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Behavioral inhibition and anxiety: The moderating roles of inhibitory control and attention shifting

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Abstract

Behavioral inhibition (BI), a temperament identified in early childhood, is associated with social reticence in childhood and an increased risk for anxiety problems in adolescence and adulthood. However, not all behaviorally inhibited children remain reticent or develop an anxiety disorder. One possible mechanism accounting for the variability in the developmental trajectories of BI is a child's ability to successfully recruit cognitive processes involved in the regulation of negative reactivity. However, separate cognitive processes may differentially moderate the association between BI and later anxiety problems. The goal of the current study was to examine how two cognitive processes - attention shifting and inhibitory control - laboratory assessed at 48 months of age moderated the association between 24-month BI and anxiety symptoms in the preschool years. Results revealed that high levels of attention shifting decreased the risk for anxiety symptoms in children with high levels of BI, whereas high levels of inhibitory control increased this risk for anxiety symptoms. These findings suggest that different cognitive processes may influence relative levels of risk or adaptation depending upon a child's temperamental reactivity.

Behavioral inhibition (BI), a temperament identified early in childhood that describes a fearful style of reacting when confronted with novelty, is linked to increased social reticence during the preschool and school years (Fox, Henderson, Marshall, Nichols, & Ghera, 2005) and a heightened risk for anxiety problems in adolescence (Chronis-Tuscano et al., 2009). However, not all behaviorally inhibited children remain reticent or develop an anxiety disorder: there is as much discontinuity as there is continuity in the expression of BI over time (Biederman et al., 1990; Degnan & Fox, 2007; Schwartz, Snidman, & Kagan, 1999). Given the variability in developmental trajectories associated with BI, there are likely certain factors, endogenous and exogenous, that increase and/or decrease the risk that a child will develop anxiety problems (Degnan & Fox, 2007; Fox, et al., 2005). Research suggests that differences in effortful control, a temperamental construct reflecting the ability to activate or inhibit one's responses and the ability to voluntarily control attention (Rothbart, Ellis, Rueda, & Posner, 2003), play an important role in moderating the associations between initial temperamental dispositions and social and emotional adjustment (e.g., Eisenberg et al., 2009). Thus, a child's capacity to flexibly recruit and employ the cognitive processes associated with effortful control (i.e., attention shifting and inhibitory control) may play an important role in moderating the associations between behavioral inhibition and later anxiety problems.

Young infants who display high levels of motor reactivity and distress to novel or unfamiliar objects, people, or locations tend to express higher levels of BI as toddlers (Fox et al., 2005). Behaviorally inhibited toddlers and children show increased vigilance during novel or unfamiliar situations, displaying high levels of avoidance and withdrawal, and are often labeled as shy or “slow to warm up” (Fox et al., 2005; Kagan et al., 1984). Over development, the ability to properly modulate these fearful reactive tendencies and reduce behaviors associated with increased anxiety (i.e., social reticence and withdrawal) may allow children with high levels of BI to engage in more frequent, rewarding, and successful interactions and protect them against poor social and emotional outcomes. As such, identifying the cognitive processes involved in successful regulation in these children is a goal of considerable importance. Although it is postulated that the cognitive processes of attention shifting and inhibitory control associated with effortful control play important roles in the regulation of emotions, behaviors, and thoughts in children (e.g., Eisenberg et al., 2004; Rothbart & Rueda, 2005), how these separate regulative cognitive processes may differentially influence adaptive regulation and how this may vary as a function of temperamental reactivity remains largely unexplored. Research has shown that for children and adolescents with high levels of fearful temperamental reactivity (e.g., behavioral inhibition), distinct cognitive regulative processes appear to differentially contribute to both adaptive and maladaptive modulation of their reactive tendencies (e.g., Henderson, 2010; McDermott et al., 2009; Thorell, Bohlin, & Rydell, 2004). Using a longitudinal design, the current study examined how the processes of attention shifting and inhibitory control differentially influence the relative levels of risk and/or adaptation for children with high levels of behavioral inhibition.

