Child Development, January/February 2017, Volume 88, Number 1, Pages 141–155

Developmental Relations Among Behavioral Inhibition, Anxiety, and Attention Biases to Threat and Positive Information

Lauren K. White
Children's Hospital of Philadelphia

Kathryn A. Degnan
Catholic University

Heather A. Henderson
University of Waterloo

Koraly Pérez-Edgar
The Pennsylvania State University

Olga L. Walker
University of Maryland, College Park

Tomer Shechner
University of Haifa

Ellen Leibenluft
National Institute of Mental Health

Yair Bar-Haim
Tel Aviv University

Daniel S. Pine
National Institute of Mental Health

Nathan A. Fox
University of Maryland, College Park

This study examined relations between behavioral inhibition (BI) assessed in toddlerhood (n = 268) and attention biases (AB) to threat and positive faces and maternal-reported anxiety assessed when children were 5- and 7-year-old. Results revealed that BI predicted anxiety at age 7 in children with AB toward threat, away from positive, or with no bias, at age 7; BI did not predict anxiety for children displaying AB away from threat or toward positive. Five-year AB did not moderate the link between BI and 7-year anxiety. No direct association between AB and BI or anxiety was detected; moreover, children did not show stable AB across development. These findings extend our understanding of the developmental links among BI, AB, and anxiety.

Behavioral inhibition (BI) is a temperament characteristic identified in early childhood, marked by heightened negative reactivity and vigilance toward novel and unfamiliar people and situations (Fox, Henderson, Rubin, Calkins, & Schmidt, 2001; Kagan, Reznick, & Snidman, 1987). Over the course of development, children identified as behaviorally inhibited in early childhood tend to display high rates of social reticence, social rejection, and anxiety-related behaviors (Fordham & Stevenson-Hinde, 1999; Walker, Henderson, Degnan, Penela, & Fox, 2014). Most notably, early identified BI is one of the strongest developmental predictors of anxiety disorders in later childhood or adolescence (Chronis-Tuscano et al., 2009; Prior, Smart, Sanson, & Oberklaid, 2000). A recent meta-analysis revealed that nearly half of individuals who express high levels of BI in childhood will develop an anxiety disorder sometime in their life, a fourfold increase in risk over individuals with no history of BI (Clauss & Blackford, 2012). Despite the significant association between BI and the emergence of anxiety symptoms, not all behaviorally inhibited children go on to develop anxiety. Therefore, it is important to identify moderating factors that shape the developmental outcomes associated with BI.

Differences in children's allocation of attention to sources of threat and danger may moderate risk for anxiety in behaviorally inhibited children. Previous work documents a link between a bias toward threat and anxiety in children (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & Van

This research was supported by grants from the National Institutes of Health (MH074454 and HD17899) to Nathan A. Fox. We would like to thank all the children and parents for their participation in this study. We would also like to acknowledge all the research assistants for their contributions.

Correspondence concerning this article should be addressed to Lauren K. White, Department of Child and Adolescent Psychiatry and Behavioral Sciences, Children's Hospital of Philadelphia, 3440 Market Street, Suite 410, Philadelphia, PA 19104. Electronic mail may be sent to whitelk@email.chop.edu.

© 2016 The Authors
Child Development © 2016 Society for Research in Child Development, Inc.
All rights reserved. 0009-3920/2017/8801-0012
DOI: 10.1111/cdev.12696

IJzendoorn, 2007). Initial reports suggest that children and adolescents with a history of BI who display a threat bias show more anxiety-related behaviors than their inhibited peers who do not display an attention bias to threat (Pérez-Edgar et al., 2010, 2011). However, there is a paucity of work examining the developmental trajectories of attention bias and only concurrent associations have been established between attention bias and anxiety. Little research examines the predictive role of attention biases at one time point on a child's anxiety at a later time point. Thus, it remains unclear if attention bias to threat in childhood prospectively predicts risk for anxiety for children with a history of BI. To advance theoretical and empirical understanding of the conditions under which BI is related to the development of anxiety, as well as the predictive role attention biases play in the development of anxiety, this study used prospective assessments of BI, anxiety, and attention to examine how a child's anxiety in middle childhood is influenced by their current and former pattern of attention biases and temperament.

Attention Bias to Threat and Anxiety in Children

Compared to their non-anxious counterparts, anxious individuals tend to preferentially allocate their attention to potential sources of threat in their environment (Bar-Haim et al., 2007). This attention bias to threat is often assessed using a dot-probe task in which anxious individuals tend to be faster to respond to a probe when it is in the location of a previously viewed threatening stimulus, compared to when the probe is in the location of a previously viewed neutral stimulus. Most prominent cognitive models of anxiety view threat-related attention biases as a central pathophysiological mechanism of anxiety (e.g., Beck & Clark, 1997; Mathews & Mackintosh, 1998; Williams, Watts, MacLeod, & Mathews, 1997); however, to date, most of the work examining associations between anxiety and attention bias to threat has been conducted in adult populations. In the extant developmental literature, there are a handful of large-scale studies that document an attention bias to threat in youth with anxiety and internalizing problems (e.g., Roy et al., 2008; Salum et al., 2013). For example, in a large group (n = 152) of 7- to 17-year-old youth, Roy et al. (2008) found that children diagnosed with generalized anxiety, social phobia, and separation anxiety disorders displayed an attention bias to threat; no such bias was found in the nonanxious youth. Moreover, a meta-analysis of attention bias literature (Bar-Haim et al., 2007) found that the effect size of attention bias to threat in anxious youth paralleled the effect size of that found in anxious adult populations. Also, research in youth documents an association between attention bias to threat and nonclinical levels of anxiety (Salum et al., 2013; Watts & Weems, 2006) and fearful temperaments (Szpunar & Young, 2012). In a large group of 6- to 12-year-old children (n = 1,411) without psychopathology, Salum et al. (2013) found that children with higher levels of internalizing problems displayed a significantly greater attention bias to threat than their nonanxious counterparts with low internalizing problems. Szpunar and Young (2012) found a positive association between self-reported levels of BI and attention bias to threat in a group of 8- to 14-year-olds.

Attention bias to threat is often considered more than an epiphenomenon, reflecting a simple by-product of an anxious or hypervigilant state (Mathews & Macleod, 2002; Van Bockstaele et al., 2014; White, Helfinstein, & Fox, 2010). Rather, the presence of a threat bias is thought to increase an individual's anxiety vulnerability, playing a role in the emergence, expression, and maintenance of anxiety (e.g., Mathews & Macleod, 2002). Supporting this notion, developmental work has documented positive relations between the magnitude of a child's attention bias to threat and their anxiety severity (Waters, Henry, Mogg, Bradley, & Pine, 2010; Waters, Mogg, Bradley, & Pine, 2008). In addition, several cognitive bias training studies have reported that an induction of an attention bias to threat in nonanxious individuals increases their subsequent susceptibility to experience anxiety (Eldar, Ricon, & Bar-Haim, 2008; Macleod, Rutherford, Campbell, Ebsworthy, & Holker, 2002) and a reduction in a threat bias decreases such susceptibility in anxious individuals (Amir et al., 2009). However, prospective assessments during early development that chart trajectories of both attention and anxiety are needed to elucidate the role of attention bias in the *development* of anxiety (Morales, Pérez-edgar, & Buss, 2014; Shechner et al., 2012); to date, little work has examined these longitudinal associations. Understanding these associations early in development is particularly important as anxiety arises in a developmental context; processes operating early in life might exert particularly powerful effects on anxiety trajectories. Attention bias might represent one particular process that powerfully shapes early life trajectories.

Despite the work supporting a causal link between attention bias and anxiety, the findings in

the extant developmental work on anxiety and attention bias to threat have been mixed. In two recent studies (Salum et al., 2013; Waters, Bradley, & Mogg, 2014), some youth with anxiety disorders displayed significant biases away from threat. This bias away from threat has also been reported in children with fearful temperaments (Morales et al., 2014). Several studies have failed to find evidence of a threat-related attention bias in anxious youth (Waters et al., 2008) or fearful temperaments (Broeren, Muris, Bouwmeester, Field, & Voerman, 2011; Pérez-Edgar et al., 2011) and several studies have documented a significant attention bias to threat in all children, regardless of anxiety status (Waters, Lipp, & Spence, 2004). Moreover, there are cognitive training studies in adults and children that found no link between change in attention bias and anxiety (e.g., Hallion & Ruscio, 2011; Shechner et al., 2014).

