ABSTRACT

Title of Document: INTERPRETIVE BIAS AND ANXIETY VULNERABILITY IN BEHAVIORALLY INHIBITED CHILDREN: DISAMBIGUATING THE COGNITIVE AND EMOTIONAL EFFECTS ASSOCIATED WITH INTERPRETIVE BIAS ACQUISITION.

Lauren K. White, Doctor of Philosophy, 2013

Directed By: Professor Nathan A. Fox, Department of Human Development and Quantitative Methodology

Behavioral inhibition (BI), a temperament characterized by a fear of novel and unfamiliar people and situations, is associated with increased risk for anxiety problems throughout life. One mechanism thought to moderate the link between BI and anxiety is a child's interpretive bias (i.e., the manner in which emotional ambiguity is interpreted). Behaviorally inhibited children who consistently interpret ambiguous information in a threatening manner are thought to be at

increased risk for anxiety. Conversely, behaviorally inhibited children who consistently interpret ambiguity as benign or non-threatening may be protected from such risk. Little research, however, has experimentally examined interpretive biases in behaviorally inhibited children. This dissertation investigates the causal relations between interpretive biases and anxiety vulnerability in behaviorally inhibited children. To examine if changes in interpretive biases affect anxiety vulnerability, a cognitive bias modification procedure was employed to induce a non-threatening interpretive bias in a group of 9-12 year old behaviorally inhibited children. After training, children were assessed on their mood, emotional vulnerability to stress, and attention bias toward threat in order to determine if bias modification affected anxiety vulnerability. The findings of this study demonstrate that the cognitive bias manipulation was successful; behaviorally inhibited children displayed decreased threat interpretations after training. No training effects on anxiety vulnerability were detected. As a result, the notion that interpretive biases are causally linked to a child's anxiety vulnerability is not supported by the findings of this study. The implications of these findings are discussed in this dissertation.

INTERPRETIVE BIAS AND ANXIETY VULNERABILITY IN BEHAVIORALLY INHIBITED CHILDREN DISAMBIGUATING THE COGNITIVE AND EMOTIONAL EFFECTS ASSOCIATED WITH INTERPRETIVE BIAS ACQUISITION

By

Lauren K. White

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Advisory Committee:
Professor Nathan A. Fox, Chair
Professor Lea R. Dougherty
Professor Luiz Pessoa
Dr. Daniel S. Pine
Professor Geetha B. Ramani

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Chapter One: Introduction

Behavioral inhibition (BI) is a temperament identified in early childhood characterized by a fear of novel and unfamiliar people or situations. When confronted with novelty, these children display high levels emotional, psychological, and physiological reactivity (Fox, Henderson, Marshall, Nichols, & Ghera, 2005; Kagan, Reznick, & Snidman, 1987), often resulting in behavioral restraint or withdrawal during such situations (Kagan, Reznick, Clarke, Snidman, & Garcia-Coll, 1984). Behaviorally inhibited children are considered hypervigilant and hypersensitive to possible sources of threat in the environment and will actively avoid unfamiliar situations and interactions with unfamiliar peers and adults. This fearful pattern of behavior is thought to remain moderately stable across childhood and adolescence (Degnan & Fox, 2007; Kagan, Reznick, Snidman, Gibbons, & Johnson, 1988).

Markedly, BI is associated with an increased risk for anxiety disorders later in life, with a particular risk for social anxiety disorder (Clauss & Blackford, 2012). Chronis-Tuscano and colleagues (2009) found that adolescents who showed stable parent-reported BI in early childhood were almost four times more likely to have had a lifetime diagnosis of social anxiety disorder. Additionally, that study showed a positive correlation between early BI and concurrent adolescent self-reported social anxiety. Schwartz and colleagues (Schwartz, Snidman, & Kagan, 1999) also reported that 15% of adolescents characterized as

highly behaviorally inhibited at 2 year of age had been diagnosed with social anxiety disorder.

Despite the significant risk for anxiety, many behaviorally inhibited children never develop an anxiety disorder. This suggests factors associated with BI that may either protect against the development of anxiety in these children and/or increase their risk of developing a disorder (Degnan & Fox, 2007). One factor thought to help account for individual differences in anxiety vulnerability in behaviorally inhibited children is the manner in which emotional ambiguity is interpreted (Dodd, Hudson, Morris, & Wise, 2012; White, Helfinstein, & Fox, 2010). That is, behaviorally inhibited children who consistently interpret ambiguous information in a threatening manner, as opposed to a non-threatening manner (i.e., a threat-related/negative interpretive bias), may be at increased risk for anxiety; behaviorally inhibited children who consistently interpret ambiguity as benign/non-threatening (i.e., non-threatening/positive interpretive bias) may be protected from such risk.

In recent years, investigations into the link between interpretive biases, both benign and threat interpretive biases, and anxiety vulnerability have prospered through the use of cognitive bias modification (CBM) techniques. By experimentally modifying how emotional information is interpreted, findings from CBM studies suggest that 1) induction of a negative interpretive bias in non-anxious individuals increases vulnerability to experience anxiety and 2) reduction of a negative interpretive bias (or induction of a positive interpretive bias) in

clinically and non-clinically anxious populations reduces anxiety (Beard, 2011; MacLeod & Mathews, 2012). Following, a systematic reduction of threat interpretations in children high in behavioral inhibition may buffer these children against increased vulnerability to experience anxiety.

To date, most of the CBM studies that demonstrate a causal link between interpretive biases and anxiety have been conducted in adult populations and no CBM work has examined the link as it relates to temperament (i.e., behavioral inhibition). Thus, it remains unclear if the same causal relations between interpretive biases and anxiety vulnerability found in adults exist in children. Moreover, it is unknown if the same decrease in anxiety vulnerability associated with non-threat interpretive bias induction in anxious individuals is true for behaviorally inhibited children at risk for anxiety. Using a CBM procedure in a sample of high behaviorally inhibited children, the present study addressed this gap by examining the impact of a non-threat interpretation bias induction procedure on subsequent anxiety vulnerability.

Specifically, the current study employed a CBM paradigm designed to train a group of behaviorally inhibited children (9-12 year olds) to interpret emotionally ambiguous information in a non-threatening manner (n = 23); another group of behaviorally inhibited children received no training (n = 22). In the current study, behaviorally inhibited children were identified based on high concurrent maternal-reports of behavioral inhibition. Following training, children in both conditions were assessed on their anxiety vulnerability directly after the

training procedure. In the current study both emotional and cognitive measures were used as an index of anxiety vulnerability. Specifically, training-related effects on mood, emotional vulnerability to a stressor, and allocation of attention toward threatening information (i.e., attention bias toward threat) were examined.

It was hypothesized that one positive interpretive training session would reduce threat-related interpretations in behaviorally inhibited children; no change in biases was expected in the non-training control condition. Additionally, it was hypothesized that compared to children in the no-training condition, behaviorally inhibited children in the training condition would a) have higher positive moods and lower negative moods, b) show less emotional vulnerability during a stress task and c) show decreased attention allocation toward threatening information.

Chapter Two: Background

The aim of the current chapter is to present theoretical and empirical work linking information processing biases (namely biases in the interpretation of ambiguous information) and anxiety vulnerability, with a specific focus on developmental research. The first part of the chapter presents information on behavioral inhibition and childhood anxiety. Here the chapter discusses behavioral inhibition across development and highlights different approaches to the assessment of BI, a point that is particularly relevant to the present study. The chapter highlights the notion that perturbations in information processing are a fundamental characteristic of childhood and adult anxiety. Next, as a useful framework to examine biases in information processing, social information processing theory is described and the specific processing biases associated with anxiety are presented. After presenting theoretical and correlational work that link threat-related processing biases to anxiety, the chapter focuses on recent experimental research that employ cognitive bias manipulation (CBM) paradigms to robustly examine the causal associations between interpretive biases and anxiety vulnerability. The extant evidence suggesting reductions in threat interpretations lead to decreased anxiety vulnerability and increases in such a bias lead to heightened anxiety vulnerability are presented. Given that the wealth of CBM studies have been conducted in adult populations, the section first presents the adult work followed by the paucity of cognitive bias manipulation work conducted in child populations. In addition, the section presents the existing

longitudinal research that examines the relations between interpretive bias and anxiety across development. The section also highlights the notion that interpretive biases exert their greatest impact on anxiety vulnerability during times of stress, a point that is important to consider when examining the causal relations between these factors. In addition to the emotional consequences associated with interpretive biases, the last section of the chapter explores cognitive anxiety vulnerability factors that may result from a child's interpretive bias. Specifically, this section presents theoretical and empirical work suggesting cognitive biases may be causally related, one bias creates another, and these biases may work in concert to shape an individual's anxiety vulnerability.

2.1 Temperament and Childhood Anxiety

Anxiety is a common emotion experienced by many children over the course of development, with anxiety symptomatology appearing as early as the preschool years (Rapee, Kennedy, Ingram, Edwards, & Sweeney, 2005). Throughout childhood children will often display fears of strangers or separation, the dark, or failure. Although anxiety and fears are thought to be adaptive (Bowlby, 1973) and show a typical developmental time course (Field & Davey, 2001; Ollendick, Yule, & Ollier, 1991), children vary in the frequency, intensity, and duration of anxiety and fears they experience. High levels of fear and anxiety, both at clinical (e.g. social anxiety disorder) and subclinical levels (e.g., trait anxiety or shy, behaviorally inhibited temperaments), cause significant detriments to children's social and emotional functioning (Pine, 1997; Rubin, Coplan, &

Bowker, 2009). Moreover, high levels of anxiety during childhood place an individual at increased risk for subsequent psychiatric disorders throughout their life (Chronis-Tuscano et al., 2009; Perez-Edgar & Fox, 2005a; Pine, 2007), with a particular risk for social and generalized anxiety disorders (Grills-Taquechel & Ollendick, 2007).

2.1a Behavioral Inhibition

A child's temperamental reactivity is thought to contribute to the frequency and magnitude in which a child experiences anxiety (Perez-Edgar & Fox, 2005b). Temperamental reactivity reflects a child's emotional, psychological, behavioral and physiological predisposition to react to their environment (Rothbart, 2012). Behavioral inhibition reflects the proclivity to react with fear and wariness when confronted with unfamiliar objects, people, or situations, in both the social and non-social domains (Fox, et al., 2005; Kagan, Reznick, & Snidman, 1988), and this pattern of fearful reactivity is moderately stable across childhood and adolescence (Degnan & Fox, 2007; Kagan, Reznick, Snidman, et al., 1988). Since Kagan and colleagues first described a group of young children as behaviorally inhibited (Garcia-Coll, Kagan, & Reznick, 1984; Kagan, et al., 1984), both dimensional and continuous approaches have been used to study behavioral inhibition as a temperament style (for a dicussion on these different approaches see Degnan & Fox, 2007). In the present dissertation, BI is treated as a continuous temperament trait, reflecting individual differences in a

child's negative reactivity to the unfamiliar across both situational and social contexts (White, Lamm, Helfinstein, & Fox, 2012).

Historically, BI is assessed in toddlerhood through behavioral observation in the laboratory. This assessment includes observations regarding children's emotional and behavioral reactions during unfamiliar situations and social interactions (Fox, Henderson, Rubin, Calkins, & Schmidt, 2001). During these situations child behaviors such as avoidance, proximity to mother, and latency to vocalize are coded and used as an index of a child's level of behavioral inhibition. These behavioral observations are used alone or often coupled with early-maternal reports of children's social and non-social fearfulness to represent a child's level of BI (Fox, et al., 2001). Although behavioral inhibition is not thought to only exist in early childhood, research often relies on early temperament assessments to prevent possible influence from other factors (e.g., self-regulation, parenting, peer rejection) on the presentation of a child's underlying pattern of reactivity (Hirshfeld-Becker et al., 2008).

Such laboratory behavioral observations, especially during such a restricted period of development, are often not economically viable and are logistically difficult; therefore examination of whether or not behavioral inhibition can be reliably assessed through maternal questionnaire report and across childhood is important (Bishop, Spence, & McDonald, 2003; Broeren & Muris, 2010; Muris, van Brakel, Arntz, & Schouten, 2011). Studies assessing BI through laboratory observation have reported moderate to high correlations with

maternal-reports of BI (Fox, et al., 2001; Garcia-Coll, et al., 1984). Similar to finings using laboratory assessed BI, maternal reported BI shows moderate stability (Broberg, 1993; Sanson, Pedlow, Cann, Prior, & Oberklaid, 1996) and significantly predicts later anxiety (Chronis-Tuscano, et al., 2009; Muris, et al., 2011). Indeed, when looking at the link between BI and adolescent anxiety problems, Chronis-Tuscano et al. (2009) found that only maternal reported BI, not laboratory assessed BI, significantly predicted later anxiety.