Effortful control, a temperamental construct that includes changes in behavioral approach or avoidance and the regulation of attention and emotion has been associated with increased social and emotional competence in children (Kieras, Tobin, Graziano, & Rothbart, 2005; Rothbart, Posner, & Hershey, 1995; Rothbart, et al., 2003). Successful execution of effortful control is achieved through efficient recruitment of several higher order cognitive processes such as attention shifting and inhibitory control (Posner & Rothbart, 2000). Attention shifting reflects the ability to flexibly reallocate attention within one’s internal and external environments to support goal-directed behaviors or meet task demands (Perez-Edgar & Fox, 2005). Inhibitory control describes the ability to inhibit and override dominant responses and behaviors in favor of more appropriate or subdominant responses and behaviors (Rothbart, et al., 2003). Employment of these cognitive processes is thought to play an essential role in the regulation of negative emotions and temperamental reactivity (Derryberry & Rothbart, 1997; Lonigan & Phillips, 2001; White, Helfinstein, Reeb-Sutherland, Degnan, & Fox, 2009). For example, research in both adults (e.g., Derryberry & Rothbart, 1988) and children (e.g., Gerardi-Caulton, 2000) demonstrates that lower levels of effortful control tend to be related to higher levels of negative affect. In a non-clinical sample of 8- to 12-year-old children, self-reported effortful control was inversely related to symptoms of anxiety, depression, and aggression, suggesting that low levels of effortful control may be a risk factor for the emergence of psychopathology (Muris, Mayer, van Lint, & Hofman, 2008).

Although the broad construct of effortful control has been found to be inversely correlated to negative affect (including symptoms of anxiety and depression), each of the cognitive processes underlying effortful control, when examined separately, likely contribute to the regulation of negative reactivity in distinct ways. For example, inhibitory control could help a child modulate the expression of an inappropriate or maladaptive emotional response, aiding in adaptive social and emotional development (Kieras, Tobin, Graziano, & Rothbart, 2005). On the other hand, attention shifting could directly reduce a child’s level of fear or negative affect by facilitating the disengagement of attention from negative thoughts or

threatening stimuli and focusing attention on more positive and adaptive stimuli (Lonigan & Vasey, 2009). As well, the manner in which inhibitory control and attention shifting contribute to adaptive regulation may differ as a function of a child's style of temperamental reactivity (Eisenberg et al., 2005; White et al., 2009).

For children high in behaviorally inhibition, it is likely that the manner in which these separate cognitive processes differentially contribute to effective regulation of negative reactivity has a strong influence on the risk for psychopathology (see Degnan & Fox, 2007 for review). High levels of attention shifting may serve as a protective factor against the development of anxiety symptoms in behaviorally inhibited children. Research has shown that behaviorally inhibited children display a heightened attention bias to threat (Perez-Edgar, Fox, Bar-Haim, Martin McDermott, & Pine, 2010). Thus, the ability to shift attention away from sources of threat in the environment and redirect attention to less salient or negative information, likely plays an important role in the frequency of anxiety experienced by a behaviorally inhibited child. Eisenberg and colleagues (1998) for example, found that children high in parental report of negative emotionality (i.e., high fear, sadness, and anxiety – a construct related to behavioral inhibition) and low in attention shifting were rated by their parents and teachers as being more shy compared to children high in attention shifting two years later. Parents, but not teachers, reported this same pattern of increased shyness up to four years later. Similarly, Henderson (2010) reported that self-reported shyness was associated with social anxiety and a negative attribution style, but only among children who displayed heightened sensitivity to conflict, as displayed by an enhanced N2 Evoked Response Potential, on a laboratory flanker task. Thus, based on both parent reports and psychophysiological assessments, there is evidence to suggest that the ability to flexibly shift attention away from conflicting or distressing stimuli may decrease the risk of anxiety problems among behaviorally inhibited or shy children.

Similar to attention shifting, inhibitory control is often thought of as a protective factor for most children. However, initial evidence suggests that for behaviorally inhibited children high levels of inhibitory control may actually increase their risk for anxiety problems. Thorell and colleagues (2004) conducted a study examining how laboratory assessed BI and inhibitory control at five years of age related to socioemotional functioning at nine years of age. Results showed that behaviorally inhibited children with high levels of inhibitory control had more teacher-reported social anxiety compared to behaviorally inhibited children with low-levels of inhibitory control. Fox and Henderson (2000) found similar results in a younger population; behaviorally inhibited four-year olds with high inhibitory control were less socially competent and more socially withdrawn than behaviorally inhibited children with low inhibitory control. Similarly, McDermott and colleagues (2009) found that behaviorally inhibited children who also displayed enhanced response monitoring during adolescence were at increased risk for later-life clinical anxiety compared to behaviorally inhibited children with low-levels of response monitoring.

It remains unclear why high levels of inhibitory control are associated with negative outcomes for behaviorally inhibited children. One possibility is that the presence of two separate control systems (the fear system and inhibitory control) leads to a heightened level of overcontrol. Children with high levels of behavioral inhibition have a highly active fear system that serves as an involuntary control mechanism (Rothbart & Sheese, 2007), constraining behaviors and attention. The presence of a highly active voluntary control system (i.e., inhibitory control) in addition to this involuntary control system (i.e., active fear system) may lead to excessive levels of control and inflexibility in the child (Block & Block, 1980; Carver, 2005). This rigidity and inflexibility may, in turn, increase a child's experience of anxiety.