These inconsistent findings have been attributed to differences in diagnostic criteria, method of attention bias and anxiety assessment, age, and other developmental factors. For example, it has been suggested that anxiety-related attention biases to threat become more prevalent as children get older (Vasey & Macleod, 2001). Others suggest that all children initially display a bias to attend threat, but only the anxious children fail to inhibit this bias later in development (Field & Lester, 2010). However, in large studies, including children 7–18 years of age (Roy et al., 2008) and 6–12 years of age (Salum et al., 2013), there was no association between age and attention bias scores. To inform the investigation of the role attention biases have in anxiety in youth and address these inconsistencies in the literature, longitudinal work, like this study, that examines the developmental patterns of attention bias to threat and its association with anxiety at different points in development is needed (Morales et al., 2014; Van Bockstaele et al., 2014). This study examined associations between threat-related attention biases and anxiety during early (5 years of age) and middle (7 years of age) childhood.

Influence of Attention Bias to Threat on the Developmental Link Between BI and Anxiety

If threat-related attention biases do play a role in the development of anxiety, understanding how these biases affect the development of anxiety in vulnerable populations is particularly important. In children with the temperament of BI, preferential allocation of attention to threat cues in the environment may be one factor that exacerbates fear-related responses and/or increases the risk for anxiety-related outcomes later in development (Fox, Henderson, Marshall, Nichols, & Ghera, 2005; Morales et al., 2014; White et al., 2010). To date, few studies have examined this hypothesis. Pérez-Edgar et al. (2010) found that adolescents with a history of BI who had greater concurrent attention biases to threat displayed higher levels of anxiety-related behaviors than adolescents with a history of BI but no attention bias. Similar findings emerged in a younger cohort. In 5-year-olds, attention bias to threat moderated the link between early BI and concurrent anxiety-related behaviors (Pérez-Edgar et al., 2011). Specifically, BI most strongly predicted anxious avoidance for children who displayed an attention bias to threat; in contrast, for children with an attention bias away from threat, there was no link between BI and anxiety. In a group of 6-year-old children, attention bias to threat was related to high levels of social withdrawal, but only for children who identified as having high levels of dsyregulated fear in toddlerhood (Morales et al., 2014). Taken together, these studies suggest that attention bias to threat is an important factor to understanding anxiety trajectories in children with a history of fearful temperament characteristics.

A limitation of these prior studies is that attention biases and anxiety-related problems were assessed concurrently; as such, prior findings could reflect multiple pathways linking attention bias to anxiety across development. For example, such findings could reflect a direct, causal association between threat biases at one point in time and either the onset or maintenance of individual differences in anxiety at later points in time. Alternatively, attention bias to threat may only influence current levels of anxiety, having little influence on anxiety at later points in time. Finally, such findings could reflect less direct associations, whereby attention biases only shape risk for anxiety in children with particular temperamental dispositions. For example, attention-related threat biases may modify a behaviorally inhibited child's negative temperamental reactivity, but may show different associations with anxiety among children with different temperaments. These and other pathways could generate findings observed previously in cross-sectional research. However, longitudinal research, such as this study, can clarify which of these pathways seems most plausible, thereby informing understandings of developmental associations among attention bias to threat, anxiety, and temperament.

This longitudinal study examined prospective and concurrent associations among threat-related

attention biases, early identified BI, and anxiety across multiple points in development. This study extends previous work in the same sample (Pérez-Edgar et al., 2011) that examined the concurrent relations between attention biases and anxiety problems at age 5. The goal of this study was to examine whether attention biases at ages 5 and 7 moderated the link between early identified BI and anxiety when the sample was reassessed 2 years later at age 7.

Attention Bias to Positive Information and Anxiety in Children

Although far less studied than attention bias to threat, attention bias to positive stimuli may also relate to anxiety in children and adults (Shechner et al., 2012; Taylor, Bomyea, & Amir, 2010). Recent work in adult populations suggests that increased attention bias to positive information is associated with decreased anxiety and emotional vulnerability to stress (Johnson, 2009; Taylor, Bomyea, & Amir, 2011) and increased positive affect (Grafton, Ang, & MacLeod, 2012). Moreover, a recent treatment study in clinically anxious children revealed that training children to attend to positive information decreased anxiety (Waters, Pittaway, Mogg, Bradley, & Pine, 2013). Prior empirical work has also shown that a positive attention bias moderated the risk between early social deprivation and maladaptive outcomes (Troller-Renfree, McDermott, Nelson, Zeanah, & Fox, 2014) and youth with a history of BI and low levels of anxiety displayed a larger attention bias to positive than BI youth with high anxiety (Shechner et al., 2012). Taken together, attention allocation toward positive cues, such as happy faces, may also influence the emergence and/or expression of a child's anxiety vulnerability across development; positive attention biases may be a protective factor against the development of anxiety.

The association between anxiety and positive attention biases, however, is not well understood, particularly in the context of BI. In fact, similar to the inconsistent findings with threat biases, the extant work in children finds mixed results on the associations between positive attention biases and anxiety. Several studies have found no direct relation between attention bias to positive stimuli and anxiety (Roy et al., 2008; Waters et al., 2010) or BI (Pérez-Edgar et al., 2011), and one study found reduced positive bias in adolescents with a history of BI (Pérez-Edgar et al., 2010). Some developmental work has reported a significant positive attention bias in all children, regardless of anxiety (Waters et al., 2010, 2014), and one study has documented a greater attention bias to positive stimuli in severely anxious youth (Waters et al., 2008). To add to the existing research examining positive attention biases, this study conducted exploratory analyses to examine the developmental patterns of positive attention bias and its association with BI and anxiety.

Study Overview

This study used a longitudinal design to investigate the developmental associations among BI, attention bias to threatening and happy facial expressions of emotion, and anxiety. BI was assessed in children during toddlerhood, a time when stable individual differences in this temperament style first appear (Fox et al., 2001). Attention bias and anxiety were assessed when the children were 5 and 7 years of age and associations among the variables were examined. Next, this study examined whether BI and age 5 attention biases to threat alone or in combination (i.e., attention bias as a moderator of the BI–anxiety link) predicted anxiety at age 7. Following, BI and attention biases to threat at age 7 were examined alone and in combination in relation to 7-year anxiety. Lastly, similar analyses were conducted to explore the direct associations between positive biases and anxiety, as well as the moderating effects of positive attention biases on the link between early identified BI and anxiety.

Consistent with previous research, it was hypothesized that attention bias to threat would be associated with anxiety across development and would significantly influence the developmental associations between BI and anxiety. It was predicted that in addition to BI, children's attention bias to threat at age 5, as well as concurrent attention bias at age 7, would significantly predict anxiety at age 7, even after controlling for anxiety at age 5. In addition, it was hypothesized that previous and concurrent attention bias would both moderate the association between BI and anxiety at age 7, where larger attention biases to threat would be positively associated with anxiety and increase the link between BI and anxiety at age 7. Although there exists much less research on attention biases to positive information, it was hypothesized that attention bias to positive stimuli would be negatively related to anxiety and such positive bias would decrease the developmental link between BI and anxiety.

Method

Participants

Participants were a subset of 291 children (135 males, 156 females) selected in infancy for an ongoing, longitudinal study on temperament and socioemotional functioning conducted in a large metropolitan area of the Mid-Atlantic region of the United States (for a detailed description of the recruitment and screening procedures for the larger longitudinal study see Hane, Fox, Henderson, & Marshall, 2008). Data collection for this longitudinal study began in 2001. Of the original sample, the sample demographics were 64.3% White, 14.1% Black, 3.4% Hispanic, 2.1% Asian, 1.4% other, and 14.7% multiracial. English was spoken in the majority of households (98%). Information on family income was not collected for the sample; however, mothers in the sample were at least college educated (84.4%) or high school graduates (15.6%).

Of the 291 children, 268 were assessed at the ages of 2 and 3 years for BI, 207 completed the attention bias assessment at age 5, and 174 completed the attention bias assessment at age 7. The mean age at each assessment was as follows: 2-year visit, $M = 26.08$ months, $SD = 2.21$; 3-year visit, $M = 36.82$ months, $SD = 1.56$; 5-year visit: $M = 63.11$ months, $SD = 3.85$; 7-year visit, $M = 91.66$ months, $SD = 2.68$. There were anxiety ratings for 225 children at the 5-year visit and 188 children at the 7-year visit. In addition to standard attrition, attention bias assessments were missing on children because they refused to complete the attention bias assessment task ($n = 4$ at 7 years), there were technical difficulties ($n = 3$ at 5 years, $n = 4$ at 7 years), or experimenter error ($n = 1$ at 7-year). The children who were missing data on at least one variable did not differ from the other children in terms of ethnicity, $\chi^2(4, N = 291) = 3.59$, $p = .46$, maternal education, $\chi^2(1, N = 291) = 0.54$, $p = .46$, or gender, $\chi^2(1, N = 291) = 2.56$, $p = .11$. In addition, children with missing data did not differ from those without missing data on BI scores, anxiety measures, or attention bias scores (all ps $> .17$).