Many of the available questionnaires used to assess maternal-reported BI are often limited to assessments of inhibiton in the social domain. Since the reactivity underlying BI reflects fear of novelty across both social and situational context, it is important to examine maternal-reports of BI across both contexts. To address this limitation, Bishop and colleagues (Bishop, et al., 2003) developed the Behavioral Inhibition Questionnaire, a 30 item parent-report of children's BI in social and situational contexts (see Appendix A and pg. 37 of the document for more information on this measure). Using a preschool-aged sample, this study found that the BIQ: had good psychometric properties, was related to laboratory assessments of BI, and showed moderate stability over the course of a year. Since then, similar findings using the BIQ have been documented in older children ranging from 7- to 15 years of age (Broeren & Muris, 2010; Broeren, Muris, Bouwmeester, van der Heijden, & Abee, 2011; Vreeke & Muris, 2012).

The research highlighted above suggests that parents can provide an apt assessment of behavioral inhibition in both early and late childhood. These

studies found parent-reports of BI correlated with laboratory assessments of BI and showed that similar to the laboratory assessments, parent-reported BI is moderately stable and related to an increased risk for anxiety.

2.1b Behavioral Inhibition, Anxiety, and Threat-Related Biases

As measurable and observable differences in anxious symptomatology and anxiety-related temperament traits are present early in life and these differences are associated with continued anxiety problems throughout development, it is important to clarify the factors that precede and maintain the experience of anxiety in children. Cognitive factors, specifically perturbations in the processing of threat-related emotional and social information, are associated with anxiety in children and are considered a fundamental hallmark of anxiety (Muris & Field, 2008; Vasey & MacLeod, 2001). In fact, many cognitive theories of anxiety posit that these information processing biases are causally linked to the experience of anxiety and to the development of anxiety disorders (Mathews & MacLeod, 2002; Williams, Watts, MacLeod, & Mathews, 1997). Moreover, developmental work speculates that these threat-related information processing biases moderate the link between temperament and internalizing problems (White, et al., 2010) and between environmental factors (i.e., parenting) and anxiety problems (Rapee, 2001).

Little work has directly examined the presence of threat-related biases as they relate to behavioral inhibition; thus, little is known regarding the presence of such biases and how they contribute to anxiety vulnerability in children high in

behavioral inhibition. In a series of studies, Perez-Edgar and colleagues found that the link between early-identified BI and social-reticence in childhood (Perez-Edgar et al., 2011) and adolescence (Perez-Edgar et al., 2010) was moderated by concurrent attention bias. Both studies showed that a history of BI, coupled with attention bias toward threat, was associated with increased anxiety vulnerability. Given that attention bias was assessed concurrently to the outcome variable, the studies do not directly speak to the causal influence of the bias, but indicate an important relation between temperament, threat-related cognitive biases and anxiety. In a recent study, Dodd et al. (2012) found no relation between threat interpretations assessed in early childhood and later anxiety. Thus, more work is needed to understand these relations across development.

2.2 Social Information Processing: Interpretive Bias

Individuals differ in the way they process social and emotional information in their environment. These processing differences are thought to shape fundamentally the development of individual differences in temperament, adaptive social behaviors, and emotional outcomes (Izard, Fine, Mostow, Trentacosta, & Campbell, 2002; Lemerise, Gregory, & Fredstrom, 2005). When investigating individual differences in the processing of social and emotional information, social information processing (SIP) models provide a useful framework to examine such differences. SIP models outline sequential stages through which information is processed, delineating the manner in which information may be "manipulated and modified" as it advances through each

stage of processing (Crick & Dodge, 1994; Daleiden & Vasey, 1997; Lemerise, et al., 2005). The most prominent SIP model, put forth by Crick and Dodge (1994), posits six general stages of processing. During the first stage, relevant information from the internal or external environment is selected for further processing (i.e., the encoding stage); next, the information is decoded or evaluated (i.e., the interpretation stage). The last stages in the model are goal selection, generation of possible responses to achieve the goal, response selection, and response enactment.

2.2a Interpretive Biases in Anxious Populations

Anxiety, both at clinical and subclinical (i.e., anxious temperamental dispositions) levels, is associated with certain information processing biases, particularly in regards to the processing of threatening or potentially threatening information (J. A. Hadwin, Garner, & Perez-Olivas, 2006; White, et al., 2010). These biases are thought to account for particularly robust individual differences related to anxiety (Mathews & Mackintosh, 1998; Mogg, Bradley, Williams, & Mathews, 1993; Rapee & Heimberg, 1997; Williams, et al., 1997). Although biases at multiple stages of information processing are associated with anxiety (Bell-Dolan, 1995; Muris & Field, 2008), biases that occur during the interpretation stage are often highlighted in anxiety related research (e.g., Beard & Amir, 2010; Hirsch & Mathews, 1997; Muris, Merckelbach, & Damsma, 2000). Compared to their non-anxious counterparts, anxious individuals tend to: interpret ambiguous information in a threatening manner; and interpret positive, mildly

negative, and highly negative events as being more negative; display negative causal attributions; and have greater negative expectations about future events (Clark & McManus, 2002; Daleiden & Vasey, 1997).

Particularly robust differences in information processing between anxious and non-anxious individuals during the interpretation stage appear during the interpretation of emotionally ambiguous information. For example, when asked to interpret why an emotionally ambiguous social event has occurred (e.g., "you are talking to an acquaintance who briefly looks out of the window"), socially anxious individuals tend to offer negative explanations (e.g., "they are bored/not interested in what I am saying"), whereas non-anxious individuals offer a benign explanations ("they saw something outside that caught their attention"). Compared to non-anxious individuals, anxious individuals tend to associate homographs with their negative meaning (Richards & French, 1992), rate ambiguous facial expression (e.g., surprise) as more negative (Yoon & Zinbarg, 2007, 2008), overestimate the likelihood that they will experience negative events in their future (McManus, Clark, & Hackman, 2000), and have greater negative interpretations of their own performance (Stopa & Clark, 1993).

The majority of research has focused on anxiety-related information processing biases in adult populations and a paucity of research examining interpretation bias in anxious children. Although the findings in children seem to be weaker than that in adults (Dodd, Hudson, Morris, Wise 2012), increasing evidence demonstrates that anxious children also show threat-related biases in

interpretation (see Castillo & Leandro, 2010 for review). When children ages 7-9 were presented with a homophone that had both a negative and positive association (e.g., week/weak), anxious children were more likely than non-anxious children to use the negative interpretation (e.g., weak) compared to the benign (e.g., week) interpretation of the word (J. A. Hadwin, Frost, French, & Richards, 1997). Compared to non-anxious children, trait anxious children are more likely to interpret ambiguous stories as negative (Muris, Meesters, Smulders, & Mayer, 2005). Furthermore, when high and low socially anxious children between the ages of 8 and 13 were read stories about social situations, high anxious children needed less information (i.e., they heard fewer sentences of the story) before they deemed the story as a "scary" story (Muris, et al., 2000). To date, only one study has directly examined interpretations in a behaviorally inhibited sample (Dodd, et al., 2012), showing little direct relation between BI and negative interpretive bias. Taken together, children with high levels of anxiety, be it at clinical or subclinical levels, tend to interpret ambiguous information in a more threatening manner as compared to their peers. It is unclear if this is also true of behaviorally inhibited children.

2.3 Interpretive Bias and Anxiety Vulnerability

2.3a Adult Populations

Although the preceding discussion highlights substantial evidence suggesting a significant positive association between negative interpretive biases and anxiety, this does not denote the biases cause anxiety. That is, the specific

processing biases may be a byproduct of an anxious temperament or disorder, not a cause of anxious symptomatology. Conversely, the two factors may be causally related; a negative interpretive bias may increase an individual's anxiety vulnerability. For many years cognitive theories of anxiety have emphasized the important interplay between anxiety and threat-related biases but shied away from attributing a causal link between the two factors. However, in the last decade mounting theoretical and empirical work do suggest a direct causal link; this work asserts that threat-related biases are causally implicated in the development and experience of anxiety (MacLeod, Campbell, Rutherford, & Wilson, 2004; Mathews & MacLeod, 2002; Williams, et al., 1997).

Findings from studies employing cognitive bias manipulation paradigms (CBM) are often taken as evidence to support the causal status of a negative interpretive bias (Grey & Mathews, 2000; Mathews & Mackintosh, 2000; Wilson, MacLeod, Mathews, & Rutherford, 2006). By constraining the manner in which ambiguous information can be interpreted in order to manipulate an information processing bias, CBM studies in adults have revealed that not only can positive/benign and negative interpretive biases be induced and manipulated, but that such bias manipulations are associated with changes in reported anxiety (see Hallion & Ruscio, 2011 for a list of representative adult studies that have examined the effects of training on anxiety symptoms).

In a series of experiments, Mathews and Mackintosh (2000) examined how negative and positive/benign interpretive bias induction (through the use of

CBM) affected mood, namely anxiety. To manipulate interpretations, individuals were presented with a string of ambiguous sentences in which the last word, presented as a fragment, would disambiguate the meaning of the sentence (e.g., "*getting ready to go, you think the new people you will meet will find you fri_ndly/bor_ng*"). Individuals in the benign training condition were presented with word fragments that would disambiguate the sentences in a neutral or positive way (e.g., *fri_ndly),* whereas individuals in the negative training condition were presented with fragments that would disambiguate the sentences in a negative manner (e.g., *bor_ng*). For each training sentence, subjects were asked to complete the word fragment and answer a reading comprehension question that was valenced in a direction congruent to their training condition (e.g., "*will you be liked/disliked by your new acquaintances*?"). In a post-training assessment of interpretive bias participants displayed interpretation tendencies that were in the same direction as their training condition; individuals in the negative training condition reported a greater post-training negative interpretive bias compared to individuals in the positive training condition. Importantly, assessments of mood before and after the training paradigm revealed training congruent mood changes. Individuals in the benign training condition reported increases in positive mood, but showed no changes in state anxiety, whereas individuals in the negative training condition reported increases in state anxiety, but did not report any changes in positive affect.

Since this initial study, many subsequent studies using CBM have replicated this finding showing significant relations between induced positive and negative interpretive biases and changes in state and/or trait anxiety (Holmes, Mathews, Dalgleish, & Mackintosh, 2006; Salemink, van den Hout, & Kindt, 2007; Standage, Ashwin, & Fox, 2010; Steinman & Teachman, 2010). Further support for the causal link between negative interpretive bias and anxiety has been gleaned from CBM studies in anxious populations. These studies have demonstrated that decreasing a negative bias (or inducing a benign or positive interpretive bias) in anxious individuals is associated with decreased reports of social anxiety (Beard & Amir, 2008), anxiety sensitivity (Steinman & Teachman, 2010), and worry (Hayes, Hirsch, Krebs, & Mathews, 2010; Hirsch, Hayes, & Mathews, 2009).

Several CBM studies, however, have failed to find interpretive bias training-related affects on self-reports of anxiety (e.g., Amir & Bomyea, 2010; Beard & Amir, 2008; Hirsch, et al., 2009; Hoppitt, Mathews, Yiend, & Mackintosh, 2010a). In a recent meta-analysis on the effects of CBM on anxiety and depression, Hallion and Ruscio (2011) found that the effect of training on symptom change was small, although significant. Findings from the meta-analysis, however, revealed evidence of publication bias, suggesting that a) CBM studies with insignificant and small mood effects exist and are not being published and b) the published CBM papers may reflect inflated effects sizes. With this information in mind, while the weight of evidence suggests that

manipulations in interpretive bias directly influence mood and anxious symptomatology, albeit to a small degree, more research is needed to further explore this relation.

Many cognitive theories posit that threat-related information processing biases assert their greatest influence on the development and maintenance of anxiety during times of stress (Mathews & MacLeod, 2002; Mogg & Bradley, 1998; Williams, et al., 1997). It is thought that during stress, the presence of a threat-related information-processing bias enhances or makes an individual more vulnerable to the negative effects associated with stress (Macleod et al., 2004). Supporting this assertion, prospective research has shown that individual variation in the level of threat processing biases under neutral conditions predict future emotional reactivity during real-life stressful situations (MacLeod & Hagan, 1992; Pury, 2002). Pury (2002) showed that in a group of undergraduates the level of negative interpretive bias during a time of low stress (towards the beginning of the semester) predicted levels of negative affect experienced during final examinations at the end of the semester, a time of high stress.