Individual differences in inhibitory control may vary independently of BI so that not all children high in BI are high in this cognitive construct. Instability of BI over time may in part be accounted for by variations in individual control processes. It is possible, however, that BI and inhibitory control may not be orthogonal constructs: a heightened ability to control and inhibit behaviors may be the result of active fear circuitry in a behaviorally inhibited child. Thus, it may be that the children with the most active fear circuitry have higher levels of both inhibitory control and anxiety problems. In either case, the maladaptive employment of high levels of inhibitory control and enhanced activation of the fear system appear to increase anxiety problems in behaviorally inhibited children compared to children of with similar temperamental reactivity style, but lower inhibitory control (Derryberry & Rothbart, 1997; Eisenberg, et al., 2005).

The current longitudinal study examined how two cognitive processes underlying effortful control (i.e., attention shifting and inhibitory control) influence the risk for anxiety symptoms in children high in behavioral inhibition. Whereas studies of BI have utilized both categorical and continuous measures of this temperament, we utilized a continuous measure of BI as assessed in the laboratory at 24 months of age in order fully capture the range and variability of BI scores. A discussion of the relative merits of both approaches and their relation to continuity and discontinuity of the temperament may be found in Degnan & Fox (2007). Performance on laboratory tasks of attention shifting and inhibitory control was assessed at 48 months of age. In addition, we examined how these factors were separately and jointly related to parent reports of anxiety symptoms at 4 and 5 years of age. We hypothesized that skill in attention shifting would serve as a protective factor against anxiety symptoms for children with high levels of BI, whereas high levels of inhibitory control would put children high in BI at increased risk for experiencing anxiety symptoms.

Methods

Participants

There were 291 subjects in this study (134 male). Children were part of an ongoing longitudinal study examining the effects of infant temperament on subsequent social behavior with an emphasis on identifying both endogenous and exogenous factors that moderate developmental trajectories of social competence. Families with young infants were originally contacted through mail and interested parents were asked to complete a short background survey. Families with typically developing infants (i.e., infants without developmental disorders or illnesses, and those that did not experience any birth complications) were invited to participate in the study. Seven hundred and seventy nine infants were screened at 4-months of age for extreme patterns of reactivity to auditory and visual stimuli (see Calkins, Fox, & Marshall, 1996 for a description of the procedures; Fox, Henderson, Rubin, Calkins, & Schmidt, 2001) and were coded for negative and positive affect and motor reactivity (see Hane et al., 2008). For a complete description of the recruitment and selection process during the infant period see Hane et al., (2008). A total of 291 children representing the full range of patterns of reactivity during the 4-month assessment were invited to continue participation in the larger longitudinal study. Of these, 156 (65 male) children completed the 24-month behavioral inhibition assessment as well as the 4- and 5- year assessments reported in the current study. Children who discontinued the study into the preschool years did not differ from those who remained in the study in terms of 4-month ratings of negative affect, positive affect, motor activity, or 24-month behavioral inhibition. Of the 156 children participating at 4 and 5 years of age, 112 were Caucasian, 23 were African American, and the remainder of the children were of other or mixed ethnicity. When looking at maternal education, of the 156 children 23 of the mother's reported being high school graduates, 70 were college graduates, 54 had some level post-college education, 8 reported 'other', and maternal education data were missing for one mother. Of these 156

children, four were excluded from further analyses due to IQ scores below 85. All subsequent analyses are reported on a sample of 152.

Measures

24-month Behavioral Inhibition Paradigm—To assess levels of behavioral inhibition in toddlerhood, at 24-months of age children's reactions to a variety of unfamiliar stimuli in the laboratory were observed and coded (see Fox, et al., 2001; Kagan, Reznick, & Snidman, 1987). Children were introduced to a series of stimuli while mothers remained in the room. Mothers were instructed to refrain from initiating contact with the child but to respond as they normally would if the child attempted to get their attention. Children were observed during the following events: (1) five minutes of free play in the novel room/environment, (2) an interaction with an unfamiliar adult, and (3) the introduction of unfamiliar objects and toys. Specifically, the task began with five minutes of free-play with a set of age-appropriate toys. During this time the child's mother worked on questionnaires while the child played independently. At the conclusion of the free-play session, the toys were removed and an unfamiliar female research assistant entered the room with a toy dump truck and some blocks. The researcher sat quietly for 1 minute and then played with the truck for another minute. If the child had not approached by this point, the researcher invited the child to join her in playing with the truck. The joint play lasted for 1 minute after which the truck was removed from the room. Next, an 18-inch battery operated robot was brought into the room. The robot had flashing lights and made loud noises as it moved around the room for a period of two minutes. Lastly, the child was asked to crawl through a pop-up tunnel.