BI Composite Score

BI was assessed via laboratory assessment and parent report when children were 2 and 3 years of age (Lahat et al., 2014; Lamm et al., 2014; Walker et al., 2014). These two methods were combined to yield a reliable and robust measure of BI across toddlerhood. The laboratory assessment of BI consisted of children's reactions to a variety of unfamiliar social and nonsocial stimuli. These stimuli included an interaction with an unfamiliar adult and introduction to a series of novel, unfamiliar objects (for additional details on laboratory observations and behavioral coding refer to Fox et al., 2001; Kagan et al., 1987). Behaviors coded from these interactions included latency to approach the unfamiliar adult and touch the novel toy, latency to vocalize, and proximity to mother during each event. The respective interrater reliability of the aforementioned behavior codes across the social and nonsocial stimuli ranged from .75 to .95 for the 2-year assessment and .97 to .99 for the 3-year assessment. In addition, the intraclass correlations of these behavior codes across interaction ranged from .84 to .89 at the 2-year assessment and .96 to .97 at the 3-year assessment. Maternal report of BI included ratings on the Social Fear Scale of the Toddler Behavior Assessment Questionnaire (Goldsmith, 1996). The scale was of particular interest to the construct of BI as it assesses children's fears to unfamiliar adults and contexts (Goldsmith, 1996). The laboratory assessment and parent report of BI were strongly correlated, $r = .44$, $p < .001$. BI scores across behavioral and maternal report measures were standardized at each age point and averaged together to create an index of BI ($N = 268$; full longitudinal sample: $M = -0.01$, $SD = 0.77$, range = -1.92–2.29). This composite represents a statistically cohesive composite (see Walker et al., 2014). Higher scores on the composite reflect higher levels of BI.

Attention Bias Assessment

Two variations in the dot-probe task were administered at 5 and 7 years of age to assess children's attention biases. These versions were based on dot-probe tasks previously used with young children (Eldar et al., 2008; Pérez-Edgar et al., 2010). At each age, a fixation cross was presented in the center of the screen followed by a display of faces. Each display consisted of two facial expressions aligned horizontally. For each face display a neutral facial expression was always paired with an angry, happy, or another neutral facial expression modeled by the same actor. Angry facial expressions, signifying potential danger, were used to capture attention bias to threat; happy facial expressions were used to capture attention bias to positive information. Facial images were taken from the NimStim face stimulus set (Tottenham et al., 2009: facial expression from actors 1–3, 5–29, and 31–43 were used across

task versions). At the 5-year assessment, there were 32 angry–neutral trials, 32 happy–neutral trials, and 16 neutral–neutral trials which were included as filler trials. For each trial the fixation appeared for 500 ms followed by the face pair for 500 ms. The probe was an asterisk that remained on the screen for 2,500 ms. Children were asked to indicate the probe's location (right or left) via button press. At the 7-year assessment, the trial count was doubled; there were 64 angry–neutral, 64 happy–neutral, and 32 neutral–neutral trials. For each trial the fixation appeared for 1,000 ms followed by the face pair for 500 ms. To increase the difficulty of the task for the 7-year-old children, the probe consisted of an arrow, oriented either up or down, that appeared for 300 ms. Children were asked to indicate the probe's orientation via button press and had up to 1,700 ms to respond.

Dot-probe reaction time (RT) and accuracy data were cleaned and processed using standard cleaning methods (Eldar et al., 2008; Pérez-Edgar et al., 2011; White, Suway, Pine, Bar-Haim, & Fox, 2011). First, incorrect trials and trials with RTs < 200 ms were excluded from analyses. Next, RTs were averaged across each trial condition (e.g., incongruent angry, congruent happy, etc.) for each participant separately for the two assessments and RTs ± 2 *SD*s of each condition were removed from analyses. Children who had poor task performance (indexed by accuracy rates < 65%: $n = 26$ at 5 years, $n = 63$ at 7 years) were excluded from the current analyses. Similar accuracy cutoffs have been used in previous dot-probe studies (e.g., Perez-Edgar, 2010). The cleaned RTs from the angry–neutral and happy–neutral trials were used to create attention bias to threat and positive scores. These scores were calculated by subtracting RTs for trials in which the probe appeared in the location of the emotion face (i.e., congruent trials) from RTs on trials in which the probe appeared behind the neutral face (i.e., incongruent trials). Positive scores indicate an attention bias to threat (or positive); negative scores indicate an attention bias away from threat (or positive). Threat and positive bias scores at each assessment point were then examined for outliers, defined as ± 2.5 *SD* of the mean bias score for each assessment point. Bias outliers were removed from the data. Specifically, two 5-year and three 7-year attention bias to positive scores were determined to be outliers. Six 5-year and two 7-year attention bias to threat scores were deemed outliers.

Anxiety Ratings

Children's anxiety was assessed via the anxiety scale of the Child Behavior Checklist (CBCL) at age 5 (CBCL/1.5–5; Achenbach & Rescorla, 2001) and age 7 (CBCL/6–18; Achenbach & Rescorla, 2001). The CBCL is a parent report questionnaire used to assess social and emotional functioning of young children. For each item in the checklist, the child's primary caregiver was asked to rate from 0 to 2 how well each item describes their child (0 = *not true*; 1 = *somewhat/sometimes true*; 2 = *very/often true*). Items from the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM*)-oriented anxiety subscale (e.g., child's level of nervousness and worry, number of children's fears) were summed to create an anxiety score for each child at each assessment point. The six-item scale has been shown to have good reliability (Ferdinand, 2008) and concurrent validity (Ebesutani et al., 2010). Raw scores (sum of all items) were used in the current analyses to maximize variability. The Anxiety scores ranged from 0 to 12 at the 5-year assessment and 0 to 9 at the 7-year assessment. Most previous dot-probe work, particularly in children, relies on *DSM*-based approaches to classification. Thus, using *DSM*-oriented scales allows the findings of this study to be more easily compared with findings from prior research on attention biases in children. Moreover, to target anxiety problems specifically as assessed in the *DSM*, the anxiety scale was used instead of the broadband internalizing scale for the present analyses. However, in the current sample the concurrent CBCL internalizing composite was significantly correlated with the anxiety scale at age 5 ($r = .75$, $p < .001$) and age 7 ($r = .76$, $p < .001$).

Statistical Analyses

First, preliminary analyses examined associations between gender and age on key study variables. Next, preliminary statistics involving attention bias scores at each age were examined, followed by correlation analyses across key study variables.

To address the main aims of the study and account for missing data across the longitudinal study, a series of linear regression models were tested in a structural equation modeling framework with maximum likelihood estimation (MLE) for all participants with data on one or more variables using M*plus* 7.11 (Muthen & Muthen, 1998–2011). This analysis estimates the log likelihood of each model for the dependent measure (7-year anxiety symptoms), conditional on the independent variables (5-year anxiety, accuracy, BI, attention bias,

BI × Attention Bias). In addition, auxiliary variables indicating reasons for missing data at 5 and 7 years (nonmissing, missing at random, or attention bias outlier) were included to inform the MLE and minimize parameter estimate biases (Asparouhov & Muthen, 2008). Accuracy scores on the task were included as a covariate in all analyses because children's performance on the dot-probe task at each age was used to filter the bias scores. To control for the effects of previous anxiety symptoms, 5-year anxiety was also included as a covariate. Similar to traditional regression analysis, all independent variables were assumed to be intercorrelated. Means and variances of all continuous variables were estimated in the model to allow for missing data among these measures. Regression models were conducted to explore the relations among BI, attention biases to threat or positive stimuli, and anxiety. All predictor variables were mean centered to reduce multicollinearity and aid in interpretation. Interaction terms were computed as the product of two mean-centered variables.