In CBM work, a robust empirical examination of this hypothesis is to examine emotional vulnerability to stress directly after bias manipulation. To date only a handful of interpretive bias modification studies have administered a stress task after training and examined changes in mood (Hoppitt, Mathews, Yiend, & Mackintosh, 2010b; Murphy, Hirsch, Mathews, Smith, & Clark, 2007; Steinman & Teachman, 2010; Teachman, Smith-Janik, & Saporito, 2007; Wilson, et al.,

2006). In one such study, twenty-four hours after undergoing either a benign or negative interpretive bias training procedure individuals were assessed on their mood before and after they watched a stressful video of an accident (Mackintosh, Mathews, Yiend, Ridgeway, & Cook, 2006). Mackintosh et al. (2006) found that compared to individuals in the benign training condition, those in the negative training condition showed increased emotional vulnerability to stress (i.e., reported a greater increases in anxiety after watching the stressful video). Moreover, the level of interpretive bias acquired after training was directly related to the level of emotional vulnerability reported to the stressor. In a similar study assessing changes in mood after viewing a series of stressful videos, Wilson et al. (2006) found that individuals who were in the benign training condition reported no increase in anxiety or depression as a result of the stress exposure, whereas individuals in the negative training condition reported significant elevations in both anxiety and depression after the stress task. In another study, after undergoing a task designed to encourage worry, individuals with Generalized Anxiety Disorder that received benign interpretive bias training reported less depression and negative thought intrusions compared to anxious controls (Hayes et al., 2010). These findings suggest that interpreting ambiguous information in a positive or benign manner may protect against the negative effects of stress, whereas a negative interpretive bias enhances anxiety vulnerability during stress.

It should be noted that several CBM studies have failed to find significant differences in emotional vulnerability to stress as a function of interpretive bias

manipulation conditions (e.g., Hirsch, et al., 2009; Salemink, et al., 2007; Steinman & Teachman, 2010). Salemink et al. (2007) found no differences in depression or anxiety vulnerability to a stress task between individuals who underwent a negative training condition compared to individuals who underwent a positive training condition. A recent CBM study conducted in our laboratory using a non-active control and a negative interpretive bias training group showed no group differences in emotional vulnerability to stress during a stress task (White, in preparation). Teachman (2007) found no group differences in reported fear levels between spider phobic adults who received benign interpretive bias training and spider phobic controls who received no training when asked to approach a large caged spider. However, the results revealed that the level of benign bias induced through training was related to decreased reports of fear during the stressful situation.

Interpretive CBM studies have also found significant training effects on reports of anxious anticipation for a future stressor (Hirsch, Mathews, & Clark, 2007; Murphy, et al., 2007). When imagining being in a stressful social situation, individuals trained to interpret ambiguous social events in a negative manner reported that they would feel more anxious and perform worse in the situation compared to individuals trained to interpret social ambiguity in a positive manner (Hirsch, et al., 2007). Similarly, socially anxious individuals trained to interpret ambiguous information in a benign manner predicted they would experience less

anxiety in a future social stressor compared to socially anxious individuals that received no training (Murphy, et al., 2007).

Taken together, although several CBM studies have not found associated changes in mood or emotional vulnerability to stress as a function of training, the weight of available findings in adult populations support current theories that suggest negative interpretive biases play a significant role in the generation, maintenance, or exacerbation of an anxious state (Macleod et al., 2004). The abovementioned CBM work suggests that interpretive biases can influence reports of current affect, trait affect, stress vulnerability, and the anticipation of future affect.

2.3b Child Populations

As the growing evidence in adult populations suggests a causal link between negative interpretive biases and vulnerability to anxiety, this link has been largely unsubstantiated in children. Similar to theories in adults, cognitive models of anxiety in children assert that threat-related information-processing biases are a fundamental characteristic to the experience of anxiety (Daleiden & Vasey, 1997; Kendall & Chansky, 1991; Vasey & MacLeod, 2001). However, unlike adult theories, the intricacies as to how threat-related biases contribute to the development of anxiety in children has received minimal theoretical and empirical discussion (c.f., Field & Lester, 2010; Muris & Field, 2008). In fact, the notion that threat-biases and anxiety are causally related in youth has been called

into questioned (e.g., Alfano, Beidel, & Turner, 2002; Muris, Huijding, Mayer, Remmerswaal, & Vreden, 2009; Salemink & Wiers, 2011).

Similar to their adult counterparts, a large body of research has documented that compared to their non-anxious counterparts, anxious children and adolescents display a negative interpretive bias (for review see Daleiden & Vasey, 1997; J. A. Hadwin, et al., 2006), where level of anxiety is correlated to the magnitude of threat interpretations (J. A. Hadwin, et al., 1997). Despite this correlation, little is known if and how these threat-related biases shape anxiety in childhood, including whether positive interpretative bias serve as a protective factor. Given that both negative interpretive biases and anxious symptomatology operate early in life and are thought to contribute to anxious behavior across the lifespan, the empirical examination of the emotional and cognitive effects associated with the threat interpretations in children is an important task.

Initial evidence of the causal links between interpretive biases and anxiety in children can be gleaned from the limited number of pediatric treatment effect studies, prospective studies in youth, and pediatric CBM studies. Creswell et al., (2005) found that anxiety treatment significantly influenced anxious children's processing biases. In a group of 7- to 15-year olds, after undergoing an 11-week family based therapy program, anxious children showed a significant decrease in their level of negative interpretive biases. Similar decreases in threat-related interpretive biases were found in a group of anxious 7-to 14-year-olds after undergoing cognitive behavioral therapy (Barrett, Dadds, & Rapee, 1996).

However, using a similar treatment design, Waters et al. (2008) showed no post-treatment decrease in anxious children's threat interpretations.

When observing children's play narratives at 5-years of age, Warren et al. (2000) found that children who displayed greater negative expectations during a series of play scenarios had higher levels of anxiety symptomatology one year later; this bias predicted subsequent anxiety above and beyond baseline levels of anxiety problems. In an older community based sample of 10- to 11-year olds, Creswell and O'Connor (2011) examined bidirectional relations between processing biases and anxiety over the span of one year. Regression analyses revealed that the endorsement of negative interpretations of ambiguous scenarios at the beginning of the year did not significantly predict level of anxiety change over the span of a year. Interestingly however, children's rating as to how distressed they anticipated they would feel if they were to experience the *ambiguous* situations described in the scenarios did significantly predict change in anxiety scores across the year. That is, children that anticipated greater feelings of distress during the ambiguous scenarios also showed greater increases in anxiety across the year. However, complicating the directionality of finding, the study also found that initial levels of anxiety significantly predicted change in threat interpretations across the year. Muris, Jacques, and Mayer (2004) found similar bi-directional relations between threat bias and anxiety across the span of one month in a group of non-clinical 9- to 13-year olds. Specifically, the study found that threat-related interpretive bias at time two (end of the month), but not at time

one (beginning of the month), significantly predicted anxiety symptoms at time two, even after controlling for anxiety at time one. Conversely, anxiety at time two, but not time one, was a significant predictor of negative interpretive bias at time two. Taken together, the above treatment and prospective studies do suggest a unique positive relation between anxiety and threat perception in children; however, the findings suggesting a negative interpretive bias predicts future anxiety are weak and inconsistent.

When examining the prospective effects of threat perception on anxiety as a function of behavioral inhibition, Dodd et al. (2012) found that after controlling for baseline anxiety levels, threat perceptions at 3- to 4-years of age uniquely predicted anxiety symptoms one year later. However, this significant effect was not seen when predicting anxiety symptoms assessed two- or five-years after baseline assessment. Importantly, this study showed no effect of behavioral inhibition; BI was not related to a child's negative interpretive bias, nor did the bias moderate the link between BI and anxiety.

As indicated from the preceding discussion in adults, CBM procedures provide a unique method to examine the directionality of the association between interpretive bias and anxiety vulnerability. These studies allow for the investigation of whether a) an induction of a threat bias in non-anxious children increases anxiety vulnerability and, importantly, b) an induction of a non-threat or positive bias in anxious or at-risk children decreases anxiety vulnerability. Despite the important implication of such investigations, only a handful of studies

have examined CBM effects on anxiety in youth, with most focusing on adolescent populations.

From the extant literature, although the majority of studies demonstrate that interpretive biases can be successfully manipulated in children, how such manipulation influences anxiety vulnerability remains unclear and largely untested. Muris and colleagues (2008; 2009) conducted the first published CBM studies in children using a computer task called the "Space Odyssey". In this task children ages 8-13 went on an imaginary space journey in which they were presented with a series of scenarios describing unfamiliar space-related situations (e.g., "*you encounter a spaceman. He has a sort of toy handgun and he fires at you*…"). Each scenario was accompanied with two ending options: one option always reflected a positive or benign ending to the scenario (e.g. *"you are laughing: it is a water pistol and the weather is fine anyway"*) and one option always reflected a negative ending (e.g., "*Oops, this hurts! The pistol produces a red beam which burns your skin!"*). During the training period, children were instructed to choose the "correct" story ending, after which feedback was provided. Children in the positive training condition always received feedback congruent to the positive ending option being correct; children in the negative training condition received feedback congruent to the negative ending option being correct. Results from the two studies revealed that the training procedure was successful: over the course of task children learned to endorse the ending option congruent with the valence of their training condition. Additionally, after

the training procedure, children in the negative training condition were quicker to endorse an ambiguous story as threatening compared to children in the positive training condition, showing bias training transferred to an additional interpretive bias assessment (Muris, et al., 2009). Post-training assessment of behavioral approach tendencies revealed that children in the negative training condition showed increased avoidance tendencies toward space-themed objects, whereas children in the positive training condition showed decreased avoidance tendencies. Although direct training-related mood effects were not assessed in either task, results from the 2009 study revealed interpretive bias training had a small but significant effect on anxiety-related behaviors (i.e., avoidance during a space-themed approach/avoidance task).

Although the number of studies employing CBM in children is growing, to date, only four CBM studies have examined effects of bias manipulation on anxiety vulnerability(Lester, Field, & Muris, 2011a, 2011b; Vassilopoulos, Banerjee, & Prantzalou, 2009; Vassilopoulos, Blackwell, Moberly, & Karahaliou, 2012). Lester and colleagues (Lester, et al., 2011a, 2011b) found mixed training related emotion effects. Both studies examined how positive and negative bias training related to changes in mood and anxious anticipations in a group of unselected children. Employing two modified versions of the "space odyssey" task with social or animal themed scenarios, both studies revealed significant training related effects on interpretations. Lester et al. (2011b) found no training effects on mood, but children in the positive training condition showed decreased

anxious anticipation of a future stressor. Nevertheless this finding was limited to one type of training (an animal-themed training paradigm) and was only significant in younger children. In a similar study that yielded mixed results, Lester et al. (2011a) found children in the positive training condition displayed decreased anxiety-related behaviors during a behavioral avoidance task: however, no emotional effects were detected directly after training or during the avoidance task.

Positive clear support for the notion that reductions threat-interpretations may protect against anxiety come from a recent CBM study designed to examine the effects of different task instructions (i.e., emphasizing imagery or verbal meaning) on the effectiveness of positive interpretive bias training. Using two active positive training conditions, Vassilopoulos et al., (2011) found significant decreases in 10-12 year-old unselected children's self-reported social anxiety after undergoing positive bias training.

Only one CBM study has been conducted in an at risk sample of children. In a non-clinical sample of socially anxious 10 and 11-year-olds, Vassilopoulos and colleagues (Vassilopoulos, et al., 2009) found that after being trained to interpret emotional ambiguity in a positive or benign way, children reported decreases in trait anxiety compared to a test-retest socially anxious control group. The study also showed that the level of change in social anxiety from pre- to post-training was significantly correlated to the level of positive interpretive bias change. Additionally, compared to the anxious controls, anxious children that

received positive training reported less anticipated anxiety regarding a future social stressor.

CBM work in adolescent populations also reveals weak or inconsistent findings of interpretation training on anxiety. Using positive and negative training conditions, Lothmann and colleagues (Lothmann, Holmes, Chan, & Lau, 2011) found adolescents in the positive training condition reported a decrease in negative affect directly after training; adolescents in the negative training condition reported a decrease in positive affect, although this finding was only significant for males. In a similar design, Lau et al. (2011) found a post-training decrease in positive affect in adolescence trained to interpret information in a negative manner, but this finding was only significant for adolescents also reporting low self-efficacy. No changes in negative affect were detected in the negative condition, nor were any mood changes associated with positive bias induction condition detected. Salemink and Wiers (2011) also found no mood effects: adolescent state anxiety did not change as a function of negative interpretive bias manipulation.

One CBM interpretation study has been conducted in a vulnerable adolescent population; Fu and colleagues (2012) found that despite a significant reduction in threat interpretations in a group of clinically anxious Chinese adolescents, bias reduction had no effect on anxiety. Thus, the findings from the CBM work in adolescents examining the effects of bias induction on anxiety in

adolescents also reveal mixed findings; when significant effects were detected, they were weak and constrained.

In sum, despite growing research in child populations, it remains unclear if a negative interpretive bias increases a child's risk for anxiety and/or whether a positive interpretive bias may protect against the development of anxiety. Indeed, only four CBM studies to date have examined the effects of interpretation modification on emotions in children. The conclusions that can be made from these studies regarding the influence of interpretive bias on anxiety are limited: these studies have yielded mixed results and only one of these studies was conducted in an at-risk (high social anxiety) sample (Vassilopoulos, et al., 2009). Clearly, more CBM research examining the relations between interpretation bias induction and anxiety vulnerability, particularly in vulnerable populations, is warranted.