Two research assistants blind to the child's four-month temperament designation coded children's behaviors from the videotaped records. Coders were trained together on 10 videotaped records. Then 20% of the records were independently coded by both coders to calculate reliability. Once reliability was achieved, the lead coder re-coded the 10 records used for training in addition to the remaining records. Similar to Fox et al., (2001), behaviors coded included latency to vocalize, latency to approach/touch the stranger/stimuli, and the proportion of time spent in proximity to mom (within an arm's reach). Intra-class correlations were used to compute reliability on these continuous measures. The inter-coder reliability coefficients across tasks were $r = .78$ for latency to vocalize, $r = .86$ for latency to approach/touch the stranger/stimuli, and $r = .87$ for the proportion of time spent in proximity to mom. For the current study, all of these measures were standardized and averaged within and across the stranger, robot, and tunnel episodes to create an overall score for behavioral inhibition.

48-month Inhibitory Control Tasks

Day-Night Stroop (Gerstadt, Hong, & Diamond, 1994): Parallel to adult versions of the Stroop paradigm, the Day-Night task requires children to actively inhibit a prepotent response and give an alternative, subdominant response. The Day-Night task has successfully been used with 48-month old children in previous studies to assess individual differences inhibitory control (Carlson, 2005; Carlson & Moses, 2001). Specifically, the children were asked to say the word "Day" when presented with a picture of the moon and "Night" when presented with a picture of the sun. The Day stimulus had a black background and contained a picture of a white moon and stars whereas the Night stimulus had a white background and contained a picture of a brightly colored yellow sun. After the initial training, children were given several practice trials (up to a maximum of 10). Testing trials began once a child responded correctly to the consecutive presentation of a Day and a Night card. There were a total of sixteen test trials, with the sun and moon pictures presented eight times each in a pseudorandom sequence. If the child hesitated during a trial, the experimenter would offer a generic prompt such as "What do you say for this one?" No

feedback was given to the child during the test trials. Children who did not get one of each trial type correct during practice trials or who completed less than half of the test trials were excluded from analyses ($n = 8$). Moreover, two children refused to participate in the Day-Night Stroop, data from four children were excluded due to experimenter error, and the task was not administered to one child. A total of 137 children fit the criteria for inclusion in the Day-Night Stroop analyses. The outcome of interest was children's response accuracy, or percent correct, on the test trials, reflecting a child's ability to inhibit a prepotent response.

Grass-Snow Stroop (Carlson & Moses, 2001): Similar to the Day-Night Stroop, the Grass-Snow Stroop required children to respond to highly salient stimuli in a counter-intuitive manner. The Grass-Snow task has successfully been used with 48-month old children in previous studies to assess individual differences inhibitory control (Carlson, 2005; Carlson & Moses, 2001). The primary difference between the Day-Night and Grass-Snow Stroop tasks is the reduction in verbal load on the Grass-Snow such that in this task children are asked to respond by pointing rather than speaking. The experimenter first verified that the child could name the colors of grass and snow by asking these two questions: "*What color is grass?*" and "*What color is snow?*" A large board was then presented that had a white card attached to the upper-left corner, a green card attached to the upper-right corner, and two foam cut-outs shaped like hands centered below the colored cards. The child was told to point to the white card when the experimenter said "grass" and to point to the green card when the experimenter said "snow." The experimenter demonstrated the procedure and then asked the child to repeat it. After the initial training, children were given several practice trials (up to a maximum of 10). The test trials began once a child responded correctly to the consecutive presentation of both a Grass and a Snow trial. There were a total of sixteen test trials, with the white and green picture cards presented eight times each in a pseudorandom sequence. If the child hesitated during a trial, the experimenter would offer a generic prompt such as "*Where do you point for this one?*" No feedback was given to the child during the test trials. Children who did not get one of each trial type correct during practice trials or who completed less than half of the test trials were excluded from analyses ($n=2$). Moreover, four children refused to participate in the Grass-Snow Stroop and data from two children were excluded due to experimenter error. A total of 144 children passed the set criteria for the Grass-Snow Stroop. The outcome of interest was children's response accuracy on the test trials, or percent correct, reflecting a child's ability to inhibit a prepotent response.