The first model examined the prospective effects of BI and previous attention bias to threat on 7-year anxiety. Variables were entered into the model in the following order: 5-year anxiety scores, 5-year attention bias accuracy, BI, and 5-year attention bias to threat scores. To examine the moderating effect of 5-year attention bias to threat on the link between BI and anxiety, the interaction term of BI by 5-year attention bias to threat was then entered into the model. A similar model was examined for attention bias to threat at age 7, substituting 7-year attention bias and accuracy for 5-year attention bias and accuracy. Lastly, a set of exploratory analyses was conducted to examine the relations among attention bias to positive information, BI, and anxiety. Significant moderations were probed and plotted according to the guidelines by Aiken and West (1991). Attention bias variables (e.g., 7-year attention bias to threat) were recentered to represent attention bias away = −1 *SD* and attention bias toward = +1 *SD* threat/positive. These recentered scores, as well as the attention bias scores at zero were used to probe the relation between BI and anxiety at different levels of attention bias.

Results

Descriptive Statistics and Intercorrelations of Key Study Variables

Descriptive statistics for study variables assessed at 5 and 7 years of age are reported in Table 1.

Table 1
Mean Anxiety Ratings, Attention Bias Scores, and Dot-Probe Accuracy Rates by Age

	M score		*SD*	
Variable	5-Year olds	7-Year olds	5-Year olds	7-Year olds
Anxiety ratings	2.40	1.42	2.19	1.70
ABT	−9.44	−6.98	106.21	71.98
ABP	−4.26	7.72	122.34	65.15
Accuracy rates, %	90	80	8.0	8.5

Note. ABT and ABP scores are based on differences in reaction times between threat (positive) incongruent and threat (positive) congruent trials on the dot-probe task (in ms). Bias scores greater than zero represent a tendency to attend toward the emotion (threat or positive). Bias scores below zero represent a bias to attend away from the emotion (threat or positive). The table does not include participants removed from data due to poor performance on the dot-probe task. ABT = attention bias to threat; ABP = attention bias to positive.

Preliminary analyses showed no gender differences on BI, attention bias scores, or anxiety (all *p*s > .14). Preliminary analyses also showed no relations between age at the time of assessment (in months) and attention bias scores or anxiety ratings (all *p*s > .2). As such, neither gender nor age was included as covariates in subsequent analyses.

At the 5-year assessment, mean attention bias to threat, $t(173) = 1.17$, $p = .24$, and mean attention bias to positive, $t(178) = -0.47$, $p = .64$, did not differ from zero. Similarly, at the 7-year assessments, the mean bias to threat, $t(108) = -1.01$, $p = .31$, and mean bias to positive, $t(107) = 1.23$, $p = .22$, did not differ from zero. Results comparing the biases across the two assessments showed that mean attention bias to threat did not differ across the two ages, $t(84) = -0.38$, $p = .71$. The mean attention bias to positive did differ at the trend level across the two ages, $t(88) = -1.93$, $p = .06$, such that 7-year scores were larger (more positive) than scores at the 5-year assessment.

The correlations between the key study variables are provided in Table 2. Results revealed no direct significant linear relations between anxiety scores and any attention bias scores. Positive attention bias was significantly correlated across the two time points at trend level; 5-year positive bias and 7-year threat bias were significantly correlated. Attention bias to threat was not significantly correlated across the two time points. Notably, the concurrent assessments of threat and positive biases were not significantly correlated, suggesting that these two biases

Table 2
Intercorrelations Between Key Study Variables

		1	2	3	4	5	6	7
1.	BI							
2.	5-Year anxiety	.15*						
3.	5-Year ABT	−.05	−.03					
4.	5-Year ABP	.03	.04	.01				
5.	7-Year anxiety	.19**	.56**	.06	.09			
6.	7-Year ABT	−.09	.11	.05	.25*	.08		
7.	7-Year ABP	.05	−.02	.01	.20^{+}	.00	−.03	

Note. ABT = attention bias to threat; ABP = attention bias to positive; BI = behavioral inhibition. $^{+}p \leq .10$. $^{*}p \leq .05$. $^{**}p \leq .01$.

are not simply the inverse of one another. BI was not significantly related to any attention bias measure, but was significantly correlated, albeit modestly, with anxiety scores at 5 years and 7 years. Additional correlation analyses confirmed there was no significant association between anxiety and overall RT on the dot-probe task at either the 5- or 7-year assessment, rs < .01, ps > .91.

Effects of BI and 5-Year Attention Bias to Threat on 7-Year Anxiety

The first models examined the main and interaction effects of BI and 5-year attention bias to threat on 7-year anxiety. Parameter estimates of the model with 5-year attention bias to threat are presented in Table 3. The results revealed no significant predictors in the model, besides 5-year anxiety. Notably, 5-year attention bias to threat did not predict later anxiety, or did it moderate the link between BI and 7-year anxiety.

Effects of BI and 7-Year Attention Bias to Threat on 7-Year Anxiety

The next models examined the main and interaction effects of BI and 7-year attention bias to threat on 7-year anxiety, controlling for 5-year anxiety. Parameter estimates of the model with 7-year attention bias to threat are presented in Table 4. The model revealed BI and 5-year anxiety were both significant predictors of anxiety. However, there was a significant interaction between BI and 7-year attention bias to threat on 7-year anxiety. Simple slope results revealed that for children with a bias away from threat (i.e., a negative attention bias to threat score) at 7 years of age, BI did not predict later anxiety, $B = .23$, $p = .26$ (Figure 1). Conversely, for children with an attention bias to threat, BI

Table 3
*Regression Model With 5-Year ABT Predicting 7-Year Anxiety (*n = *265)*

Variable	*B*	*SE B*
Model 1: Main effects ($R^2 = .39$, $p < .001$)		
5-Year anxiety	.44***	.05
5-Year dot-probe accuracy	.02	.01
BI	.17	.16
5-Year ABT	.001	.001
Model 2: With interaction effect ($R^2 = .39$, $p < .001$)		
5-Year anxiety	.44***	.05
5-Year dot-probe accuracy	.02	.01
BI	.17	.16
5-Year ABT	.001	.001
BI × 5-Year ABT	.000	.002

Note. BI = behavioral inhibition; ABT = attention bias to threat. $^{***}p \leq .001$.

Table 4
*Regression Model With 7-Year ABT Predicting 7-Year Anxiety (*n = *223)*

Variable	*B*	*SE B*
Model 1: Main effects ($R^2 = .35$, $p < .001$)		
5-Year anxiety	.44***	.08
7-Year dot-probe accuracy	−.001	.02
BI	.43**	.16
7-Year ABT	.001	.002
Model 2: With interaction effect ($R^2 = .37$, $p < .001$)		
5-Year anxiety	.44***	.08
7-Year dot-probe accuracy	−.001	.02
BI	.49**	.15
7-Year ABT	.001	.002
BI × 7-Year ABT	.004*	.002

Note. BI = behavioral inhibition; ABT = attention bias to threat. $^{*}p \leq .05$. $^{**}p \leq .01$, $^{***}p \leq .001$.

significantly predicted 7-year anxiety, $B = .78$, $p = .004$. As well, for children with no bias to threat (i.e., 0 ms), BI significantly predicted 7-year anxiety, $B = .49$, $p \leq .001$.

Effects of BI and 5-Year Attention Bias to Positive on 7-Year Anxiety

The next models examined the main and interaction effects of BI and 5-year attention bias to positive on 7-year anxiety. Parameter estimates of the model with 5-year attention bias to positive are presented in Table 5. The exploratory analyses revealed no significant predictors in the model, besides 5-year anxiety. Moreover, the interaction term was not significant, revealing that 5-year

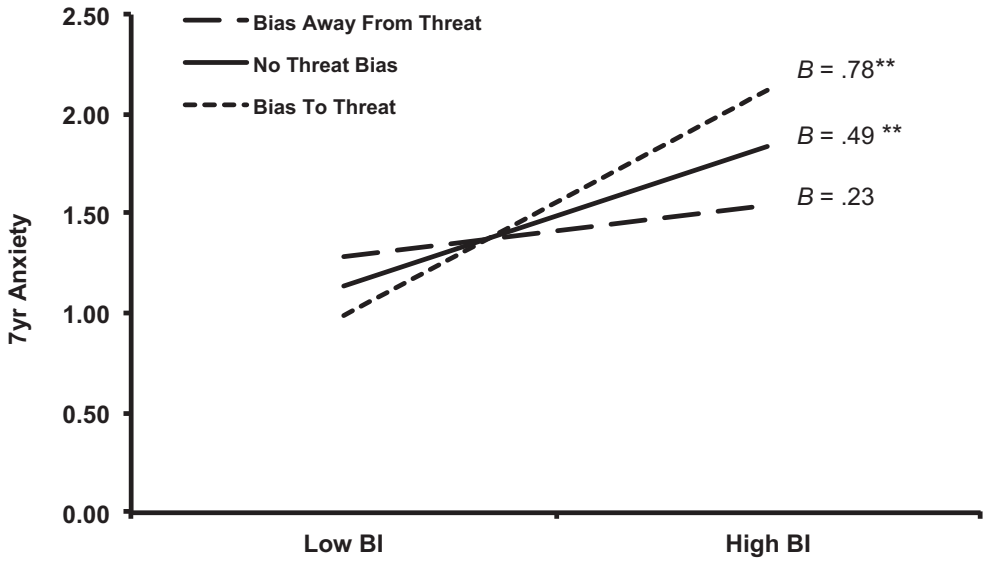

Figure 1. The effect of behavioral inhibition (BI) on 7-year anxiety at different levels of threat attention bias. Unstandardized parameter estimates are plotted, $^{**}p \leq .01$.

attention bias to positive scores did not influence the association between early identified BI and 7-year anxiety.