To fully understand the nature of the bias/anxiety link, it is essential that future research examines the effects of training on anxiety during periods of stress, when biases are thought to exert their greatest influence on anxiety. Indeed, no study has examined the effects of positive interpretation training on anxiety vulnerability to stress in vulnerable children (e.g., high behavioral inhibited children). It is important to examine whether an induction of a non-threat/positive interpretive bias (i.e., a reduction in a threat bias) is linked to decreased anxiety vulnerability in children at risk for anxiety.

Although the CBM work looking at the effect of interpretation on anxiety in children revealed inconsistent findings, the significant mood effects that were detected were tied to the positive training condition. This suggests that in children, the causal relations between interpretive bias and anxiety vulnerability may be specific to the reduction of threat interpretations (Lester, et al., 2011a, 2011b; Vassilopoulos, et al., 2009; Vassilopoulos, Blackwell, Moberly, & Karahaliou, 2011). Thus, the induction of a non-threatening interpretive bias in behaviorally inhibited children may protect against anxiety.

2.4 The Cognitive Consequences of Interpretive Bias Acquisition

2.4a Attention Bias

A negative interpretive bias may also influence anxiety vulnerability by causing subsequent threat-related perturbations in a child's cognitive processing. Although the stages in the SIP models are inherently sequential, Crick and Dodge (1994) stress that online information processing is a nonlinear process. Models of anxiety also stress the additive properties of multiple biases to the disorder, implying bi-directionality or interactive influence on anxiety vulnerability (Everaert, Koster, & Derakshan, 2012; Rapee & Heimberg, 1997). Accordingly, a threat-related bias at one level of information processing can imbue all stages of information processing, transforming representations of information as they are encoded and advance through the stream of cognitive processes (Daleiden & Vasey, 1997). The acquisition of a bias at one processing stage (e.g. interpretation) may generate threat-related biases at other information-processing

stages (e.g., attention). For example, if a child interprets a situation as a threat, this may create an overall hyper vigilance of threatening information, resulting in an attention bias towards threat. Conversely, if a child displays increased non-threat interpretations, their hypervigilance for threat in the environment may decrease, as evidenced by a lower attention bias toward threat. Given that attention biases toward threat are thought to have the same causal associated to anxiety as interpretive biases (Eldar, Ricon, & Bar-Haim, 2008; MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002), the biases may operate in concert, jointly increasing anxiety vulnerability.

Most of the work exploring the causal link between cognitive biases and anxiety has focused on one specific bias in isolation, as such little is known about the causal relations between biases. Given that both biases may shape an individual's vulnerability to anxiety, it now becomes important to understand the bidirectional link between these threat-biases. Understanding the nature of relations between these threat-related biases and their combined influence on anxiety vulnerability will help elucidate mechanisms behind the development of anxiety disorders in children.

The notion of causal relations between different stages of threat biases has begun to receive empirical support in adult populations. In our laboratory, through the use of a CBM procedure we recently documented that changes in attention bias towards threat significantly affected how emotionally ambiguous information was interpreted in a sample of non-anxious undergraduates (White, Suway, Pine,

Bar-Haim, & Fox, 2011). This study showed that compared to a placebo control group, individuals who underwent a training paradigm designed to induce an attention bias toward threat showed increased anxiety-related negative interpretations after training. Empirical research also suggests that manipulating interpretive biases influences the manner in which threat is attended (Amir et al., 2010). In a group of socially anxious individuals, Amir and colleagues showed that after undergoing a benign interpretation training procedure, anxious individuals showed decreased difficulty disengaging attention away from threat, a pattern not detected in the anxious control group (Amir & Bomyea, 2010). Recent unpublished data from our laboratory found no relation between the induction of a negative interpretive bias and subsequent attention bias toward threat in unselected young adults (White, in preparation). Taken together, empirical work while limited, suggests that acquiring one threat-related bias may put an individual at risk for subsequent maladaptive processes.

The causal relations between threat-related biases remain virtually unexplored in children. When a child acquires a negative interpretive bias they may be introduced to a host of other maladaptive cognitions. Similarly, when threat interpretations are reduced, reductions in attentional vigilance towards threatening information may follow. Examining how interpretative biases may impact a child's attentional hypervigilance towards threat is an important step in understanding how the threat biases may jointly or separately contribute to increases in a child's emotional vulnerability.

2.5 Summary

Behaviorally inhibited children are at increased risk for anxiety. As such, it is important to identify possible risk factors that may contribute to anxiety vulnerability in these children. One factor thought to influence the risk for anxiety in behaviorally inhibited children is the child's interpretive bias. As such, the present chapter reviewed both theoretical and empirical work exploring the links between threat-related (negative) and non-threatening (positive) interpretive bias and anxiety. Although the chapter presented the ever-growing empirical findings linking negative interpretive biases to anxiety vulnerability in adults, the review also emphasized the clear lack of empirical work examining (and supporting) this link in children. To understand the developmental link between BI and anxiety, it is important to understand the relations between threat biases and anxiety vulnerability in children, a time when stable individual differences in biases and anxiety first appear.

The present study contributes to this important area of research by empirically examining anxiety-related cognitive and emotional effects associated with the interpretation of emotional ambiguity in behaviorally inhibited children. Specifically, the current study examines if a reduction in threat interpretations in behaviorally inhibited children leads to 1) decreased emotional vulnerability to a stressor and 2) a decrease in attention bias towards threat.

Chapter Three: Methods

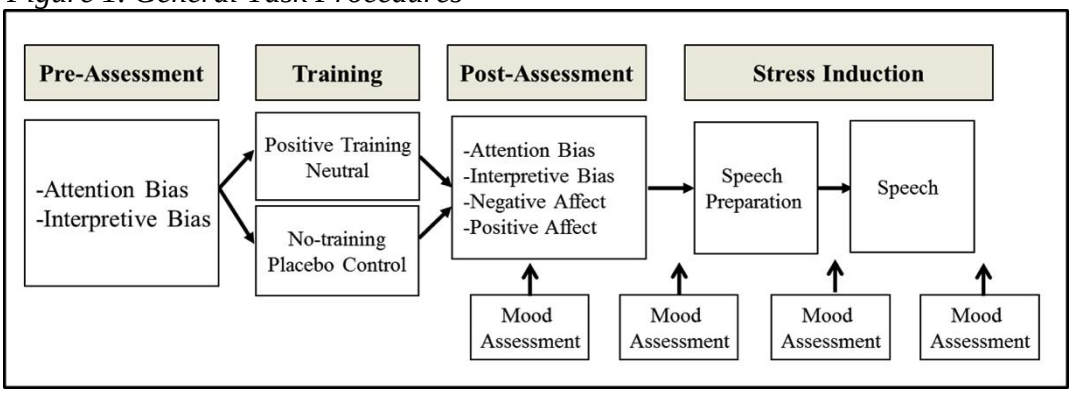
3.1 Procedures

The current study involved five phases. Four phases took place during one laboratory visit: (i) the pre-training assessment phase, (ii) the training phase, (iii) post-training assessment phase, and (iv) a stress phase (see Fig. 1). The fifth phase was a follow-up internet assessment phase that occurred 24-hours after the laboratory visit.

Prior to the start of experiment, informed consent regarding the study procedures was obtained from the parent and children were briefed on the procedures and assent was obtained. In the pre-training assessment phase, baseline measures of attention bias toward threat and negative interpretive bias were assessed. Participants then completed the training phase of the experiment. All children were randomly assigned into one of two training conditions: the positive interpretation training condition or the placebo control training condition. Randomization order was determined prior to the start of the study. Directly after the training phase, participants were again assessed on attention bias towards threat and negative interpretative bias. Following, participants were asked to give a speech as part of the stress induction phase. After the speech phase was complete, participants were informed of the nature of the stress task. At set times throughout the visit participants reported of their current levels of positive and negative affect. Parents completed several anxiety and temperament questionnaires while their children completed the laboratory tasks.

For the fifth phase of the study, participants were asked to complete an additional interpretative bias assessment one day after the laboratory visits. This assessment was administered over a secure website and was to be completed at the participant's home.

Figure 1. General Task Procedures



3.2 Participants

Participants were 45 behaviorally inhibited children (29 males; 16 females) 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 males, 9 females) or Placebo Control (n=22; 15 males, 7 females). The two training conditions did not differ in age, $t(43) = -0.95$, $p = .35$; sex, $\chi^2(1) = 0.26$, $p = .61$; or BIQ scores, $t(43) = 0.15$, $p = .88$.

3.2a Participant Selection

Interested families with children between the ages of 9 and 12 were recruited from the Washington, DC metropolitan area through mailings and advertisements. The age range of 9-12 was chosen for several reasons. First, anxiety and fears in the social domain become increasingly prevalent during

middle childhood and early adolescents (Westenberg, Drewes, Goedhart, Siebelink, & Treffers, 2004). Second, shyness and social inhibition during this age range seems to have a particular influence over the development of later anxiety problems (Prior, Smart, Sanson, & Oberklaid, 2000). Third, a series of coherent findings identify both attention bias towards threat and negative interpretive bias in trait anxious children in this age range (Eldar, et al., 2008; J. A. Hadwin, et al., 1997 ; Muris, et al., 2005; Vasey, Daleiden, Williams, & Brown, 1995). Lastly, a series of studies have documented that interpretive biases can be manipulated in children in this age range (Muris et al., 2008; 2009; Lester et al., 2011).

To identify high behaviorally inhibited children, interested families with children between the ages of 9 and 12 were asked to complete the Behavioral Inhibition Questionnaire (BIQ: Bishop, Spence, & McDonald, 2003; see Appendix A). Parental informed consent was obtained for the pre-screening procedure prior to completion of the BIQ. The BIQ total score was used for recruitment to capture behavioral inhibition across both social and situational contexts (internal consistency was good, $\alpha = .86$). Based on BIQ score norms reported in a large developmental study ($n = 293$ children; age range: 9 to 15 years; Broeren and Muris, 2010), a BIQ score reflecting the top tercile of the population was used as the behavioral inhibition criterion (i.e., "cut off" score) in the current study[1].

[1]Children with BIQ scores equal to or above 97.5 were eligible to participate in the current study.

A total of 284 families indicated they were interested in completing the BIQ questionnaire; completed questionnaire were received for 187 children. Seventy-six children met the eligibility requirements and were actively recruited for the current study, of which 45 participated. Out of the remaining children that qualified for the current study, 7 families declined to participate, 19 were non-responsive to study invitations, and five were pilots for the current study. Out of the 76 children who qualified, those that participated in the current study did not differ in age, sex, or BIQ scores from those that did not participate.

3.3 Questionnaires

Behavioral Inhibition Questionnaire: (BIS; Bishop, et al., 2003; Broeren & Muris, 2010). The BIQ is a 30-item parent-report questionnaire used to assess temperamental behavioral inhibition 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". See Appendix 3 for a full list of items. Parents endorse each item for their child using a likert scale ranging from 1 "hardly ever" to 7 "almost always"; parents were asked to endorse each item as it relates to their child.

Studies that have examined the psychometric properties of the BIQ have yielded positive results in younger (Bishop, et al., 2003) and older (Broeren & Muris, 2010) children. The BIQ shows good internal consistency, construct

validity, and test-retest reliability (Bishop, et al., 2003; Broeren & Muris, 2009, 2010; Edwards, Rapee, & Kennedy, 2010). Moreover, the BIQ has been shown to relate to behavioral observations of behavioral inhibition (Bishop, et al., 2003).

Screen for Child Anxiety and Related Emotional Disorders: (SCARED; Birmaher et al., 1999; Birmaher et al., 1997). 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 3 "very true or often true". Of particular interest for the current study were the Social Phobia and Generalized Anxiety Disorder subscales, as well as the total scale. Total and subscale scores were created by summing relevant items. The SCARED has been successfully used in previous research to assess anxiety in children 9-12 years or age (Muris, et al., 2011).

Early Adolescent Temperament Questionnaire-Revised: (EATQ-R; Ellis & Rothbart, 2001). The EATQ is a 65-item parent-report questionnaire used to assess temperament in children between the ages of 9-15 years of age. The questionnaire assesses ten dimensions of temperament, including shyness, the scale of interest for the current study. Parent endorse each item using a 5-point scale: 1 "Almost always untrue of your child" to 5 "Almost always true of your child". An average was computed from relevant items to create the shyness scale.

3.4 Interpretive Bias Training and Assessment Task

New School Task:

The New School Task consisted of four phases: pre-training bias assessment, bias modification, post-training bias assessment, and 24 hour follow-up assessment. The New School Task is a modified version of the social interpretive bias modification task used in Lester et al., (2011) which was adapted from the non-social "Space Odyssey" interpretive bias modification task successfully used by Muris et al., (2008; 2009). In the current 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" (see Fig. 2 for examples). Prior to the start of the task, participants were instructed to imagine that they had started attending a new school and were in the situations described[2]. At the beginning of the task, the experimenter walked the participant through a practice scenario to ensure that the task instructions were fully understood. During this time the experimenter emphasized how the self-imagery should be employed during the ambiguous scenarios.

