Evidence for training interpretation bias

To determine efficacy of training, we conducted planned weighted contrasts based on the hypothesis that the Positive training condition would result in more beneficial outcomes relative to the two Control conditions (No training and Neutral training), which were not expected to differ from one another. Contrast weights for all condition comparisons were: Positive training +2, No training −1, Neutral training −1. Further, as noted, the B-BBSIQ was used as a covariate for all omnibus training outcome analyses. Finally, for the post-training ASI, BBSIQ and PANAS-FS measures (where matching baseline or preselection data were available), standardized residuals were calculated so that training group differences in post-training scores could be examined independent of baseline/preselection scores (i.e., the

[2]Test probe scenarios related to AS (eight positive and eight negative) were included in both the Positive and Neutral training conditions to determine whether training altered reaction time to complete positive versus negative scenarios. This measure is not described in the current paper due to inadequate reliability (Cronbach's alpha in the second half of training ranged from .41 to .61), making interpretation of these results difficult. There were no significant main or interactive test probe effects related to training condition (all $p>.10$). Additionally, participants completed a self-report version of the Panic Disorder Severity Scale (Shear et al., 1997), which is not described further because this measure was not central to the current hypotheses.

[3]The training-irrelevant task used in the No training condition was the Go/No-go Association Task (GNAT; Nosek & Banaji, 2001). The GNAT measures automatic associations in memory that reside outside of conscious control. In the GNAT, participants are asked to classify words into more general categories. Individuals are believed to be faster at classifying stimuli when the general categories match (versus contradict) their implicit associations. In this study, participants were presented with three categories: Physical Sensations, Alarming, and Meaningless. Participants were asked to classify words while pairing the Physical Sensations category (e.g., dizzy, sweating) with the category Alarming (e.g., scary, dangerous) or with the category Meaningless (e.g., trivial, insignificant). Due to an administrative error, seven participants in the no training condition completed the GNAT after being exposed to the recognition scenarios.

[4]The post-training ASI was not administered to the first six participants.

baseline/preselection score was regressed on the post-training score; see recommendations for examining change in Hummel-Rossi & Weinberg, 1975).

Recognition ratings for valenced interpretations of novel scenarios—To evaluate whether training influenced subsequent, novel interpretations related to AS, post-training recognition ratings for the 10 AS-relevant ambiguous scenarios were examined. Recall that participants rated four response options that each clarified the emotional meaning of the original ambiguous scenarios in a different way: a positive interpretation related to AS (Positive AS), a negative interpretation related to AS (Negative AS), a positive interpretation unrelated to AS (Positive Foil) and a negative interpretation unrelated to AS (Negative Foil). A repeated measures ANCOVA using the planned weighted contrast with one between-subjects factor: training condition (Positive Training, Control Conditions), two within-subjects factors: interpretation valence (Positive, Negative) and target (AS, Foil), and one covariate (B-BBSIQ) was conducted.

Results indicated a main effect for valence, such that participants gave higher recognition ratings for Positive than Negative items, $F_{(1,71)} = 135.86$, $p < .001$, $\eta_p^2 = .66$. Not surprisingly, there was also a main effect of target, indicating that participants gave higher recognition ratings for AS than Foil items, $F_{(1,71)} = 338.50$, $p < .001$, $\eta_p^2 = .83$. There was also a significant valence by training condition interaction ($F_{(1,71)} = 18.14$, $p < .001$, $\eta_p^2 = .20$), and a valence by target interaction ($F_{(1,71)} = 98.48$, $p < .001$, $\eta_p^2 = .58$). Importantly, these two-way interactions were subsumed by a significant valence by target by training condition three-way interaction, $F_{(1,71)} = 25.97$, $p < .001$, $\eta_p^2 = .27$.

To understand the three-way interaction, each of the four recognition options were examined separately using *t*-tests to check for training group differences. As expected, the Positive training group (compared to Controls) gave lower recognition ratings for Negative AS items, $t(72) = 3.72$, $p < .001$, $d = 0.88$, and higher ratings for Positive AS items, $t(72) = 3.23$, $p = .002$, $d = 0.76$, indicating that training was effective (see Figure 1). There were no significant training effects for either the Positive or Negative Foil items (both $p > .10$), suggesting that training was specific to AS.

Impact of training on state fear immediately following CBM paradigm—To check whether training altered state fear directly (as opposed to subsequent emotional vulnerability), a univariate ANCOVA was conducted for the post-training PANAS-FS residual (after accounting for baseline fear) with training condition as a between-subjects factor (using the planned weighted contrast) and B-BBSIQ as a covariate. Results indicated no significant main effect tied to training condition, $F_{(1,72)} = .01$, $p = .94$, $\eta_p^2 < .001$, suggesting that training was not simply an affect manipulation.