Effects of BI and 7-Year Attention Bias to Positive on 7-Year Anxiety

The next models examined the main and interaction effects of BI and 7-year attention bias to positive on 7-year anxiety, controlling for 5-year anxiety. Parameter estimates of the model with 7-year attention bias to positive are presented in Table 6. The model revealed that besides BI and 5-year anxiety, there were no other direct predictors of 7-year anxiety. However, the interaction effect of BI and 7-year attention bias to positive was significant. Results of the simple slopes tests revealed that when children have a bias to positive information, BI was not related to 7-year anxiety, $B = .10$, $p = .53$ (Figure 2). However, BI was related to 7-year anxiety for children with a bias away from positive information (i.e., a negative attention bias to positive score), $B = .89$, $p < .001$, and for children with no positive bias (i.e., 0 ms,), BI significantly predicted 7-year anxiety, $B = .52$, $p = .001$.

Table 5
Regression Model With 5-Year ABP Predicting 7-Year Anxiety (n = 265)

Variable	*B*	*SE B*
Model 1: Main effects ($R^2 = .39$, $p < .001$)		
5-Year anxiety	.44***	.05
5-Year dot-probe accuracy	.02	.01
BI	.16	.16
5-Year ABP	.001	.001
Model 2: With interaction effect ($R^2 = .40$, $p < .001$)		
5-Year Anxiety	.44*	.06
5-Year Dot-Probe Accuracy	.02	.01
BI	.16	.16
5-Year ABP	.001	.001
BI × 5-Year ABP	−.002	.001

Note. BI = behavioral inhibition; ABP = attention bias to positive.
$^{*}p \leq .05$, $^{***}p \leq .001$.

Discussion

This study examined developmental associations among temperament, attention biases, and anxiety, finding that threat and positive attention biases moderated the developmental association between early identified BI and anxiety symptoms in middle childhood. Importantly, this study did not find evidence of a direct association between attention biases and subsequent reports of anxiety; moreover, children did not show stable patterns of attention biases across development.

Consistent with previous work, this study showed that BI characterized in early childhood predicted anxiety ratings some 5 years later; however, this developmental link was moderated by a child's attention bias to threat. Specifically, high levels of BI in early childhood were associated with greater levels of anxiety in middle childhood for children displaying either high attention bias to

Table 6
Regression Model With 7-Year ABP Predicting 7-Year Anxiety (n = 223)

Variable	*B*	*SE B*
Model 1: Main effects (R^2 = .35, p < .001)		
5-Year anxiety	.44***	.08
7-Year dot-probe accuracy	.001	.02
BI	.43**	.16
7-Year ABP	.000	.002
Model 2: With interaction effect (R^2 = .39, p < .001)		
5-Year anxiety	.46***	.08
5-Year dot-probe accuracy	.003	.02
BI	.52**	.16
7-Year ABP	.001	.002
BI × 7-Year ABP	−.006**	.002

Note. BI = behavioral inhibition; ABP = attention bias to positive. **$p \leq .01$. and ***$p \leq .001$.

threat scores, reflecting an attention bias to threat, or attention bias to threat scores near zero (i.e., no bias); however, the data suggest that the presence of high attention bias to threat scores conferred greater anxiety vulnerability for these children than the presence of no bias. Conversely, for children displaying low attention bias to threat scores, reflecting an attention bias away from threat, BI was not associated with anxiety. Thus, the level and direction of threat bias scores (toward or away from threat) determined whether attention bias was a risk or protective factor for children with BI.

Although positive attention biases were not directly associated with BI or anxiety, children's positive attention biases at age 7 also moderated the link between early BI and 7-year anxiety. Specifically, those behaviorally inhibited children who displayed low attention bias to positive scores, reflecting an attention bias away from positive, or positive bias scores near zero (i.e., no bias) displayed greater symptoms of anxiety at age 7. For children displaying high attention bias to positive scores, reflecting an attention bias to positive, BI was not related to later anxiety. Although much of the work on attention biases has focused on attention bias to threat, the current findings suggest that patterns of attention allocation to positive information may also relate to anxiety. These findings may inform future prevention and treatment research. Cognitive training studies that focus not just on inducing a bias away from threat, but promoting a bias toward positive information may help reduce risk for anxiety in children with a history of BI (e.g., Waters et al., 2013). Of note, at 7 years, attention bias to threat was not associated with attention bias to positive stimuli. Thus, the two biases do not appear to simply be a reciprocal of one another, suggesting that attention biases to threat and positive information may differentially influence anxiety. Future work should examine how threat and positive biases may interact to influence anxiety.

Of note, the moderating effects of positive and threat attention biases on the BI–anxiety link were only found for the 7-year bias assessment. The fact

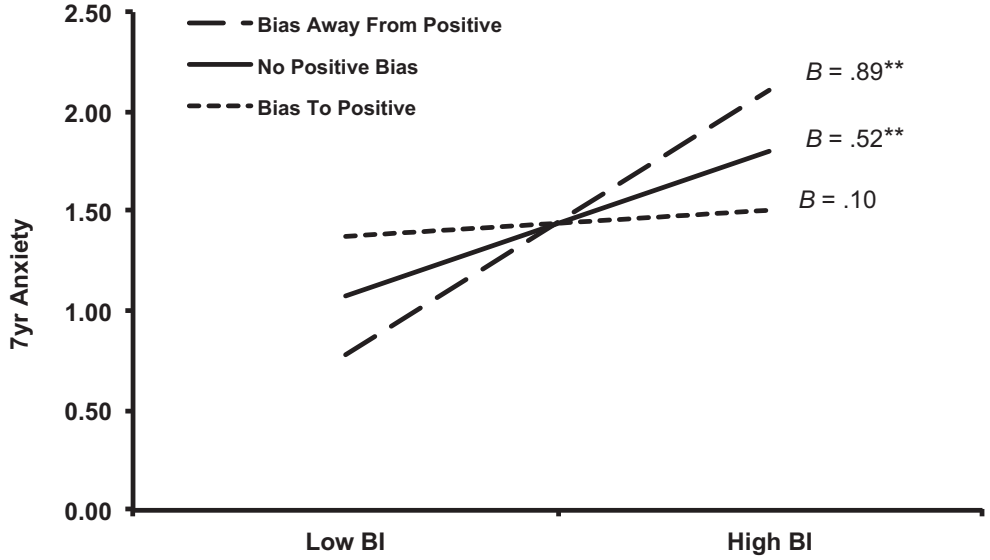

Figure 2. The effect of behavioral inhibition (BI) on 7-year anxiety at different levels of positive attention bias. Unstandardized parameter estimates are plotted, **$p \leq .001$.

that the moderating effect of attention biases was limited to concurrent assessments of attention and anxiety at 7 years of age could reflect the view that the association between anxiety and attention biases becomes stronger across development (Field & Lester, 2010; Vasey & Macleod, 2001). Thus, attention biases, even those identified early in life, may only affect anxiety later in development; however, attention bias to threat was found to moderate current levels of anxiety in 5-year-olds (Pérez-Edgar et al., 2011) and 6-year-olds (Morales et al., 2014) with a history of inhibited temperaments. The current findings may reflect attention biases' role in the expression and maintenance of current anxiety or negative reactivity, and not the emergence of anxiety problems at a later point in time. Thus, in a child with a predisposition for fear or negative reactivity (e.g., BI), an attention bias away from threat or toward positive may dampen their hypervigilant and fearful disposition and an attention bias to threat or away from positive may encourage and increase such hypervigilance and fearfulness. The anxiety–BI association found in children displaying no bias (bias scores near zero) may reflect the continuation, or typical developmental stability, of the child's fearful temperament, uninfluenced by attention biases. Attention biases may regulate certain emotional responses (Todd, Cunningham, Anderson, & Thompson, 2012) that directly influence the child's *expression* or level of fearfulness, hypervigilance, and anxiety.