The training session consisted of 50 scenarios and the pre-training, post-training, and follow-up assessment phases each consisted of 10 scenarios (a total of 80 scenarios were used in the task). The scenarios presented at pre- and post-

[2] In keeping with previous CBM work demonstrating imagery-facilitated training (Holmes, Lang, Shah, 2009; Holmes, Mathews, Dalgleish, 2006), the current instructions were implemented.

training assessment were counterbalanced across participants[3]: All scenarios used in the task were different (i.e., no scenario was presented to the participant more than once). Thirty of the scenarios were taken from the social training condition in Lester et al. (2011) and the remaining scenarios were adopted from other established child interpretive bias measures (Bogels & Zigterman; 2000; Muris et al., 2000; Waters, Craske, Bergman, & Treanor, in press) or created in the Child Development Laboratory. The laboratory portion of the New School Task was programmed in E-Prime 2 and administered on a laptop computer. Participant responses were collected via computer response.

The New School Task: ***Bias Modification Phase***

In the training portion of the task a scenario appeared on screen for five seconds followed by the presentation of two possible ending options. One ending option always reflected a non-threat ending and one option always reflected a threat-related ending (see Fig. 2 for examples). Participants were instructed to choose the ending option that was closest to how they would think or feel in the situation or how they thought the situation would continue. Participants were informed that in this phase of the task they would find out if their choice were *right* or *wrong*. Participants chose an option by selecting a corresponding button on the computer. Following a response, feedback appeared on the screen (i.e., "Correct" accompanied by a green check mark or "Wrong" accompanied by a red X). Children in the positive training condition received feedback that the non-

[3] The 20 scenarios used during pre- and post-assessment points were randomly divided into two sets: set A and set B. Half the participants received set A at pre-assessment and set B at post-assessment; half the participants received the sets in reverse order.

threatening ending was the *correct* choice for 90% of the scenarios to reinforce positive interpretations. The remaining 10% of trials were "catch" trials such that the negative ending option was *correct.* These ten trials were presented in a fixed order across training trials. In the placebo condition, the non-threat and threat ending options were each *correct* on 50% of the trials. In effort to reinforce the training condition, participants in both conditions were instructed to think about how that ending could explain the situation described once they were informed of the *correct* option.

The New School Task: ***Pre- and Post-Training Assessment Phase***

The assessment phase of the task was modified to include three interpretation assessments: *Threat Ending Option Scores, General Threat Outcome Scores,* and *Anticipated Distress.*

Similar to the training phase, participants were presented with an ambiguous scenario followed by two ending options: a non-threat ending and a threat ending. Participants were instructed to choose the ending option that was closest to how they would think or feel in the situation or how they think the situation would continue. For these trials, children were informed that there was *no* right or wrong answer. The total number of non-threat and threat endorsed endings were summed for each participant. Total non-threat endorsements were subtracted from total threat endorsements to create a *Threat Ending Option Score* for each assessment phase. Higher scores reflect a greater endorsement of the threat ending options, whereas low (or negative) scores reflect a higher

endorsement of non-threat ending options. A score of zero means that threat and non-threat endings were equally endorsed.

The New School Task assessment phase also included assessment of an initial, general interpretation of the situation before any specific ending options were presented to the participant. Five seconds after scenario presentation, the question "*how do you think this situation will end?*" appeared on screen paired with three choices: "in a good way", "in a bad way", or "in a neutral/in-between way". Participants selected their answer via keyboard response. For each assessment phase, "good" and "neutral" responses were summed to create a total count of non-threat interpretations. Next, the total non-threat interpretations were subtracted from the sum of threat interpretations (i.e., "bad" responses) to create a *General Threat Outcome Score* for pre- and post-training assessments. Higher scores indicate a greater endorsement of general threat interpretations (i.e., selection of "the situation will end in a bad way"), whereas lower/negative scores indicate greater endorsement of general non-threat interpretations (i.e., selection of "the situation will end in a good/neutral way").

The task was also modified to include a measure of anticipated distress. After the general threat outcome response was made, the question "*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". Participants were told that for the purpose of the task, distress meant they would feel nervous, worried, sad, or uncomfortable in the situation. Distress ratings across all ten scenarios were

averaged to create an *Anticipated Distress Score* at each assessment point. Higher scores indicate higher levels of anticipated distress across the scenarios.

Prior to the start of the task, the experimenter went over the task instructions in detail with the participant. Additionally, after instructions the experimenter walked the participant through a full practice trial.

Threat Ending Option Scores, *General Threat Outcome Scores*, and *Anticipated Distress Scores* were significantly correlated at both baseline (*r*s range from .50 to .56, *p*s $\leq$.001) and post–training assessments, (*r*s range from .36 to .54, *p*s $\leq$.02). All interpretation scores were standardized and averaged to create a composite score. A composite score was computed at each assessment time to reflect total threat-related interpretive bias (chronbach's α for the composite scores were .72 to .83). Higher scores represent larger threat-related interpretation scores and lower scores reflect greater non-threat interpretations.

New School Task**: *24-hour Follow-Up Assessment***

The online version of the task was identical in structure to the laboratory assessments and included 10 ambiguous scenarios. At the end of each lab visit, children and their parents were instructed on how to complete the online assessment. Families were given reminder calls or emails regarding their completion of the online assessment. Out of the 45 participants in the study, 34 completed the follow-up assessment. The time between laboratory visit and participant's follow up assessment are as follows: one day (*n*=21), 2-3 days (*n*=6), 4-5 days (*n*=3), and 7-14 days (*n*= 4). Participants with more than 5 days

between lab visit and follow up assessment were excluded from analyses (n=4). Data from one participant was lost due to technical difficulties. Follow-up analyses were conducted on 29 participants (Training condition: *n*=14; Control Condition: *n*=15).

Scenario	Option A	Option B
You attend a new classmate's birthday party. When you arrive, you don't recognize anyone you know and everyone looks in your direction.	No one says anything to you as you walk in the room. [threat option]	Everyone says, "Hi!" and welcomes you. [non-threat option]
You are talking to your new classmates and after you say something to them there is a long pause.	They are thinking about what to say next. [non-threat option]	They thought what you said was odd and have nothing more to say. [threat option]
Your class is going on a field trip to a museum. On the bus, someone sits next to you that you don't know very well.	You become friends and have lots to talk about. [non-threat option]	You two didn't talk to each other for the entire ride. [threat option]
Your teacher tells you they need to speak to you after class.	You worry you did something wrong and are in trouble. [threat option]	You aren't worried at all. They probably just have a question to ask you. [non-threat option]
Some of your new classmates came over to your house to hang out. The next day at school you hear them talking about it.	They say it was "fine" and start talking about something else. [threat option]	They say it was a lot of fun and want to hang out with you again. [non-threat option]
You have a brand new haircut. When you get to school the next day your new classmates comment on how you look.	They think it looks terrible and you get embarrassed. [threat option]	They think it looks great and you are happy! [non-threat option]

Figure 2. Examples of scenarios and ending options presented in the New School Task. Each scenario is paired with two ending options, a non-threat and threat option.

3.5 Attention Bias Assessment Task

Dot-Probe Task:

The dot-probe was administered at two different time points. The current study used a standardized version of the dot-probe task provided by Tel-Aviv University/National Institute of Mental Health Attention Bias Modification Treatment

(TAU/NIMH: http://www.tau.ac.il/~yair1/ABMT.html). Similar versions of this task have been successfully used in 7-12 year-old children (e.g., Eldar et al., 2008).

Dot-probe Task Procedure:

Each trial began with the presentation of a white fixation cross presented in the center of the screen for 500ms. Following, a face pair display of neutral-angry or neutral-neutral facial expressions appeared on the screen for 500ms. A probe (an arrowhead pointing either left or right: " < ", " > ") then appeared in the location of one of the previously viewed faces. Participants were required to identify the target ("<" or ">") by pressing one of two buttons on a computer mouse. The target remained on the screen until the participant's response.

Each assessment phase consisted of 120 trials, with 80 of the trails containing an angry-neutral face display and 40 containing a neutral-neutral display. On the angry-neutral trials the target appeared in the location of the previously viewed angry face on 50% of trials (i.e. threat congruent trials). Angry-face location, target location, and target type were fully counterbalanced across trials. At each assessment, if participant 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.

Dot-probe trials with incorrect responses and reaction times (RT) less than 200 *ms* or greater than 2000 *ms* were excluded from further analyses. Z-scores were calculated for each face display (i.e., neutral-threat, neutral-neutral) and

probe location (i.e., threat congruent, threat incongruent). Trials with Z-scores greater than |2.5| were removed from analysis and mean RTs were calculated. Participants reaction times and accuracy data at pre- and post-assessments were examined for significant outliers. One participant was removed from dot-probe analyses due to extremely low accuracy rate. No RT outliers were detected.

To calculate attention bias scores, threat congruent mean RTs were subtracted from threat incongruent mean RTs. Higher scores reflect an attention bias toward threat and negative scores reflect and attention bias away from threat. A score of zero reflects no bias.

Dot-Probe Task Stimuli: The face stimuli are photographs of 10 different actors (5 male, 5 female) taken from the NimStim stimulus set (Tottenham, et al., 2009). For each of the 10 actors, two photographs were used, one depicting an angry facial expression and one a neutral expression. Neutral-angry and neutral-neutral face displays always consisted of photographs from the same actor. Each face photograph subtends 45mm in width and 34mm in height. The face photographs are presented with equal distance to the top and bottom of the fixation cross, with a distance of 14mm between them. The top photograph is positioned about 20mm from the top edge of the screen. Task was programmed in E-Prime 2 and administered on a laptop computer.

3.6 Mood Change and Emotional Vulnerability Assessment

3.6a Mood Assessment

To assess self-report of mood, participants were presented with a series of analogue scales throughout the experiment. Most CBM work only assesses child self-reported mood via ratings of anxiety; however, to better help capture training-related changes in a child's negative and positive affect, the scales used to the following labels: "*happy, great", "nervous, worried",* "*sad, depressed*", and "*angry, frustrated".* A 15 cm horizontal line divided into 30 equal sized partitions was displayed on each scale with the terminal labels "not at all" and "very much". Participants were instructed to circle the mark on the scale that best reflected their current mood state in regards to each of the four labels. Mood ratings could range from 0 to 30, with higher ratings reflecting higher levels of positive or negative affect. Scales were administered: directly after completion of the New School Task (mood scales 1), directly before the stress induction procedure (mood scales 2), directly after the speech preparation period (mood scales 3), and directly after the speech (mood scales 4). The first mood assessment was not administered to one participant. At each assessment point, correlations between mood ratings on the negative affect (sad, nervous, and angry) scales ranged from low to high (*r*s=.22 to .72). Correlations between the positive (happy scales) and negative scales also showed large variation (*r*s= .07 to -.54).

3.6b Stress Induction

For the stress induction procedure, participants gave a speech on the topic: "*why we* [the experimenter] *should vote for you* [the participant] *for 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, after only two minutes participants were informed the speech task was finished. To allow for assessment of emotional reactivity when anticipating the stress, participants were given two minutes to prepare their speech after which the experimenters entered the room and the speech began. Experimenters were instructed to remain neutral during the speech and provided standard set of prompts if the participant fell silent before the two minutes were finished. After the speech was competed, children evaluated 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.

3.7 Data Analyses Plan

Prior to hypothesis testing, correlations between BIQ scores and questionnaire scales related to the construct of behavioral inhibition were examined. Intercorrelations between dependent measures at were also examined.

Next, the ability to modify successfully interpretations of ambiguous information in 9- to 12 year-old high behaviorally inhibited children was examined. We hypothesized that children in the positive training condition would

show a reduction in threat-related interpretations after the modification procedure. To test this hypothesis, the interpretation composite scores were subjected to a repeated measures ANCOVA with Time (Pre-Training, Post-Training) as a within subjects repeated factor and Training Condition (Positive Training, Placebo Control) as a between subjects factor[4]. To control for unintended order effects of the scenarios, scenario set order was entered as a covariate in the above analyses[5].

Second, we examined whether training related effects on interpretation could be detected 24-hours post-training. Interpretation scores at the follow up assessment were compared to pre-training scores. The follow-up scores were subjected to a repeated measures ANCOVA with Time (Pre-Training, Follow-Up) as a within subjects repeated factor and Training Condition (Positive Training, Placebo Control) as a between subjects factor. To control for time lapse between training and follow-up assessment, the number of days between the laboratory visits and completion of the follow-up assessment was entered as a covariate.