Impact of training on subsequent AS—To evaluate the hypothesis that ASI scores would decrease following Positive Training, a univariate ANCOVA with training condition as a between-subjects factor (using the planned weighted contrast) and B-BBSIQ as a covariate was conducted. As expected, Positive training led to lower AS (using the post-training ASI residual scores) than the Control Conditions, $F_{(1,66)} = 4.68$, $p = .03$, $\eta_p^2 = .07$ (See Figure 2).

Impact of training on BATs (interoceptive exposures)—To examine whether Positive training resulted in less fear following training, PANAS-FS results for the Candle Blowing and Straw Breathing BATs were averaged to create a more reliable indicator, given that both tasks elicit similar bodily sensations. To examine peak BAT-fear across the tasks, a univariate ANCOVA using the post-training BAT fear residual (after accounting for baseline fear) was conducted with training condition as a between-subjects factor (using the planned weighted contrast) and B-BBSIQ as a covariate. Although the training effect did not reach significance

($F_{(1,71)}$ = 2.94, p = .09, η_p^2 = .04), the effect size suggested a small to moderate effect in the anticipated direction. A chi-square test evaluating avoidance indicated no significant effects of training on the percentage of participants who completed at least one of the two BATs for the full 60 seconds (χ^2 = .12, p = .74). However, avoidance results should be interpreted with caution due to likely ceiling effects (88% of participants completed the full time for at least one of the BATs).

Immediate impact of training on bodily sensation items of BBSIQ—To explore whether an immediate change on the Bodily Sensation items of the BBSIQ would be apparent, a standardized residual was again used. Note, given that B-BBSIQ was included in the standardized residual, it was not included as a covariate in this analysis. A *t*-test comparing Positive training to the Control conditions revealed that the post-training interpretation bias residual was not significantly different between training conditions, $t(73)$ = 1.45, p = .15, d = .34, though the effect size suggested a small to moderate effect in the anticipated direction.

Investigating knowledge of hypotheses—To investigate participants' awareness of the purpose of training or the primary hypotheses, we examined participants' responses to the funnel debriefing. Notably, only two participants (both in the Positive training condition) reported such awareness, based on coding by two raters of statements that training was supposed to either minimize anxiety and/or influence interpretations following training. As a conservative check, we excluded these two participants and re-ran our primary analyses. Importantly, none of the effects tied to training condition changed substantially. These findings suggest demand effects did not likely play a substantial role in the results.

Discussion

The current study aimed to modify interpretation biases in a sample with elevated AS by training participants to complete a series of ambiguous scenarios with a positively valenced outcome (Positive training), relative to two control conditions (Neutral or No training). In line with hypotheses, participants who received Positive training subsequently endorsed less negative and more positive interpretations related to AS, compared to participants in the Control conditions. Further, the Positive training group had significantly lower scores on a questionnaire measure of AS symptoms post-training, relative to the Control groups. Finally, only minimal support was evident for the effect of Positive training on emotional vulnerability during the interoceptive exposures, with a small effect for self-reported subjective fear but not for time spent doing the exposures.

Significance of changing interpretations and anxiety sensitivity

This study is the first to provide evidence that cognitive bias training can successfully shift interpretations in a sample with elevated AS. This adds to the mounting evidence that interpretation-based CBM can change interpretations, even in highly anxious samples (e.g., Murphy et al., 2007; Teachman & Addison, 2008), and suggests that the interpretation styles of people with AS are not inflexible. Notably, Positive training not only modified interpretations, but also reduced a questionnaire measure of AS symptoms that is usually thought of as a trait-based measure (the ASI, which reflects both cognitive and affective AS symptoms). However, it is worth noting that Positive training did not significantly affect the BBSIQ, despite the BBSIQ and ASI measuring related constructs. The mixed results may be due to the pre- and post-test BBSIQ administrations being so close in time that participants could recall their previous responses. It may also reflect the close tie between the content on the ASI and the training paradigm (recall that training scenarios were based in part on items from the 36-item ASI-Revised), suggesting training did not generalize to less directly linked measures. Overall, these results provide partial evidence that training may be able to influence an important vulnerability marker for future anxiety pathology, albeit a self-report one. Further, in line with cognitive models of anxiety (e.g., Beck & Clark, 1997), this study provides some evidence that interpretation biases may be causally related to AS.