Despite growing body of work that suggests a causal link between attention biases and anxiety, the current longitudinal findings did not find evidence that a threat bias in early childhood, regardless of temperament, predicted anxiety at a later point in development. It is possible that the causal link appears later in development and the bias–anxiety association is not established by middle childhood. However, as detailed above, the current findings did find attention biases predicted concurrent anxiety for some children (i.e., children with a history of BI). Thus, attention bias on its own, in the absence of other vulnerability factors (e.g., BI), may not directly affect anxiety (Van Bockstaele et al., 2014). Future longitudinal work should implement more frequent assessments of attention biases and anxiety to better capture the nature of their association over time and thus better understand how attention biases may differentially affect the expression of anxiety at different stages of development. As well, assessing anxiety and attention bias to threat at multiple levels of analysis (e.g., psychophysiology, neuroimaging) will increase our understanding of the mechanisms associated with threat-related attention biases and anxiety and help delineate the processes that underlie the relation between the two across development.

Given that the direction of threat and positive biases differentially influence anxiety vulnerability for children with a history of BI raises interesting questions regarding how children come to acquire such biases. Perhaps certain internal or external factors contribute to how children attend to emotional information in the environment. For example, parents may influence the development of attention biases: children may be more likely to display threat-related information processing biases if their parents highlight potential sources of threat in the child's development (Hane & Barrios, 2011). A child's motivational goals have also been linked to their allocation of attention to emotional cues in the environment (Derryberry & Rothbart, 1997). Thus, children who are more motivated to avoid potential sources of danger in their environment may come to acquire a bias to attend threat. Differences in a child's executive function ability may also influence different patterns of attention biases in behaviorally inhibited children. For example, children who show efficient ability to flexibly shift their attention may be able to disengage their attention from threat, resulting in the absence of a threat bias (Lonigan, Vasey, Phillips, & Hazen, 2004; White, McDermott, Degnan, Henderson, & Fox, 2011). An interesting point for future developmental work would be to identify those factors that contribute to the development of such biased patterns of attention in some, but not all, behaviorally inhibited children. Notably, this work would also inform treatment research: Understanding the factors that lead to an attention bias to threat or away from positive in behaviorally inhibited children may help focus prevention work to target those factors that lead to threat-related biases.

This study also allowed for the examination of the developmental trajectories of attention biases as well as bias stability across a 2-year period of time. Findings revealed that attention biases did not statistically differ across the two assessments, or did children display a significant attention bias at either assessment. Within individuals, there was little evidence for stability of biases across the two assessment points. The lack of stability could be attributed to differences in certain emotional or cognitive factors that impact children's biases differently across development. For example, previous research suggested that threat-related cognitive biases become more defined and trait like across

development (Bell, Luebbe, Swenson, & Allwood, 2009; Luebbe, Bell, Allwood, Swenson, & Early, 2010; Nolen-Hoeksema, Girgus, & Seligman, 1992). Thus, young children may be prone to fluctuations in their attention biases. Attention biases to threat and positive information could be more variable or plastic in children and may be quite responsive to microvariations in state anxiety, a child's motivational goals, or environmental threats or rewards. There may also be normative developmental changes in attention biases or other developmental factors, such as more efficient attentional control, that differentially contribute to attention biases between ages 5 and 7. Although most recent work in developmental samples does not find a direct association between age and attention bias (Broeren et al., 2011; Roy et al., 2008; Salum et al., 2013; Szpunar & Young, 2012), in a study with children between the ages of 4 and 12, Broeren et al. (2011) did report that young children tended to show more variability in their RTs and bias scores. Thus, basic developmental differences in task performance, like variations in RTs, may contribute to the lack of stability in children's attention bias scores across development.

The lack of threat bias stability across time could also be due to methodological limitations with the current assessment of attention bias. Reliability of measures based on RT difference scores, such as attention bias scores, can be difficult to detect (Salthouse & Hedden, 2002). As such, the RT-based bias measures used in this study may be too noisy to reliably capture attention biases across different assessment points. This may be especially true for younger samples that show great variability in their RTs (Britton et al., 2013; Brown et al., 2014). Although the dot-probe task has been frequently used in children, a recent study examining the temporal stability of several attention bias tasks in a large group of 9-year-olds revealed poor temporal stability across tasks, including the dot probe (Brown et al., 2014). The methodological differences (e.g., probe type, probe duration) between the versions of the dot-probe tasks administered at the two assessment points may also have contributed to the lack of threat bias relations across time. Previous work has demonstrated that the different versions of dot-probe task, like those administered at the two assessments in this study, yield similar attention bias scores within the same individuals (Mogg & Bradley, 1999), but this was demonstrated in an adult population. Thus, task variations may lead to discrepant bias scores in younger populations. Taken together, issues with the dot-probe task itself and the small discrepancies between the 5- and 7-year assessments may have contributed to the lack of stability. Understanding the stability or plasticity of threat and positive biases across development has important implications for understanding the etiology of anxiety and the developmental trajectories associated with BI. The findings from this study stress the need for future work to assess attention bias across development using multilevel bias assessments, such as psychophysiology, neuroimaging, or eye-tracking methodologies. In a small study with children, Britton et al. (2013, Experiment 2) showed that although RT-based measures of bias score were not stable across time, associated brain activity of a child's threat bias was stable. Using techniques that do not rely solely on RT-based measures may offer more robust assessments of a child's attention bias across time, thus, elucidating the remaining questions regarding bias stability. Of note, these robust measures of attention bias will help us better understand the interplay among BI, attention bias, and anxiety across development.

The current findings should be considered in light of several limitations. First, anxiety was assessed in a normative sample. Thus, findings may not generalize to clinical samples. Second, there was substantial missing data in this study due to poor performance on the dot-probe task. Despite efforts to include participants with data missing at random, the current results cannot be generalized to the children who displayed poor performance on the task. In addition, the fact that many of the children had difficulty on the task raises questions about how to best titrate difficulty by age when assessing young children with the dot probe.

In sum, the current findings add to the body of work linking BI as a risk factor for later anxiety problems and shed light on the role of attention biases to threat and positive information on the BI–anxiety link. The results showed that differences in the direction of a child's attention bias to threat *and* positive information significantly influence the relations between early BI and later anxiety. These findings suggest that for children with high levels of BI in toddlerhood, high positive bias scores (attention bias to positive) or low threat bias scores (attention bias away from threat) protected these children against the risk for anxiety, whereas high threat bias scores (attention bias to threat), low positive bias scores (attention bias away from positive), or the absence of a bias was associated with greater levels of concurrent anxiety in middle childhood. Of note, the data suggest

that the presence of high threat bias scores or low positive bias scores conferred greater anxiety vulnerability than bias scores near zero in these children. The interaction between temperament and attention bias was only detected for concurrent assessment of attention biases and anxiety; the results found no evidence of a longitudinal influence of attention bias on anxiety. Interestingly, this study did not find evidence of direct associations between threat-related attention biases and anxiety in early or middle childhood, or did it find evidence of bias stability across development.

References

Achenbach, T. M., & Rescorla, L. A. (2001). *Manual for the ASEBA preschool forms & profiles. English*. Burlington, VT: Department of Psychiatry, University of Vermont.

Aiken, L. S., & West, S. G. (1991). *Multiple regression: Testing and interpreting interactions*. Newbury Park, CA: SAGE.