Third, we examined training related effects on mood. To do this we first examined mood changes directly after the training paradigm. We hypothesized that in comparison to the control condition, the positive training condition would show lower negative affect and greater positive affect directly after training. To test this hypothesis, positive affect scores directly after training were subjected to

[4] Data were also subjected to a doubly multivariate repeated measures design (Steven, 2009; Tabachnick & Fidell, 2012), treating all three interpretation measures as dependent measures. This analyses yielded similar results to the composite score analyses.
[5] Analyses were also conducted with SCARED social anxiety scores as a covariate of interest to examine effects of social anxiety on bias change. Social anxiety was not a significant factor and did not influence any of the reported results.

one-way ANOVA with Training Condition (Positive Training, Placebo Control) as a between subjects factor. To examine post-training negative moods scales, a MANOVA was conducted using all the negative affect ratings (angry, nervous, sad) as dependent measures with Training Condition (Positive Training, Placebo Control) as a between subjects factor.

Fourth, we examined training effects on emotional vulnerability to stress. We hypothesized that the positive training would serve as a buffer against increased negative responses across the stress phase, including during the anticipation of stress and during the stress task itself. To address this hypothesis, differences in mood scores were examined at three points: prior to speech induction (i.e., directly before speech instructions), after the speech preparation period (directly before giving the speech), and directly after the speech task. To test changes in mood, positive affect scores were subjected to a repeated measures ANOVA using Time (Pre-Stress Induction, Post-Speech Preparation, Post-Speech) as within subject factors and Training Condition (Positive Training, Placebo Control) as a between subjects factor. To examine changes in negative scores over the stress task, angry, nervous, and sad scores were used as dependent measures in a doubly multivariate repeated measures design (Steven, 2009; Tabachnick & Fidell, 2012). The negative mood scales were subjected to a repeated measures MANOVA 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.

Next, we examined training related effects on attention bias toward threat. We hypothesized that as a function of training, participants in the positive training condition would show a decrease in attention bias toward threat from pre- to post-training compared to the control condition. To examine this hypothesis, attention bias data was subjected to a repeated measures ANOVA with Time (Pre-Training, Post-Training) as within subject factors and Training Condition (Positive Training, Placebo Control) as a between subjects factor.

Significant interactions in the ANOVA analyses were probed with simple main effects analyses on estimated means using a Sidak adjustment for multiple comparisons.

Lastly, using correlation analyses we examined if the change in interpretations as a function of training (i.e., magnitude of training) was related to: interpretation scores at the 24 hour follow-up, attention bias change, mood directly after training, and stress vulnerability. Pre- to post-training change scores were created for the interpretation composite and attention bias toward threat scores (*change score* = [Post-Training Assessment Score] – [Pre-Training Assessment Score]). Emotional vulnerability scores to the stressor were also created for each mood scale (happy, sad, angry, and nervous) by looking at changes in mood from before to after the stress task (*vulnerability score* = [Mood Scale Before Speech Instructions] – [Mood Scale After Speech Instructions]). We hypothesized larger training-related decreases in threat interpretations (i.e., more negative change scores) would be related to lower threat interpretations at the

follow up assessment, greater decreases in attention bias towards threat, and lower emotional vulnerability to stress.

To correct for normality, interpretation scores at the three assessments and both attention bias scores were transformed using the square root transformation. Mood scale data was transformed using log transformation (reverse score transformations were implemented for the positive mood scales). Means tables for each variable (i.e., Table 1, 2, 3, and 4) report values for the untransformed data. For each variable, outlier status was defined as a *z* score of ±3.13 (which is appropriate for sample sizes between 40-50; Barnett & Lewis, 1994). No outliers were detected.

Additionally, all study variables were examined to check for possible sex (via independent samples t-tests) and age (via correlation analyses). After Bonferroni adjustment, age was significantly negatively correlated to positive mood ratings at the last three mood assessments (*r*s between -.45 to -.52, *p*s<.002); older children reported overall lower positive affect. No other age correlations were significant. There were no significant sex differences on any of the variables.

Chapter Four: Results

4.1 Intercorrelations Between Study Variables

Means for the questionnaires can be found in Table 1. BIQ was modestly related to parent-reports of anxiety on the SCARED total score, $r(45)=.35$, $p = .02$, as well the general anxiety, $r(45)=.31$, $p = .04$, and social anxiety, $r(45)=.31$, $p = .03$, subscales. Additionally, BIQ was significantly correlated to parent-reported shyness on the EATQ, $r(45)=.41$, $p = .01$, but not to the EATQ fear scale, $r(45)= -.05$, $p = .74$.

At baseline assessment, threat interpretations and attention bias toward threat were significantly negatively correlated, $r(44)= -.30$, $p = .05$; higher threat interpretation scores were related to greater attention biases *away* from threat. No correlation was detected between these measures at post-assessment, $r(44)=.09$, $p = .55$. Additionally, pre-interpretation scores were not associated with post-attention bias scores, $r(44)=.13$, $p = .41$, nor were pre-attention scores significantly correlated with post-interpretation scores, $r(44)= -.25$, $p = .09$. Pre-training interpretation scores were significantly related to post-training interpretations scores, $r(45)=.55$, $p<.001$. Of note, attentions bias scores at pre- and post-training assessments were not correlated, $r(44)=.14$, $p=.38$.

Pre-training and post-training interpretation scores were not correlated with any of the positive or negative mood scale ratings, (all rs < .26, ps > .10). Additionally, pre-training attention bias ratings were not related to any mood scale, but post-training attention bias scores were negatively correlated with

happy ratings at each mood assessment (*rs* were between -.29 and -.33, *ps* between .03 and .07).

The above correlation analyses reveal that BIQ scores in the current sample were positively related to theoretically similar constructs as assessed by parent report. Of note, interpretation scores and attention bias scores were negatively related at the baseline assessment. Several correlations indicate that attention bias toward threat scores were negatively related to positive mood. However, it should also be noted that most of the above reported correlations were small in magnitude.

Table 1. Means (*SDs*) for Questionnaires

BIQ	SCARED-Total	SCARED-SP	SCARED-GAD	EATQ-Shyness	EATQ-Fear
120.16	18.78*	7.49*	5.64*	3.41*	2.79
16.65	*9.83*	*3.07*	*3.84*	*0.64*	*.71*

4.2 Training Effects on Interpretation of Ambiguous Information

See Table 2 for means and standard deviations for each separate interpretation measure and the composite scores.

Table 2. Means (*SDs*) of Interpretation Scores for Training Conditions by Time

	Interpretation Composite Score		**Threat Ending Option Scores**		**General Threat Outcomes**		**Anticipated Distress Scores**	
	Training Condition	Control Condition	Training Condition	Control Condition	Training Condition	Control Condition	Training Condition	Control Condition
Pre-Training[a]	.13 *(.74)*	-.14 *(.91)*	0.04 *(4.40)*	-2.18 *(4.70)*	-2.43 *(3.01)*	-3.36 *(4.68)*	2.34 *(0.44)*	2.31 *(0.46)*
Post=Training[a]	-.17 *(.73)*	.18 *(-.17)*	-3.74 *(3.88)*	-1.36 *(4.07)*	-4.35 *(4.03)*	-3.00 *(3.59)*	2.22 *(0.38)*	2.27 *(0.56)*
Follow-Up[b]	-.002 *(.85)*	-.01 *(.97)*	-1.71 *(5.12)*	-1.33 *(4.70)*	-5.14 *(3.82)*	-4.67 *(3.90)*	2.20 *(0.41)*	2.07 *(0.63)*

[a] *represents means of full sample (n = 45) ;* [b] *represents means of sub-sample (n= 29)*

All analyses on interpretation data were conducted on the square root transformed interpretation composite scores (untransformed values are reported in the ta ble). The composite score was calculated by averaging the standardized scores for each interpretation measure. Higher scores reflect greater threat interpretations.

Interpretation Composite Scores: Analyses of the interpretation composite scores revealed a main effect of Time, $F(1,42) = 4.23$, $p = .05$, partial $\eta 2 = .09$, which was qualified by a significant Time x Training Condition interaction, $F(1,42) = 9.95$, $p < .01$, partial $\eta 2 = .19$ (see Fig. 3). Simple effects reveal individuals in the training condition showed a significant reduction in their threat interpretation scores over time, $F(1,42) = 4.74$, $p = .035$, partial $\eta 2 = .10$. Interestingly, an opposite pattern was found in the control condition: threat interpretations increased over time, $F(1,42) = 5.21$, $p = .03$, partial $\eta 2 = .11$. Simple effects test also reveal no Training Condition differences before, $F(1,42) = 1.23$, $p = .27$, or after training, $F(1,42) = 2.50$, $p = .12$. No other effects were significant.

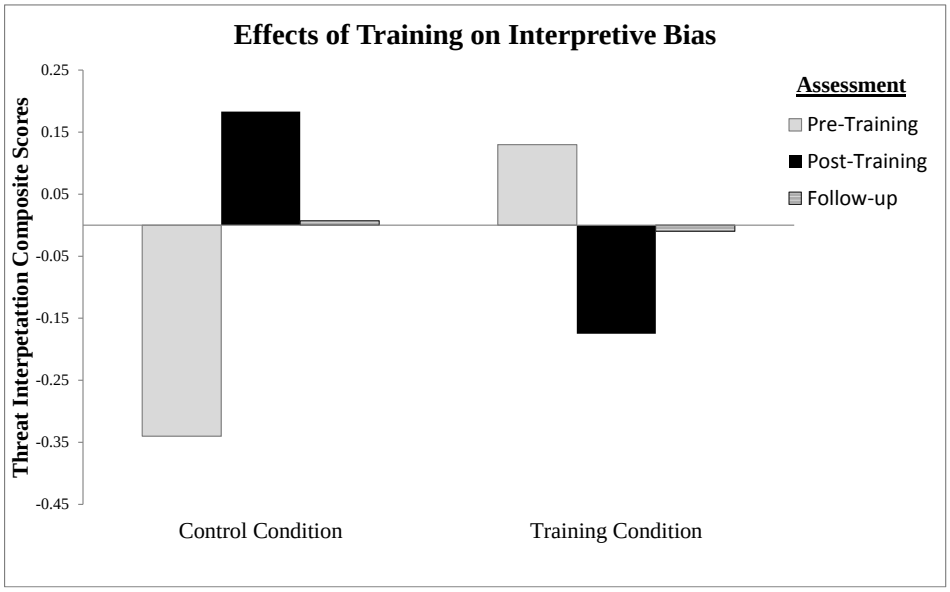


Figure 3. Interpretation scores as a function of Training Condition and time of assessment (pre-training, post-training, and follow-up). Displayed values are the non-transformed composite score. Larger positive values reflect greater threat interpretation scores.

These results revealed that the positive interpretation procedure significantly decreased threat interpretations in the training conditions. Interestingly, undergoing the control procedure increased threat interpretations. It

should be noted that the two conditions did not differ in their interpretation scores at either assessment.

4.3 Lasting Effects of Training on Interpretations

24 hour Follow-up: See Table 2 for means and standard deviations. For the follow-up analyses, results show no significant main effect of Time, F (1,25) <1. The Time x Training Condition interaction was also not significant, F (1,25) = 2.02, p = .17, partial η2 =.08 (see Fig. 3). No other effects were significant.

The above analyses reveal that training effects did not have lasting effects on participant's interpretations.

4.4 Training Effects on Mood and Emotional Vulnerability to Stress

See Table 3 for means and standard deviations for training conditions for each mood assessment.

Mood Rating Scores: Directly after the training procedure there was no effect of Training Condition on negative mood scales, Wilks' Lambda = .997, F(3,40) < 1. There was a trend effect of Training Condition on positive mood, F(1,42) = 3.60, p =.07, partial η2 =.08. Contrary to hypothesis, the control condition tended to have more positive affect compared to the Training Condition.

These analyses reveal that overall the training procedure had minimal effect on mood; however, there was a non-significant effect of higher post-training positive affect in the control condition.

Stress Vulnerability: Analyses of the negative affect scales reveal there was a main effect of Time, Wilks' Lambda = .42, F(6,36) =8.42, p < .001, partial η2

=.58, indicating that all participants increased in negative affect as a function of the stress task. There was no effect of Training Condition, Wilks' Lambda = .95, $F(3,39) < 1$, or Time x Training Condition, Wilks' Lambda = .81, $F(6,36) = 1.45$, $p = .22$, partial $\eta 2 = .20$.

Analysis on the positive affect scales reveal a main effect of Time, $F(2,80) = 10.54$, $p < .001$, partial $\eta 2 = .21$, indicating an overall decrease in positive affect over time. There was no effect of Training Condition, (1,40) = 1.87, $p = .18$, partial $\eta 2 = .05$, or Time x Training Condition, $F < 1$.