48-month Attention Shifting Task

Dimensional Change Card Sort (DCCS; Frye, Zelazo, & Palfai, 1995; Zelazo, 2006): The DCCS task is a non-verbal task that requires children to shift their attention between two rule sets in order to correctly perform the task. Namely, children were presented with two sorting boxes with a model card mounted on the back wall of each of the boxes and were first trained to sort a set of practice cards according to one dimension (i.e., color) using sorting cards that vary only in that one dimension (i.e., red and blue circles). Next, children were trained to sort according to a second dimension (i.e., shape) using a different pair of sorting cards which also varied only on that one particular dimension (i.e., yellow trucks and yellow stars). For testing, the model cards varied on both dimensions with one card depicting a red truck and the other card depicting a blue star whereas the sorting cards depicted either a blue truck or a red star. Thus, during the test phase no sorting card matched a model card on both color and shape. The order of sorting rule presentation was counterbalanced across children with the first testing rule always matching the last training criteria. For example, if a child was first trained to sort according to shape and was then trained to sort by color, the first test rule was to sort according to color and the rule for sorting by shape was tested last. This type of card sort task has successfully been used with

48-month old children to assess individual differences in a child's ability shift their attention between rule-sets (Carlson, 2005; Carlson & Moses, 2001; Frye, et al., 1995).

Testing consisted of two phases: the pre-switch phase and the post-switch phase. In the pre-switch phase children sorted 6 cards (3 blue trucks and 3 red stars presented in a pseudo-random sequence) according to the rule for one dimension (i.e., color). In the post-switch phase, the experimenter announced that they were going to play a new game and instructed the child to sort an additional 6 cards (3 blue trucks and 3 red stars presented in a pseudo-random sequence) according to the alternate dimension (i.e., shape). Performance on each test trial was classified as correct or incorrect. Of special interest in the post-switch phase was the number of trials in which the child responded perseveratively based on the pre-switch rule. Children who did not complete the practice portion of the task or those who did not correctly sort at least 80% of the pre-switch trials were excluded ($n=12$). Two children refused to perform the DCCS, data from one child was excluded due to experimenter or technical errors, and the task was not administered to one child. A total of 136 children passed the set criteria for the DCCS. The outcome of interest was response accuracy, or percent correct, on the post-switch sort test trials, reflecting a child's ability to shift their attention to a new rule-set.

48-month Inhibitory Control and Attention Shifting Questionnaire

Children's Behavior Questionnaire (CBQ; Rothbart, Ahadi, Hershey, & Fisher, 2001):

The CBQ is a commonly used questionnaire to assess maternal report of temperament in children ages 3–7 (Rothbart, et al., 2001). CBQ scales were used to compare maternal report of children's attention shifting and inhibitory control skills at 48-months of age to the laboratory assessed measures of attention shifting and inhibitory control. Mothers responded to whether 195-items were true about their child (rated from 1 = extremely untrue to 7 = extremely true). Three sub-scales were used in the current assessment: inhibitory control, attention shifting, and attention focusing. The sub-scale inhibitory control was composed of 13 items. Given that the sub-scale of attention shifting was only composed of five items, we created an attentional control scale composed of both attention shifting and attention-focusing (the attention focusing scale was composed of nine items). The attention shifting and attention focusing sub-scales were significantly correlated in our sample, $r(141) = .18$, $p = .03$. In the current study Chronbach's alphas for the inhibitory control, attention focusing, attention shifting, and the attentional control composites are .73, .69, .69, and .68 respectively.

48-month IQ assessment

Wechsler Preschool and Primary Scale of Intelligence (WPPSI; Wechsler, 2002): The WPPSI is a measure of intelligence. The WPPSI is appropriate assessment of intelligence for children ages 2.6 – 7.3 (Wechsler, 2002) and was administered by an experimenter in the laboratory. The raw scores of the verbal IQ subset were transformed and age adjusted to scale scores. The vocabulary intelligence subscale was used in the current analyses to control for separate effects that a child's IQ may have on their inhibitory control and attention shifting performance.

4- and 5-year Social and Emotional Functioning

Child Behavior Checklist (CBCL; Achenbach & Ruffle, 2000): The CBCL is parent report questionnaire that is used to examine social and emotional functioning in preschool-aged children. Of primary interest in the current study was the anxiety problems subscale (e.g., child's level of nervousness, amount of fears, how upset a child becomes upon parental separation). Each item was rated on a scale ranging from not true (0) to very/often true (2). To maintain the maximum range of variability, raw scores (sum of the score for all anxiety

related items) were included in the analyses. To compute a composite of children's anxiety symptoms over the preschool years, ratings on the CBCL anxiety problems scale were averaged over the 4- and 5-year assessment points, $r(131) = .63, p < .001$. Out of the children that had completed the BI assessment in addition to the inhibitory control and attention shifting measures, 8 children did not have data for the anxiety problems sub-scale on the CBCL at the 4-year assessment, but did have the data at the 5-year assessment. Additionally, 13 children completed the 4-year CBCL, but did not have data from the 5-year assessment. Given the high correlation of the two assessment time points, for these children the existing data point was used to prevent loss of data. Children's CBCL anxiety scores ranged from 0–13, where four of the children fell within the clinical range.