Amir, N., Beard, C., Taylor, C. T., Klumpp, H., Elias, J., Burns, M., & Chen, X. (2009). Attention training in individuals with generalized social phobia: A randomized controlled trial. *Journal of Consulting and Clinical Psychology*, *77*, 961–973. doi:10.1037/a0016685

Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M. J., & Van IJzendoorn, M. H. (2007). Threat-related attentional bias in anxious and nonanxious individuals: A meta-analytic study. *Psychological Bulletin*, *133*(1), 1–24. doi:10.1037/0033-2909.133.1.1

Beck, A. T., & Clark, D. A. (1997). An information processing model of anxiety: Automatic and strategic processes. *Behaviour Research and Therapy*, *35*, 49–58. doi:10.1016/S0005-7967(96)00069-1

Bell, D. J., Luebbe, A. M., Swenson, L. P., & Allwood, M. A. (2009). The Children's Evaluation of Everyday Social Encounters Questionnaire: Comprehensive assessment of children's social information processing and its relation to internalizing problems. *Journal of Clinical Child and Adolescent Psychology*, *38*, 705–720. doi:10.1080/15374410903103585

Britton, J. C., Bar-Haim, Y., Clementi, M. A., Sankin, L. S., Chen, G., Shechner, T., . . . Pine, D. S. (2013). Training-associated changes and stability of attention bias in youth: Implications for attention bias modification treatment for pediatric anxiety. *Developmental Cognitive Neuroscience*, *4*, 52–64. doi:10.1016/j.dcn.2012.11.001

Broeren, S., Muris, P., Bouwmeester, S., Field, A. P., & Voerman, J. (2011). Processing biases for emotional faces in 4- to 12-year-old non-clinical children: An exploratory study of developmental patterns and relationships with social anxiety and behavioral inhibition. *Journal of Experimental Psychopathology*, *2*, 454–474. doi:10.5127/jep.016611

Brown, H. M., Eley, T. C., Broeren, S., Macleod, C., Rinck, M., Hadwin, J. A., & Lester, K. J. (2014). Psychometric properties of reaction time based experimental paradigms measuring anxiety-related information-processing biases in children. *Journal of Anxiety Disorders*, *28*, 97–107. doi:10.1016/j.janxdis.2013.11.004

Chronis-Tuscano, A., Degnan, K. A., Pine, D. S., Pérez-Edgar, K., Henderson, H. A., Diaz, Y., . . . Fox, N. A. (2009). Stable early maternal report of behavioral inhibition predicts lifetime social anxiety disorder in adolescence. *Journal of the American Academy of Child and Adolescent Psychiatry*, *48*, 928–935. doi:10.1097/CHI.0b013e3181ae09df

Clauss, J. A., & Blackford, J. U. (2012). Behavioral inhibition and risk for developing social anxiety disorder: A meta-analytic study. *Journal of the American Academy of Child and Adolescent Psychiatry*, *51*, 1066–1075. doi:10.1016/j.jaac.2012.08.002

Derryberry, D., & Rothbart, M. K. (1997). Reactive and effortful processes in the organization of temperament. *Development and Psychopathology*, *9*, 633–652. doi:10.1017/S0954579497001375

Ebesutani, C., Bernstein, A., Nakamura, B. J., Chorpita, B. F., Higa-McMillan, C. K., & Weisz, J. R. (2010). Concurrent validity of the Child Behavior Checklist DSM-oriented scales: Correspondence with DSM diagnoses and comparison to syndrome scales. *Journal of Psychopathology and Behavioral Assessment*, *32*, 373–384. doi:10.1007/s10862-009-9174-9

Eldar, S., Ricon, T., & Bar-Haim, Y. (2008). Plasticity in attention: Implications for stress response in children. *Behaviour Research and Therapy*, *46*, 450–461. doi:10.1016/j.brat.2008.01.012

Ferdinand, R. F. (2008). Validity of the CBCL/YSR DSM–IV scales anxiety problems and affective problems. *Journal of Anxiety Disorders*, *22*, 126–134. doi:10.1016/j.janxdis.2007.01.008

Field, A. P., & Lester, K. J. (2010). Is there room for "development" in developmental models of information processing biases to threat in children and adolescents? *Clinical Child and Family Psychology Review*, *13*, 315–332. doi:10.1007/s10567-010-0078-8

Fordham, K., & Stevenson-Hinde, J. (1999). Shyness, friendship quality, and adjustment during middle childhood. *Journal of Child Psychology and Psychiatry*, *40*, 757–768. doi:10.1111/1469-7610.00491

Fox, N. A., Henderson, H. A., Marshall, P. J., Nichols, K. E., & Ghera, M. M. (2005). Behavioral inhibition: Linking biology and behavior within a developmental framework. *Annual Review of Psychology*, *56*, 235–262. doi:10.1146/annurev.psych.55.090902.141532

Fox, N. A., Henderson, H. A., Rubin, K. H., Calkins, S. D., & Schmidt, L. A. (2001). Continuity and discontinuity of behavioral inhibition and exuberance: Psychophysiological and behavioral influences across the first four years of life. *Child Development*, *72*(1), 1–21. doi:10.1111/1467-8624.00262

Goldsmith, H. H. (1996). Studying temperament via construction of the Toddler Behavior Assessment Questionnaire. *Child Development*, *67*, 218–235. doi:10.1111/j.1467-8624.1996.tb01730.x

Grafton, B., Ang, C., & MacLeod, C. (2012). Always look on the bright side of life: The attentional basis of positive affectivity. *European Journal of Personality*, *26*, 133–144. doi:10.1002/per.1842

Hallion, L. S., & Ruscio, A. M. (2011). A meta-analysis of the effect of cognitive bias modification on anxiety and depression. *Psychological Bulletin*, *137*, 940–958. doi:10.1037/a0024355

Hane, A. A., & Barrios, E. S. (2011). Mother and child interpretations of threat in ambiguous situations: Relations with child anxiety and autonomic responding. *Journal of Family Psychology*, *25*, 644–652. doi:10.1037/a0024149

Hane, A. A., Fox, N. A., Henderson, H. A., & Marshall, P. J. (2008). Behavioral reactivity and approach-withdrawal bias in infancy. *Developmental Psychology*, *44*, 1491–1496. doi:10.1037/a0012855

Johnson, D. R. (2009). Goal-directed attentional deployment to emotional faces and individual differences in emotional regulation. *Journal of Research in Personality*, *43*, 8–13. doi:10.1016/j.jrp.2008.09.006

Kagan, J., Reznick, J. S., & Snidman, N. (1987). The physiology and psychology of behavioral inhibition in children. *Child Development*, *58*, 1459–1473. doi:10.1111/j.1467-8624.1987.tb03858.x

Lahat, A., Lamm, C., Chronis-Tuscano, A., Pine, D. S., Henderson, H. A., & Fox, N. A. (2014). Earlybehavioral inhibition and increased error monitoring predict later social phobia symptoms in childhood. *Journal of the American Academy of Child & Adolescent Psychiatry*, *53*, 447–455. doi:10.1016/j.jaac.2013.12.019

Lamm, C., Walker, O. L., Degnan, K. A., Henderson, H. A., Pine, D. S., McDermott, J. M., & Fox, N. A. (2014). Cognitive control moderates early childhood temperament in predicting social behavior in 7-year-old children: An ERP study. *Developmental Science*, *17*, 667–681. doi:10.1111/desc.12158

Lonigan, C. J., Vasey, M. W., Phillips, B. M., & Hazen, R. A. (2004). Temperament, anxiety, and the processing of threat-relevant stimuli. *Journal of Clinical Child and Adolescent Psychology*, *33*, 8–20. doi:10.1207/S15374424JCCP3301_2

Luebbe, A. M., Bell, D. J., Allwood, M. A., Swenson, L. P., & Early, M. C. (2010). Social information processing in children: Specific relations to anxiety, depression, and affect. *Journal of Clinical Child and Adolescent Psychology*, *39*, 386–399. doi:10.1080/15374411003691685

Macleod, C., Rutherford, E., Campbell, L., Ebsworthy, G., & Holker, L. (2002). Selective attention and emotional vulnerability: Assessing the causal biases of their association through the experimental manipulation of attentional bias. *Journal of Abnormal Psychology*, *111*, 107–123. doi:10.1037/0021-843X.111.1.107

Mathews, A., & Mackintosh, B. (1998). A cognitive model of selective processing in anxiety. *Cognitive Therapy and Research*, *22*, 539–560. doi:10.1023/A:1018738019346

Mathews, A., & Macleod, C. (2002). Induced processing biases have causal effects on anxiety. *Cognition and Emotion*, *16*, 331–354. doi:10.1080/02699930143000518

Mogg, K., & Bradley, B. P. (1999). Some methodological issues in assessing attentional biases for threatening faces in anxiety: A replication study using a modified version of the probe detection task. *Behaviour Research and Therapy*, *37*, 595–604. doi:10.1016/S0005-7967(98)00158-2