Table 3. Means (*SDs*) of Mood Scales for Training Conditions by Time

	Time of assessment							
	After New School Task		**Before to Speech Instructions**		**After Speech Preparation**		**After Speech**	
	Training Condition	Control Condition	Training Condition	Control Condition	Training Condition	Control Condition	Training Condition	Control Condition
Nervous/ Worried	5.36 *(6.49)*	5.72 *(7.04)*	2.17 *(2.53)*	4.45 *(7.47)*	12.13 *(9.73)*	12.55 *(11.09)*	11.68 *(9.99)*	12.29 *(10.69)*
Angry/ Frustrated	2.50 *(4.70)*	3.50 *(6.09)*	2.96 *(5.65)*	4.77 *(7.30)*	5.87 *(9.61)*	4.27 *(7.39)*	8.05 *(10.08)*	5.81 *(9.29)*
Sad/Depressed	1.82 *(2.68)*	2.68 *(5.18)*	2.36 *(4.67)*	1.82 *(3.79)*	1.83 *(2.57)*	2.5 *(5.17)*	6.55 *(9.67)*	2.38 *(4.73)*
Happy/Great	17.98 *(7.75)*	21.86 *(7.23)*	18.52 *(8.36)*	22.45 *(7.51)*	13.61 *(9.68)*	19.14 *(9.13)*	14.41 *(9.32)*	16.29 *(10.35)*

Mood analyses were conducted on log transformed data, but for interpretation the untransformed data are displayed.

Lastly, examination of participants negative self-evaluation score regarding their speech performance revealed that the Training Condition ($M = .24$, $SD = 1.57$) did not differ from the Control Condition ($M = -.24$, $SD = 1.9$), $F < 1$.

The above results suggest the speech task was successful in inducing stress: all participants showed increased stress response. However, effects of training condition on participant's response to stress were not detected.

4.5 Training Effects on Attention Bias Towards Threat

For means and standard deviations for attention bias scores see Table 4. Overall accuracy rate on the task was high ($M_{pre\text{-}training}$ = 96.74%, SD = 5.48%; $M_{post\text{-}training}$ = 96.11%, SD = 3.74%).

Table 4. Means (*SDs*) of Attention Bias Toward Threat for Training Conditions by Time

	Training Condition	Control Condition
Pre-Training	12.67 *ms* *(32.65)*	-3.71 *ms* *(33.88)*
Post-Training	9.35 *ms* *(38.34)*	-3.75 *ms* *(29.75)*

Analyses of the Attention Bias Scores revealed no main effect of Time, $F < 1$, or Time x Training Condition interaction, $F < 1$ (see Fig. 4). The main effect of Training Condition was significant at trend level, $F(1,41) = 3.65$, $p = .06$. This effect was not influenced by training. Examination of the means suggests that overall the training condition tended to display a larger attention bias towards threat compared to the control condition. Simple effects analyses revel that the two groups did not statistically differ in attention bias score at pre-training, $F(1,41) = 2.60$, $p = .11$, or post-training assessment, $F(1,41) = 1.53$, $p = .22$. No other effects were significant.

These results suggest that the interpretation modification procedure did not affect how threat was attended as assessed by the dot-probe task.

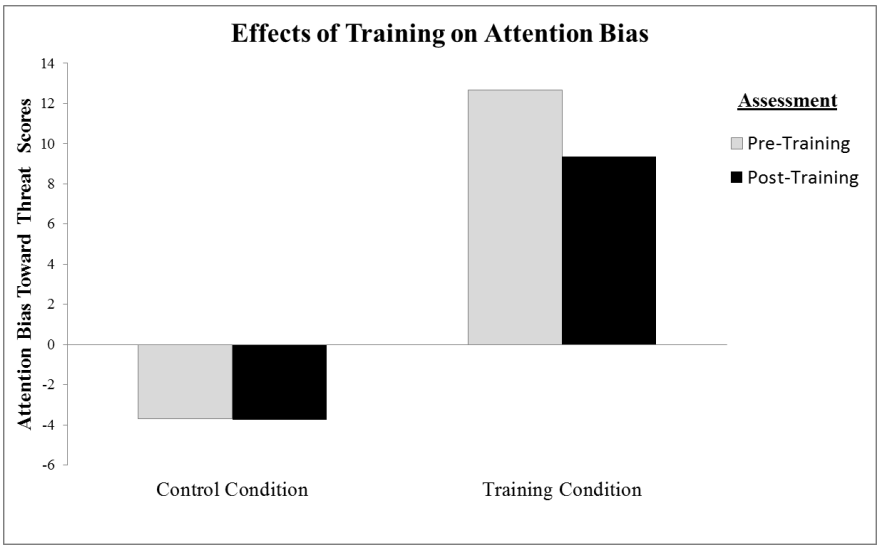


Figure 4. Attention bias scores as a function of Training Condition and time of assessment. More positive scores reflect a bias toward threat; negative score reflect a bias away from threat.

4.6 Relations between Interpretive Bias Change and Subsequent Training Effects

Looking within the training condition, the next set of analyses explored the relations between the level of interpretation change and the following variables: follow-up interpretations, mood, emotional vulnerability, and attention bias change. Results revealed that interpretive bias change was significantly correlated to follow-up interpretation scores, $r(14)=.57$, $p = .04$, and this correlation was significantly different than the control condition, Zs = 2.65, ps< .001; larger reductions in threat bias (greater negative change scores) were associated with lower threat interpretations at follow-up assessment.

Level of interpretation change in the training condition was not correlated to mood directly after training ($r_{\text{nervous}} =.18$; $r_{\text{sad}} =.29$; $r_{\text{frustration/anger}} =.26$; $r_{\text{happy}}=.03$, ps>.21) or emotional vulnerability ($r_{\text{nervous change score}} = -.28$; $r_{\text{sad change score}} = -.26$;

$r_{\text{frustration/anger change score}}$ = -.23; $r_{\text{happy change score}}$ =.29 and *p*s>.31). Additionally, interpretation change was not related to attention bias change, $r(23)$= -.05, p = .79.

These result show that the amount of bias change in the training condition (e.g., success of training) was significantly related to their interpretations one day after training: the larger the reduction in threat interpretations as a function of training the lower the follow-up threat interpretations scores. Magnitude of bias change was not significantly correlated to mood, emotional vulnerability to stress, or attention bias change.

Chapter Five: Discussion

The overarching goal of the current study is to examine the relations between interpretive bias and anxiety vulnerability in a group of behaviorally inhibited 9-12 year-old children. The current study aimed to 1) examine if threat interpretations could be experimentally reduced in behaviorally inhibited children through the use of a cognitive bias modification (CBM) procedure 2) investigate the effects of CBM on mood and emotional reactivity to stress in children and 3) explore the influence of CBM on attention allocation towards threatening information. To address these aims, the current study employed a CBM procedure in 45 high behaviorally inhibited children; half the children were trained to interpret ambiguity in a non-threatening manner, half received no training. Directly after training children in both conditions were assessed and compared on: interpretive bias, attention bias, mood, and emotional vulnerability to a stressor. Interpretive biases were reassessed one day following training.

In line with the initial hypothesis, findings from the current study showed that a single positive training session significantly decreased threat interpretations in behaviorally inhibited children. The decrease in threat interpretations, however, was not detected at the 24-hour post-training follow-up assessment. Unlike previous CBM reports in adults, the current study showed no effect of training on mood or emotional vulnerability to stress, nor did training affect attention biases towards threat. Although the current study demonstrates interpretations are malleable in behaviorally inhibited children, the findings did not provide support

for the hypothesis that interpretive biases are causally linked to a child's anxiety vulnerability. A more detailed discussion of the current findings, as well as their theoretical and practical implications, is presented below.

5.1 Modification of Threat Interpretations in Behaviorally Inhibited Youth

The current study demonstrates that threat interpretations can be significantly reduced in behaviorally inhibited children through the use of CBM. Prior to the current study, only two previous CBM studies have investigated interpretation modification in vulnerable youth populations; one investigation was in clinically anxious adolescents (Fu, et al., 2012) and the other was in non-clinical socially anxious children (Vassilopoulos, et al., 2009). Thus, the current finding is promising, adding to the extant work showing threat interpretation biases are amenable to change in children at-risk for anxiety. This finding is particularly noteworthy in light of previous CBM work that suggests threat-related biases may be easy to acquire in vulnerable populations, but hard to reduce (Muris, et al., 2008; Taylor, Bomyea, & Amir, 2011; White, in preparation).

Despite the robust CBM effects on post-training interpretations, the current study found no condition difference in interpretations at the 24-hour follow-up assessment. The lack of training effects detected at the follow-up assessment raises important questions about the transient nature of bias modification. The current study did find that larger training-related reductions in threat bias were related to lower threat interpretation scores at follow-up. This suggests that lasting effects may have been present, but limited to children who

showed the greatest training response. Besides the present study, all previous CBM work in youth assessed interpretation-related training effects on the same day as training administration; thus, the lasting effects of CBM in children are unclear and should be investigated further.

Interestingly, results from the current study also revealed a significant change in interpretive bias within the control condition: these children displayed a significant *increase* in their threat interpretations as a function of time. There are several possible reasons that could account for such bias change. First, this result could be a function of the feedback contingencies embedded in the study's control condition; for half of the training scenarios, children in the control condition received feedback congruent to the negative interpretation being *correct.* This level of negative interpretation feedback may have been sufficient to increase the frequency of threat interpretations in the behaviorally inhibited sample. In support of this explanation, previous research has shown that children with anxious or fearful temperaments show facilitated learning in regards to negative information (Field, 2006; Fulcher, Mathews, Mackintosh, & Law, 2001; Muris, et al., 2008). The behaviorally inhibited children may have been sensitive to the negative feedback trials in the control condition, and *learned* that the ambiguous scenarios ended in a negative way.

Alternatively, the change in bias detected in the control condition, as well as the change detected in the training condition, could simply be driven by the condition differences in interpretation scores at baseline. Although the current

findings should be interpreted with this caveat in mind, there are two points that can help address this limitation. First, the interpretation scores at baseline were not statistically significantly different. Second, the hypotheses of the current study were concerned with change in interpretation scores as a function of time to reflect the effect of the training procedure on bias. See section 5.4 for a more detailed discussion of this limitation.

Taken together, the current findings demonstrate that CBM is a useful method to reduce threat interpretations in behaviorally inhibited children; however, the findings also suggest that such training may be short-lived. Future research should continue to assess the lasting effects of bias modification and explore whether increased training sessions lead to long-term bias change in children.

5.2 Mood and Emotional Vulnerability

The current findings showed minimal effect of training on mood or emotional vulnerability to a stressor. The lack of support for the causal hypothesis may indicate that biases, especially in children, have minimal causal effects on emotion processing (Dodd, et al., 2012; Hallion & Ruscio, 2011; Salemink, van den Hout, & Kindt, 2009).

The results showed that the training conditions differed at trend level on positive affect scores directly after the training paradigm; no differences were detected in the negative affect scores. Contrary to the hypotheses, children in the control condition tended to have higher positive affect compared to children in the

training condition. Given the lack of mood assessment at baseline, it is difficult to determine if this mood difference was a function of the training paradigm, or if state mood effects existed prior to the training paradigm. Given the higher levels of attention bias toward threat and threat interpretations in the training condition at baseline, it is possible that these children had lower positive affect prior to training. Alternatively, the training paradigm could have had a direct effect on mood. The social nature of the scenarios may have represented a source of threat to some behaviorally inhibited children, thereby decreasing their positive affect. The fact that similar findings were not detected in the negative affect scores, coupled with the small effect size suggests that further research is needed to examine if such an effect is replicated.

The current findings also raise interesting questions regarding the roles development and population characteristics may have on the link between biases and anxiety vulnerability. Since most of the work substantiating the bias-anxiety link is in adults, the causal pathway may differ across development. A substantial number of developmental studies show no effect of age on threat-related processing biases (e.g., Ambrose & Rholes, 1993; J. Hadwin, Frost, & French, 1997; Moradi, Neshat Doost, Taghavi, Yule, & Dalgleish, 1999; Taghavi, Moradi, Neshat Doost, Yule, & Dalgleish, 2000). Nonetheless, a few studies have demonstrated that age significantly moderates the relation between processing biases and anxiety (Cannon & Weems, 2010; Weems, Berman, Silverman, & Saavedra, 2001). In a group of clinically anxious and non-referred youth between

the ages of 7 and 17 years, negative interpretive style was a significant independent predictor of clinical status; age was not (Cannon & Weems, 2010). However, the interaction between age and interpretative processing style was a significant predictor of clinical status. This study found that for children 11 years and older negative interpretive style significantly predicted anxiety diagnosis; this link was not seen in younger children. An earlier study by Weems et al. (2001) found similar results in a large sample of disordered youth. Although correlation analyses revealed significant relations between negative interpretive biases and self-reported anxiety for younger (6 to 11 year-olds) and older (12 to 17year-olds) ages, regression analyses revealed findings similar to Cannon and Weems in which age moderated the relation between bias and anxiety. If threat interpretations only contribute to individual differences in anxiety vulnerability in older children, the age range in the current study may have been too young to capture the causal relation.