Data Analyses Strategy—First, relations among performance on the cognitive regulatory tasks were explored. Second, we examined how the laboratory assessed measures of the cognitive regulatory tasks related to parental report of these measures. Third, the relations between predictor variables (i.e., inhibitory control, attention shifting, behavioral inhibition), outcome variables (i.e., anxiety problems), age, sex, and IQ were examined. Finally, separate hierarchical multiple regression analyses were computed to examine whether attention shifting and inhibitory control moderated the link between behavioral inhibition and anxiety problems.

Results

Descriptive statistics

Means and standard deviations for behavioral inhibition, the attention shifting and inhibitory control tasks, CBQ inhibitory and attentional control scales, and CBCL Anxiety Problem scores are shown in Table 1.

Attention shifting and inhibitory control measures

First, for children that had usable data on all three tasks, simple correlations were run between the two Stroop tasks and the DCCS. The Day-Night and Pointing Stroop tasks were significantly correlated, $r(118) = .32, p = .001$. Neither the Day-Night, $r(118) = 0.06, p = 0.52$, nor the Grass-Snow Stroop, $r(118) = 0.04, p = 0.66$, tasks were correlated with DCCS. The two Stroop tasks were standardized and averaged together to form the *Inhibitory Control* measure. The DCCS was standardized to form the *Attention Shifting* measure.

To examine how the current laboratory assessed measures of inhibitory control and attention shifting related to parent questionnaire measures of inhibitory control and attentional control (attention shifting and attention focusing) from the Children's Behavior Questionnaire (CBQ; Rothbart, et al., 2001) correlations between the measures were computed. Laboratory assessed attention shifting was not significantly correlated to the CBQ attentional control composite, $r(125) = .11, p = 0.23$, or the attention shifting subscale, $r(125) = 0.02, p = 0.85$. However, laboratory assessed attention shifting was correlated with the CBQ subscale of attention focusing, $r(125) = .17, p = .06$. Laboratory assessed inhibitory control was not related with the CBQ subscale of inhibitory control, $r(121) = -0.02, p = 0.87$.

Predictor and Outcome variable relations with age, sex, and IQ

Age was not related to inhibitory control, $r(131) = .11, p = .21$, or attention shifting, $r(136) = .08, p = .34$, likely due to the relatively small range of ages at the 48-month assessment period ($M = 49.29$ months, $SD = 1.30$). Age was also not correlated to 24-month behavioral inhibition, $r(152) = -.02, p = .80$, or anxiety, $r(152) = .03, p = .73$. There were no significant sex differences in attention shifting, $r(134) = -0.40, p = .69$ or inhibitory control, $r(129) = -1.70, p = .10$. There were no sex differences in 24-month behavioral inhibition, $r(150) =$

$-1.06, p = .29$, or anxiety, $t(150) = -0.75, p = .46$. Child IQ as assessed by the WPPSI at 48 months was significantly correlated with inhibitory control, $r(131) = .25, p = .004$, and with attention shifting, $r(135) = .15, p = .09$, at trend. IQ was not correlated to 24-month behavioral inhibition, $r(151) = -.08, p = .35$, or anxiety problems, $r(151) = -.02, p = .85$.

Predictor variable relations with outcome variable

The correlations between the predictor variables (i.e., behavioral inhibition, laboratory assessed inhibitory control, and attention shifting), and the outcome measure of preschool anxiety problems are presented in Table 2. Importantly, correlation results revealed that neither the inhibitory control nor attention shifting were related to behavioral inhibition, suggesting that these are assessing independent aspects of a child's temperament. In addition, the inhibitory control and attention shifting did not correlate with anxiety problems. However, behavioral inhibition was significantly and positively related to anxiety symptoms, $r(152) = 0.22, p < .01$.

Effects of attention shifting and inhibitory control on anxiety

Separate hierarchical multiple regression analyses were computed to examine whether attention shifting and inhibitory control moderated the link between behavioral inhibition and anxiety symptoms. To reduce multicollinearity and aid in interpretation, standardized and mean-centered predictors were used. Then, the interaction terms were computed as the product between the continuous measures of behavioral inhibition and attention shifting or inhibitory control. Sex and IQ were entered as covariates in the first step of two regression analyses. Twenty-four month behavioral inhibition and attention shifting (or inhibitory control) were also entered in the first step of the regression analyses. To test for significant moderation effects of attention shifting (or inhibitory control) on the link between behavioral inhibition and anxiety, the two-way interaction term between behavioral inhibition and attention shifting (or inhibitory control) was entered in the second step of the regression analyses. Although the entire regression models were examined for significance, to test the moderation hypotheses we examined if the second step of each model significantly increased the variance explained by the model. Interactions were probed and plotted according to the guidelines by Aiken and West (1991). High and low levels of the moderators (attention shifting or inhibitory control) were computed as ± 1 SD. Follow up statistical tests from these probes are reported in the text below.