The current study suggests that it is possible to modify interpretations and reduce AS symptoms without inducing fear (e.g., through exposures) or though traditional cognitive restructuring. Both of these mechanisms have previously been proposed to be necessary for successful anxiety treatment (see Beck & Clark, 1997; Foa & Kozak, 1986). An important next step will be to understand the mechanisms of change involved in CBM. Although this study was not designed to evaluate mechanisms, the results suggest that effects are not simply due to changes in state fear (recall that self-reported fear did not increase following training), or due to demand effects (results did not change when participants who were aware of the purpose of training were excluded). The study also suggests training does not work by inducing a response bias towards positive answers in general, since there were not training condition differences for the foil options on the recognition test.

Several researchers have suggested potential mechanisms of change operating in CBM. Mathews and MacLeod (2002) posited that repeatedly reading scenarios that end positively may prime participants to select positive interpretations for future ambiguous scenarios. However, the current study suggests training does not simply prime benign meanings; rather, priming affects cognitive processes when the content of the subsequent interpretations matches the content targeted in training (AS-specific in this case). In a related proposal, Murphy et al. (2007) suggested that training works by conditioning participants to associate situations related to AS with benign interpretations, and this conditioning then transfers to novel situations. Alternatively, training may change the decision-making process used when explicitly thinking about interpretations (MacLeod, Koster, & Fox, 2009). It is also possible that CBM results are driven in part by the similarity between the training paradigm and outcome measures (e.g., learning to give a positive response after reading a brief scenario). The observed training effects on the recognition scenarios, which are structurally similar to the training scenarios, may have been influenced by this similarity. However, Positive training also significantly decreased ASI scores, and this measure follows a different format than the training (despite content overlap), suggesting that measurement similarity cannot fully account for CBM effects. Future studies that can discriminate between these various learning accounts may help clarify the mechanisms underlying CBM.

Training effects on emotional vulnerability

This study provided only minimal support for the effect of Positive training on subsequent emotional vulnerability, as measured by fear and avoidance during interoceptive exposures. There was no significant training condition difference for the amount of time participants spent doing the exposures (avoidance). However, there was a small to moderate effect size (at the level of p=.09) for Positive training to result in less self-reported fear during exposures. Given the effect size in the anticipated direction, the lack of a significant effect may be due to the relatively small sample size. Also, participants were asked to do the exposures for a maximum of 60 seconds, which the vast majority of participants completed. More exposure time and/or more challenging tasks may lead to more variation in both time and self-reported fear. Finally, it may be that multiple sessions of training or more time for effects to consolidate are necessary in order to see larger effects of Positive training on emotional vulnerability.

In reviewing the training evidence more broadly, it is clear that interpretation, attention, and implicit association training can all significantly modify cognitive biases (e.g., Amir et al. 2008; Clerkin & Teachman, Manuscript submitted for publication; Teachman & Addison, 2008). However, the CBM literature suggests that, in general, subsequent emotional vulnerability seems to be more consistently affected by attention training paradigms (particularly using the dot probe task; e.g., Amir et al. 2008) than interpretation training paradigms. While a few studies have provided some support for the effects of interpretation training on emotional vulnerability using the Mathews and Mackintosh paradigm, the effects tend to be relatively modest. For instance, effects are at the level of nonsignificant trends rather than being significant (e.g., the current study), or effects are not directly tied to training condition (e.g., Teachman & Addison, 2008), or effects are shown for predicted rather than actual anxiety (e.g., Murphy et al., 2007). We speculate that the modest nature of these effects is tied to the particular training paradigm used, rather than some feature linked to training interpretation (versus attention) biases more generally.

It is unclear why some training paradigms seem to affect emotional vulnerability more consistently than others. One possibility is that the training tasks used vary in how directly they modify actual interpretations (personal communication with C. MacLeod, March, 2009); that is the extent to which people are actually making online interpretations or attending to stimuli versus just thinking about how they would make interpretations or attend to stimuli in imagined situations. For instance, the Mathews and Mackintosh (2000) interpretation training paradigm is a level removed from making online interpretations about an event because participants are asked to make interpretations about imagined scenarios (i.e., how they believe they would interpret a situation if it were to occur). On the other hand, the homograph-based interpretation training task used by Hirsch et al. (2009), which did result in significant effects on emotional vulnerability, seems to be a more direct task in that it requires participants to make actual benign interpretations about homographs. Similarly, the dot probe CBM paradigm encourages actual attentional shifts away from threatening stimuli (as opposed to imagining shifting attention). Note that directness in this case has to do with the nature of the training task, not the type of cognitive bias being modified (i.e., modifying interpretation biases is not inherently less direct than modifying attention biases).