Morales, S., Pérez-edgar, K., & Buss, K. A. (2014). Attention biases towards and away from threat mark the relation between early dysregulated fear and the later emergence of social withdrawal. , *46*(6), 1067–1078. doi:10.1007/s10802-014-9963-9

Nolen-Hoeksema, S., Girgus, J. S., & Seligman, M. E. (1992). Predictors and consequences of childhood depressive symptoms: A 5-year longitudinal study. *Journal of Abnormal Psychology*, *101*, 405–422. doi:10.1037/0021-843X.101.3.405

Pérez-Edgar, K., Bar-Haim, Y., McDermott, J. M., Chronis-Tuscano, A., Pine, D. S., & Fox, N. A. (2010). Attention biases to threat and behavioral inhibition in early childhood shape adolescent social withdrawal. *Emotion*, *10*, 349–357. doi:10.1037/a0018486

Pérez-Edgar, K., Reeb-Sutherland, B. C., McDermott, J. M., White, L. K., Henderson, H. A., Degnan, K. A., . . . Fox, N. A. (2011). Attention biases to threat link behavioral inhibition to social withdrawal over time in very young children. *Journal of Abnormal Child Psychology*, *39*, 885–895. doi:10.1007/s10802-011-9495-5

Prior, M., Smart, D., Sanson, A., & Oberklaid, F. (2000). Does shy-inhibited temperament in childhood lead to anxiety problems in adolescence? *Journal of the American Academy of Child and Adolescent Psychiatry*, *39*, 461–468. doi:10.1097/00004583-200004000-00015

Roy, A. K., Vasa, R. A., Bruck, M., Mogg, K., Bradley, B. P., Sweeney, M., . . . Pine, D. S. (2008). Attention bias toward threat in pediatric anxiety disorders. *Journal of the American Academy of Child & Adolescent Psychiatry*, *47*, 1189–1196. doi:10.1097/CHI.0b013e3181825ace

Salthouse, T. A., & Hedden, T. (2002). Interpreting reaction time measures in between-group comparisons. *Journal of Clinical and Experimental Neuropsychology*, *24*, 858–872. doi:10.1076/jcen.24.7.858.8392

Salum, G. A., Mogg, K., Bradley, B. P., Gadelha, A., Pan, P., Tananaha, A. C., . . . Pine, D. S. (2013). Threat bias in attention orienting: Evidence of specificity in a large community-based study. *Psychological Medicine*, *43*, 733–745. doi:10.1017/S0033291712001651

Shechner, T., Britton, J. C., Pérez-Edgar, K., Bar-Haim, Y., Ernst, M., Fox, N. A., . . . Pine, D. S. (2012). Attention biases, anxiety, and development: Toward or away from threats or rewards? *Depression and Anxiety*, *29*, 282–294. doi:10.1002/da.20914

Shechner, T., Rimon-Chakir, A., Britton, J. C., Lotan, D., Apter, A., Bliese, P. D., . . . Bar-Haim, Y. (2014). Attention bias modification treatment augmenting effects on cognitive behavioral therapy in children with anxiety: Randomized controlled trial. *Journal of the American Academy of Child and Adolescent Psychiatry*, *53*(1), 61–71. doi:10.1016/j.jaac.2013.09.016

Szpunar, M., & Young, A. (2012). Information processing biases in behaviorally inhibited children: Response to threat and novelty. *Child Health and Education*, *4*(1), 47–63. doi:10.1007/s10802-011-9495-5

Taylor, C. T., Bomyea, J., & Amir, N. (2010). Attentional bias away from positive social information mediates the link between social anxiety and anxiety vulnerability to a social stressor. *Journal of Anxiety Disorders*, *24*, 403–408. doi:10.1016/j.janxdis.2010.02.004

Taylor, C. T., Bomyea, J., & Amir, N. (2011). Malleability of attentional bias for positive emotional information and anxiety vulnerability. *Emotion*, *11*, 127–138. doi:10.1037/a0021301

Todd, R. M., Cunningham, W. A., Anderson, A. K., & Thompson, E. (2012). Affect-biased attention as emotion regulation. *Trends in Cognitive Sciences*, *16*, 365–372. doi:10.1016/j.tics.2012.06.003

Tottenham, N., Tanaka, J. W., Leon, A. C., McCarry, T., Nurse, M., Hare, T. A., . . . Nelson, C. (2009). The NimStim set of facial expressions: Judgments from untrained research participants. *Psychiatry Research*, *168*, 242–249. doi:10.1016/j.psychres.2008.05.006

Troller-Renfree, S., McDermott, J. M., Nelson, C. A., Zeanah, C. H., & Fox, N. A. (2014). The effects of early foster care intervention on attention biases in previously institutionalized children in Romania. *Developmental Science*, *18*(5), 713–722. doi:10.1111/desc.12261

Van Bockstaele, B., Verschuere, B., Tibboel, H., De Houwer, J., Crombez, G., & Koster, E. H. W. (2014). A review of current evidence for the causal impact of attentional bias on fear and anxiety. *Psychological Bulletin*, *140*, 682–721. doi:10.1037/a0034834

Vasey, M. W., & Macleod, C. (2001). Information-processing factors in childhood anxiety: A review and developmental perspective. In T. Developmental (Ed.), *Psychopathology of anxiety* (pp. 253–277). New York, NY: Oxford University Press.

Walker, O. L., Henderson, H. A., Degnan, K. A., Penela, E. C., & Fox, N. A. (2014). Associations between behavioral inhibition and children's social problem-solving behavior during social exclusion. *Social Development*, *23*, 487–501. doi:10.1111/sode.12053

Waters, A. M., Bradley, B. P., & Mogg, K. (2014). Biased attention to threat in paediatric anxiety disorders (generalized anxiety disorder, social phobia, specific phobia, separation anxiety disorder) as a function of "distress" versus "fear" diagnostic categorization. *Psychological Medicine*, *44*, 607–616. doi:10.1017/S0033291713000779

Waters, A. M., Henry, J., Mogg, K., Bradley, B. P., & Pine, D. S. (2010). Attentional bias towards angry faces in childhood anxiety disorders. *Journal of Behavior Therapy and Experimental Psychiatry*, *41*, 158–164. doi:10.1016/j.jbtep.2009.12.001

Waters, A. M., Lipp, O. V., & Spence, S. H. (2004). Attentional bias toward fear-related stimuli: An investigation with nonselected children and adults children with anxiety disorders. *Journal of Experimental Child Psychology*, *89*, 320–337. doi:10.1016/j.jecp.2004.06.003

Waters, A. M., Mogg, K., Bradley, B. P., & Pine, D. S. (2008). Attentional bias for emotional faces in children with generalized anxiety disorder. *Journal of the American Academy of Child & Adolescent Psychiatry*, *47*, 435–442. doi:10.1097/CHI.0b013e3181642992

Waters, A. M., Pittaway, M., Mogg, K., Bradley, B. P., & Pine, D. S. (2013). Attention training towards positive stimuli in clinically anxious children. *Developmental Cognitive Neuroscience*, *4*, 77–84. doi:10.1016/j.dcn.2012.09.004

Watts, S. E., & Weems, C. F. (2006). Associations among selective attention, memory bias, cognitive errors and symptoms of anxiety in youth. *Journal of Abnormal Child Psychology*, *34*, 841–852. doi:10.1007/s10802-006-9066-3

White, L. K., Helfinstein, S. M., & Fox, N. A. (2010). Temperamental factors associated with the acquisition of information processing biases and anxiety. In J. A. Hadwin & A. P. Field (Eds.), *Information processing biases and anxiety: A developmental perspective* (pp. 233–252). Hoboken, NJ: Wiley-Blackwell.

White, L. K., McDermott, J. M., Degnan, K. A., Henderson, H. A., & Fox, N. A. (2011). Behavioral inhibition and anxiety: The moderating roles of inhibitory control and attention shifting. *Journal of Abnormal Child Psychology*, *39*, 735–747. doi:10.1007/s10802-011-9490-x

White, L. K., Suway, J. G., Pine, D. S., Bar-Haim, Y., & Fox, N. A. (2011). Cascading effects: The influence of attention bias to threat on the interpretation of ambiguous information. *Behaviour Research and Therapy*, *49*, 244–251. doi:10.1016/j.brat.2011.01.004

Williams, J. M. G., Watts, F. N., MacLeod, C., & Mathews, A. (1997). *Cognitive psychology and emotional disorders* (2nd ed.). Chichester, UK: Wiley.