We also examined if a child's IQ had a moderating effect on the link between early behaviorally inhibition and anxiety symptoms during the preschool years. Results revealed that IQ had no influence on the link between BI and anxiety.

Moderating effect of attention shifting on the relation between BI and anxiety

The full model using attention shifting was significant at trend level, $F(4, 130) = 2.10, p = .08$, explaining 6% of the variance in preschool anxiety problems. Although IQ and attention shifting were not significantly related to anxiety problems, behavioral inhibition at two years of age significantly predicted anxiety problems during the preschool years, $\beta = .24, t(130) = 2.74, p = .01$ (see Table 3). The addition of the interaction term between attention shifting and behavioral inhibition significantly improved the model, $\Delta R^2 = 0.02, F(5, 139) = 2.40, p = .04, \beta = -.22, t(129) = -1.85, p = .07$ (see Figure 1).

Follow-up regressions revealed that behavioral inhibition was related to preschool anxiety problems only when children exhibited poor attention shifting. Specifically, within children who exhibited poor attention shifting, high levels of behavioral inhibition predicted anxiety symptoms during the preschool years, $\beta = .40, t(129) = 3.26, p < .01$. However, when

children showed good attention shifting, behavioral inhibition was not associated with later anxiety symptoms, $\beta = .08$, $t(129) = 0.71$, $p = .48$.

Moderating effect of inhibitory control on the relation between BI and anxiety

Overall, the inhibitory control model significantly predicted a child's anxiety problems during preschool, $F(4,126) = 2.33$, $p = .06$, explaining 7% of the variance in preschool anxiety symptoms. Sex, IQ, and inhibitory control were not significantly related to anxiety symptoms, but behavioral inhibition significantly predicted anxiety in the preschool years, $\beta = .26$, $t(126) = 3.04$, $p < .01$ (see Table 3). The addition of the behavioral inhibition and inhibitory control interaction also significantly improved the model, $\Delta R^2 = 0.04$, $F(5,125) = 2.91$, $p = .02$, $\beta = .20$, $t(124) = 2.23$, $p = .03$ (see Figure 2).

Follow-up regressions revealed that behavioral inhibition was related to preschool anxiety problems only when children exhibited high levels of inhibitory control. Specifically, within children who exhibited high levels of inhibitory control, high levels of behavioral inhibition predicted anxiety problems during the preschool years, $\beta = .49$, $t(125) = 3.69$, $p < .001$. However, when children exhibited lower levels of inhibitory control, behavioral inhibition was not associated with later anxiety problems, $\beta = .10$, $t(125) = 0.90$, $p = .37$.

Discussion

Behavioral inhibition identified early in childhood is linked to increased social reticence and anxiety over the course of development (Chronis-Tuscano, et al., 2009; Fox, et al., 2005). The current study examined how two cognitive processes, attention shifting and inhibitory control, may influence the negative developmental trajectories associated with behavioral inhibition. Results revealed that while 24-month behavioral inhibition significantly predicted maternal report of anxiety symptoms during the preschool years, attention shifting and inhibitory control differentially moderated this link. Specifically, high levels of attention shifting appear to serve as a protective factor, whereas high levels of inhibitory control may put a behaviorally inhibited child at risk for heightened anxiety symptoms. Taken together, the two distinct forms of regulatory processes showed differing patterns of contribution to the risk for psychopathology in behaviorally inhibited children.

The ability to flexibly shift attention is thought to play an important role in adaptive regulation of negative temperamental reactivity (Eisenberg, Smith, Sadovsky, & Spinrad, 2004; Rothbart, Ziaie, & O'Boyle, 1992). Indeed, in the current study, laboratory assessed attention shifting significantly moderated the relation between behavioral inhibition and anxiety symptoms during the preschool years. Specifically, high levels of behavioral inhibition in toddlerhood predicted high levels of anxiety symptoms during the preschool years only for children exhibiting low levels of attention shifting; this association was not detected in children showing high levels of attention shifting abilities. Thus, the current study suggests that ability to flexibly shift attention protects a behaviorally inhibited child from the development of negative emotional outcomes.