Thus, the relatively weak effects on emotional vulnerability in the current study may relate to the specific training paradigm used. To the extent that the Mathews and Mackintosh (2000) training alters cognitive biases by modifying participants' beliefs about how they will interpret future scenarios, rather than modifying their online interpretations, this may weaken the impact when participants are confronted with actual emotional provocations. Although this idea is speculative, previous research has demonstrated that people's beliefs about how they will feel in the future often do not predict their actual future feelings (Wilson & Gilbert, 2005).

Clinical implications

The current study suggests that it is possible to modify interpretations and potentially reduce AS, a known vulnerability factor and correlate of treatment outcome for anxiety difficulties (Smits et al., 2004). Although durability of the effects is not clear from this study and achieving a broader impact on emotional vulnerability is desirable, the study results point to the potential of CBM paradigms to one day help prevent and/or treat anxiety disorders. In the future, it will be important to see how interpretation-based CBM compares to more traditional treatments, and how it works as an add-on to already established treatments. MacLeod, Koster, and Fox (2009) predict that using cognitive bias training with traditional treatments will result in "therapeutic synergies" in which therapy and training positively impact each other (p. 97).

Limitations and conclusion

A few limitations must be taken into account when interpreting the results from this study. First, only the immediate impact of training was assessed, so the durability of these effects is not clear. However, past studies using similar training paradigms with low anxiety samples have shown preliminary evidence that training effects remain robust up to 24 hours later (Yiend et al., 2005) and persist despite changes in environmental context (Mackintosh et al., 2006).

Second, multiple sessions of training and/or more time between training and testing would have been ideal to determine whether these could enhance the effects of training on emotional vulnerability. Finally, some of the measures and design choices were not ideal regarding sensitivity to detect effects of Positive training (e.g., close administration of the pre- and post-training BBSIQs and see Footnote 2 regarding low reliability on the probe latency measure).

Despite these limitations, this study provides a first look at modifying interpretation biases in a sample with high AS. The findings provide some support for general cognitive models of anxiety and provide evidence that interpretation biases may be causally related to AS. Moreover, this study adds to the mounting evidence of the value of interpretation bias training in highly anxious samples.