Additionally, the majority of research demonstrating effects of interpretation modification on emotional vulnerability has been conducted in non-vulnerable adult populations. As such, the non-significant emotion effects in the current study could be due to the high emotional reactivity in the current sample; a heighted risk to experience intense levels of emotional reactivity, particularly during stress, may decrease the ability to detect training related emotional effects. This may be especially true in the current study given the emotional difficulty of the social stress task (i.e., a speech) for high behaviorally inhibited children. If the

effect of interpretations on emotional vulnerability is small (Hallion & Ruscio, 2011), the level of stress produced by the speech task may have eradicated any buffer effects of the positive training. Indeed, the previous CBM work showing effects of positive interpretation training on emotional vulnerability in children has assessed emotions in response to mildly stressful events (e.g., Vassilopoulos, et al., 2009). Thus, the buffer effects of positive training on emotional vulnerability may only be present in mild or ambiguous stress tasks.

Recent research also indicates that the effects of interpretation modification on emotions may be fairly constrained in nature; such 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 (i.e. the tasks employed to elicit emotional responses). In a series of experiments, Mackintosh, Mathews, Eckstein, and Hoppitt (in press) only found effects of interpretation training on emotional vulnerability to stressor if the training material was *related* to the stressor. Specifically, using a failure themed stress task, emotional effects were only found if the training material itself was failure themed (e.g., non-threatening interpretations of failure-related scenarios). Following this finding, we could speculate that the use of either performance-related ambiguous scenarios during training or implementation of a peer social-interaction stressor in the current study could have yielded significant emotion vulnerability results. Inconsistent emotional effects of interpretation modification (e.g., Lester, et al., 2011b; Salemink, et al., 2009) coupled with the above experiments by Mackintosh et al.

(in press), raise important questions about the specificity of training effects that should be addressed in future work.

The impact of CBM on an individual's emotional response may extend beyond negative affectivity. That is, the influence of positive interpretation training on emotions during a negative emotion-inducing task (i.e., stress task) may be minimal; such training may exert stronger influence during positive emotion inducing situations. In support of this notion, Grafton and Macleod (2012) found that positive attention bias training was related to positive emotional experience during a reward task. This study found that compared to individuals trained to avoid positive stimuli, individuals trained to attend to positive information reported greater increases in positive affect after a pleasant experience. In a recent commentary Mathews (2012) addressed this point, speculating that processing biases affect a wider scope of an individual's emotional reactions, likely shaping anxiety vulnerability in a multifaceted way.

Understanding the precise emotional effects in CBM work will improve our understanding of the relation between interpretive biases and individual differences in anxiety vulnerability. The claim that threat biases have broad negative emotional effects may need to be tempered, particularly in regards to children. Interpretive biases may have fairly specific effects on emotions and the relation with anxiety vulnerability may differ across development and temperaments. Out of the four longitudinal studies that have examined the prospective relation between negative interpretive bias and anxiety, none of the

studies found strong support that negative interpretive biases shape a child's anxiety vulnerability (Creswell & O'Connor, 2011; Creswell, Shildrick, & Field, 2011; Dodd, et al., 2012; Muris, et al., 2004). Indeed, the opposite pattern was true: anxiety predicted later negative interpretations. To fully understand the development of anxiety and identify if threat biases are in fact a risk factor for behaviorally inhibited children, more research on these relations is needed in children, especially in at-risk children.

5.3 Attention Bias Toward Threat

The current study found no effect of interpretation modification on attention bias toward threat. The current lack of support for a causal relation between interpretation and attention biases is in line with adult work in our laboratory (White et al., in prep), but fails to replicate two prior CBM training regimens (Amir, Bomyea, & Beard, 2010; White, et al., 2011). The failure to replicate could reflect limitations in the generalizability of bias modification to other cognitive processes. For example, CBM may only influence information processing of stimuli that are similar to that used in the training procedure. Amir and colleagues (Amir & Bomyea, 2010) used social words in both their attention bias and interpretation assessments, and White et al. reported that the attention bias towards threat training effects on interpretation were restricted to anxiety specific and not general negative interpretations. Moreover, Browning and colleagues (2012) found that attention-bias training did not generalize across different types of stimuli. Thus, similar to how training effects on emotions may

be dependent on the type of material used in the study, a similar stimulus dependent relation may be true for the effects of CBM on subsequent cognitive processing,

Alternatively, the relation between attention and interpretation may be small, limiting the level of influence each bias can have on the other. Although research suggests separate threat-related cognitive biases uniquely contribute to individual difference in anxiety in both children (Watts & Weems, 2006) and adults (Gotlib et al., 2004), these studies reveal weak (or non-existent) intercorrelations between threat-related cognitive biases. Despite models proposing that interpretation and attention stem from the same underlying processes (Mathews, Mackintosh, & Fulcher, 1997; Williams, et al., 1997), they might be independent processes that operate in parallel (Everaert, et al., 2012). However, the current study detected a significant negative correlation between interpretation and attention biases at baseline; increased threat interpretations were related to an attention bias toward threat. Given the dearth of work directly examining the correlations between attention and interpretative biases it is hard to reconcile this negative correlation with the current literature. There exists some work linking psychopathology to an attention bias away from threat (e.g., Pine et al., 2005; Salum et al., 2012; Wald et al., 2011). Thus, the tendency to interpret ambiguous information in a threatening manner may coincide with a tendency to avoid threat in behaviorally inhibited children; however, more research is needed to examine if such a pattern can be replicated.

Additionally, there may be measurement constraints in the current assessment of attention bias towards threat that contribute to the lack of CBM effects on attention. First, although the dot-probe is a widely used assessment of attention bias in both children and adults (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van, 2007), several investigations using the dot-probe have revealed no association between attention bias towards threat and anxiety or behavioral inhibition in children (Broeren, Muris, Bouwmeester, Field, & Voerman, 2011; Perez-Edgar, et al., 2011). Second, research has found little relation between dot-probe performance and different measurements of attention bias (e.g., emotional stroop, spatial cueing tasks: Dalgleish et al 2004) and test-retest reliability of the dot-probe tends to be low (Salemink, van den Hout, & Kindt, 2007; Schmukle, 2005). Lastly, children show great variation in RTs and bias scores on the dot-probe, as was seen in the current study, and because its dependence on RTs, the dot-probe task may not be an effective measure of attention biases in children (Broeren, Muris, Bouwmeester, Field, et al., 2011).

The current findings suggest that interpretive biases may not be causally linked to attention processes. Despite this, future work should move away from studying cognitive biases in isolation. Understanding interpretive and attention biases as separate, but possibly additive, processes may be an important step to fully understand *if* and *how* threat-related cognitive biases shape individual differences in anxiety vulnerability. It may also be important to examine how the relations between threat-related cognitive biases differ across development; the

relations between the two biases, and their joint contribution to anxiety, may fluctuate over time.

5.4 Limitations and Additional Considerations

The current results should be interpreted in light of the following limitations: first, the current study design only implemented one training session. The effects bias modification on emotions and attention may differ after more extensive bias training. Second, the standard deviations in interpretation and attention bias measures were high, indicating a wide spread of scores. Although such variance in cognitive bias measures in children is common, it may have led to reduced power in the current analyses. Third, the assessment of emotion via self-reported mood on an analogue scale may not have been sensitive enough to detect emotional effects of training. Fourth, there was high attrition (35%) at the follow-us assessment, making it harder to assess training effects at the follow-up assessment. Fifth, the current sample had more males than females and tended to be on the older end of our age range (M_{age} = 11.42). As such, the current study may have not been able to detect age and gender effects.

Although random assignment was used in the current study, children in the training condition started with larger threat-related biases in interpretation and attention compared to children in the control condition. Due to the random assignment design used in the current study, it was impossible to control for such pre-training differences. Future work could use a bias-match design for condition assignment so as to prevent any baseline group differences.

The method used to assess behavioral inhibition in the current study, as well as the time of assessment, should be considered when placing the current findings in the larger temperament literature. First, as opposed to the more traditional laboratory-based observational assessment, the current study used parental-reported behavioral inhibition to select a high behaviorally inhibited sample (for a detailed discussion of this issue see p. 7-9 of the current dissertation). Although laboratory observations of BI have been shown to significantly relate to parent-reports of BI (e.g., Bishop, et al., 2003; Fox, et al., 2001; Garcia-Coll, et al., 1984), there may be significant differences between children identified as highly behavioral inhibited in toddlerhood via laboratory observations and children identified as highly behaviorally inhibited via concurrent parent-reports (as is the case in the current sample). For example, the manifestation of BI in middle childhood may be heavily influenced by other external factors (e.g., oversolicitous parenting, increased peer rejection) and the underlying biological profiles of these two groups may be different. These differences may impact factors such as the bias malleability and the contribution of a cognitive bias to anxiety.

5.5 Conclusions and Future Directions

The current study has implications for prevention research. Theoretical and empirical work (Beard & Amir, 2008, 2010; Mathews & MacLeod, 2002) would suggest that reducing threat interpretations in populations at increased risk for anxiety, such as behaviorally inhibited children, may reduce such risk. In fact,

research implementing CBM as a treatment for adult anxiety is wide spread (for review see: Beard, 2011; Hallion & Ruscio, 2011; MacLeod & Mathews, 2012); thus, it is not surprising that CBM has become an attractive prospect for prevention research (March, 2010). The current findings, however, coupled with previous CBM work in anxious adolescents (Fu, et al., 2012), suggest that CBM may not be an effective tool to prevent anxiety in youth. Further support for this conclusion is offered from prospective research that reveals weak associations between threat interpretations and later anxiety vulnerability (Creswell & O'Connor, 2011; Creswell, et al., 2011; Dodd, et al., 2012; Muris, et al., 2004). In sum, more research is needed before interpretation based CBM can be effectively implemented in prevention and intervention work.

There are likely internal (e.g., attention control, emotional regulation) and external (e.g., parenting) factors that play an important role in the relations between temperament, threat biases, and anxiety vulnerability. Future CBM work should take into account how these factor influences the emotional and cognitive effects of bias modification. For example, experimental work has shown that a mother's own negative interpretive bias regarding unfamiliar information a) extends their child's environments (Lester, Field, & Cartwright-Hatton, 2012) b) directly shapes their child's fears (Muris, van Zwol, Huijding, & Mayer, 2010; Remmerswaal & Muris, 2011) and c) creates threat-related processing bias regarding the unfamiliar information in their children (Remmerswaal, Muris, Mayer, & Smeets, 2010). Thus, a promising avenue of research is to target

maternal interpretative bias in at risk children; reducing the mother's threat bias, in addition to the child's bias, may lead to more significant, lasting reductions in threat interpretations.

In sum, through the use of CBM, the current study demonstrated a reduction in threat interpretations in a group of behaviorally inhibited children. Children trained to interpret emotional ambiguity in a positive manner showed a decrease in threat interpretations after training. The study showed that bias modification had no impact on subsequent anxiety-related cognitive or emotional processing. The current findings, taken with the above discussion, highlight the need for continued investigation into the relations between interpretations and anxiety in children. The existing evidence suggests that the causal relations between interpretive biases and anxiety may be quite different for children as they are for adults. To better understand these relations in children, future CBM research should systematically explore: how relations between threat biases and anxiety vulnerability differ as a function of age and temperament; CBM effects on both positive and negative emotional reactions; and the differential effects that extended training sessions and training materials have on the effectiveness of bias modification. Additionally, the current CBM findings highlight the need for more longitudinal work that examines the stability of interpretive bias across development and explores the interactions between age, temperament, and anxiety vulnerability.

Appendices

Appendix A:
Item from the Behavioral Inhibition Questionnaire (Parent Form)

1. Approaches new situations or activities very hesitantly
2. Will happily approach a group of unfamiliar children to join in their play
3. Is very quiet around new (adult) guests to our home
4. Is cautious in activities that involve physical challenge (e.g., climbing, jumping from heights)
5. Settles in quickly when we visit the homes of people we don't know well
6. Enjoys being the center of attention
7. Is comfortable asking other children to play
8. Is shy when first meeting new children
9. Happily separates from parent(s) when left in new situations for the first time (e.g., school)
10. Is happy to perform in front of others (e.g., singing, dancing)
11. Quickly adjusts to new situations (e.g., kindergarten, preschool, childcare
12. Is reluctant to approach a group of unfamiliar children to ask to join in
13. Is confident in activities that involve physical challenge (e.g., climbing, jumping from heights)
14. Is independent
15. Is very quiet with adult strangers
16. Seems comfortable in new situations
17. Is very talkative to adult strangers
18. Is hesitant to explore new play equipment
19. Gets upset at being left in new situations for the first time (e.g., school)
20. Is very friendly with children he or she has just met
21. Tends to watch other children, rather than join in their games
22. Dislikes being the center of attention
23. Is clingy when we visit the homes of people we don't know well
24. Happily approaches new situations or activities
25. Is outgoing
26. Seems nervous or uncomfortable in new situations
27. Happily chats to new (adult) visitors to our home
28. Takes many days to adjust to new situations (e.g., school)
29. Is reluctant to perform in front of others (e.g., singing, dancing)
30. Happily explores new play equipment

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