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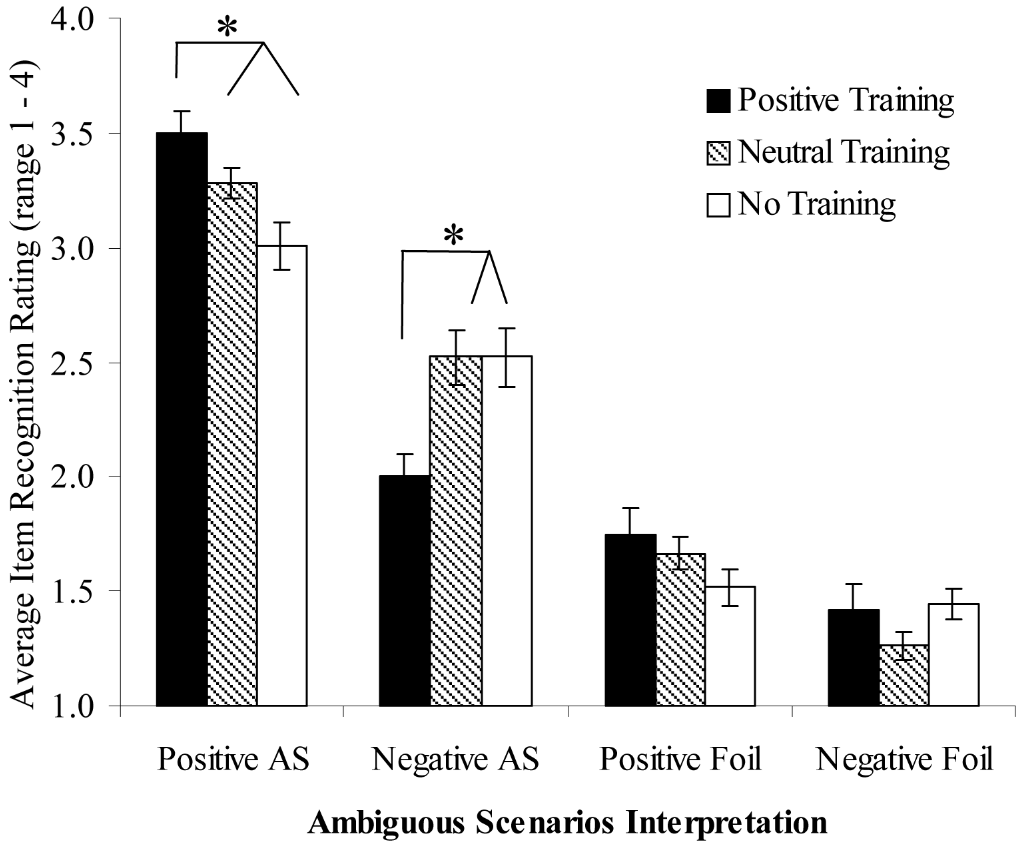
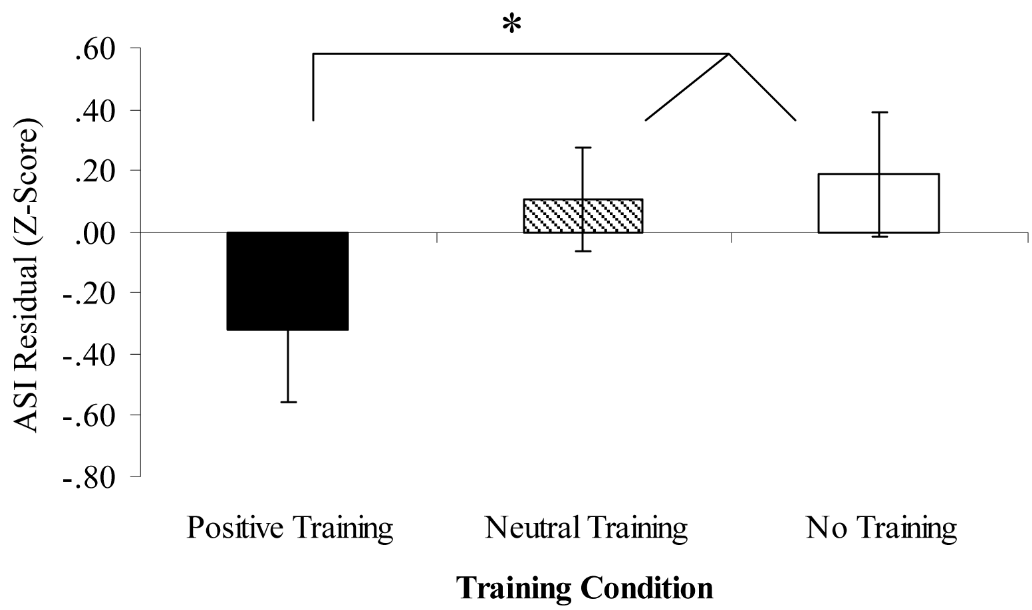


*$p<.01$

Figure 1.

Interpretation ratings on post-training recognition test as a function of training condition.



*$p<.05$

Figure 2.
Post-training Anxiety Sensitivity Index residual scores (after regressing baseline Anxiety Sensitivity Index scores) as a function of training condition.

Table 1

Descriptive statistics (Means and SDs) for pre- and post-training measures

	Positive training		Neutral training		No training	
	M	***SD***	***M***	***SD***	***M***	***SD***
Pre-training measures						
Anxiety Sensitivity Index	34.88	5.97	34.52	6.23	35.44	6.81
Bodily Sensation Items on BBSIQ	2.25	1.46	2.59	1.47	1.74	1.05
State Fear (PANAS-FS)	8.08	2.18	7.40	1.22	7.76	2.24
Post-training measures						
Anxiety Sensitivity Index	24.64	9.51	27.73	8.18	28.80	9.37
Bodily Sensation Items on BBSIQ	2.20	1.70	2.82	1.70	1.99	1.15
State Fear (PANAS-FS)	8.48	3.61	7.84	2.23	8.20	2.58
Interpretation ratings on recognition test						
Positive AS	3.50	.45	3.28	.33	3.00	.52
Negative AS	2.00	.46	2.52	.59	2.52	.64
Positive Foil	1.75	.55	1.67	.36	1.52	.40
Negative Foil	1.41	.55	1.26	.31	1.44	.34
Emotional vulnerability: Interoceptive exposures						
State Fear	12.04	5.28	13.42	4.61	12.24	3.90
Exposure Time (seconds)	54.23	7.34	53.46	8.10	54.78	6.20

Note. BBSIQ = Brief Body Sensations Interpretation Questionnaire; PANAS-FS = Positive and Negative Affect Schedule-Fear Subscale.