Although the current study cannot tease apart the exact mechanisms in which attention shifting appears to reduce the presence of anxiety symptoms, the ability to flexibly shift attention within their environment may help to attenuate the negative reactivity experienced by the behaviorally inhibited child (Eisenberg, et al., 2004). The ability to shift attentional focus away from threat, whether it be a specific stimuli or a negative thought, is likely one protective mechanism afforded to the child by high levels attention shifting. Previous research has shown that children and adolescents with fearful temperaments tend to allocate their attention towards threatening information (Lonigan & Vasey, 2009; Lonigan, Vasey, Phillips, & Hazen, 2004; Perez-Edgar, et al., 2010), a processing bias associated with

increased emotional vulnerability and the development of anxiety (MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002). However, children with fearful temperaments that exhibit high levels of attentional control do not show the bias to allocate their attention towards threat (Lonigan & Vasey, 2009; Lonigan, et al., 2004) and as a result may experience less anxiety symptoms across development. Thus, for children with a proclivity to attend to threatening information in their environments, the inability to flexibly shift their attention away from such threat may lead to increased experiences of anxiety, whereas the ability to flexibly shift attention away from threat may reduce a behaviorally inhibited child's vulnerability to experience anxiety symptoms (White, Helfinstein, & Fox, 2010).

Even though the current study did not assess attention shifting in the presence of emotional stimuli or during an emotional induction procedure, it is possible that the ability to shift attention as assessed in the current task under neutral conditions would generalize to situations in which emotional content is present. That is, a child's attention shifting measured in the current task of the DCCS likely reflects their ability to shift attention across a variety of contexts (e.g., when experiencing a negative emotion or in the presence of a threat cue). Future research should further assess how attention shifting in the context of neutral and emotional contexts is related and explore the specific mechanisms by which attention shifting aids in the reduction of negative reactivity and anxiety vulnerability.

Whereas relatively high levels of attention shifting served as a protective factor against the development of anxiety symptoms for children high in behavioral inhibition, high levels of inhibitory control served as a risk factor for these children. For most children, high levels of inhibitory control are an adaptive factor for social and emotional development. However, the current study suggests that high levels of inhibitory control put behaviorally inhibited children at increased risk for experiencing anxiety symptoms. The combination of high levels of involuntary control, as result of active fear circuitry associated with behavioral inhibition, and high levels of voluntary control (i.e., inhibitory control) likely leads to excessive levels of behavioral and cognitive control that exacerbate anxious symptoms in these children.

Although the exact mechanisms by which increased inhibitory control can lead to increased anxiety symptoms in behaviorally inhibited children remains unclear, high levels of both involuntary and voluntary control systems may lead to an inability to modulate one's level of control across different contexts. The ability to adapt or adjust one's level of control over a variety of contexts is thought to play an import role in healthy developmental outcomes (Block & Block, 1980; Eisenberg, Fabes, Guthrie, & Reiser, 2002). Heightened behavioral inhibition is associated with a pattern of heightened vigilance and behavioral monitoring (McDermott et al., 2009); behaviorally inhibited children are excessively concerned about their performance, making mistakes and are constantly evaluating their own performance in a social context. A child with this pattern of behavior who is also high in inhibitory control may not flexibly engage their control processes, resulting in a pattern of rigid, inflexible, and overcontrolled behaviors (Derryberry & Rothbart, 1997; Rothbart & Sheese, 2007). Overcontrol likely results in increased anxious behaviors (e.g., increased withdrawal behaviors or decreased approach behaviors during unfamiliar situations) in these children.

Additionally, over the course of development, as children with heightened BI increase their proclivity for anxious cognitions (e.g., worry and rumination) (Muris, Merckelbach, Meesters, & van den Brand, 2002), high levels of inhibitory control may facilitate anxious cognitions. In a group of anxious adults, high levels of inhibitory control (as measured by Stroop performance) were associated with increased worry and anxiety symptoms (Price & Mohlman, 2007). The authors speculate that high levels of inhibitory control may actually facilitate worry, thereby elevating anxiety in some individuals. Nolen-Hoeksema (2000) has

also suggested that increased monitoring of past performance may be associated with increased rumination, a cognitive process associated with psychopathology. Behaviorally inhibited children with high levels of inhibitory control may be better able to monitor their responses and reflect on past errors, leading to increased levels of rumination (McDermott & Fox, 2010) and increased anxiety symptoms.

Another way of interpreting the current results is to view the enhanced inhibitory control as a result of heightened cautiousness in some behaviorally inhibited children. Behaviorally inhibited children are reticent to approach unfamiliar adults or peers (Fox, et al., 2005; Kagan, Reznick, Clarke, Snidman, & Garcia-Coll, 1984). They are also more cautious in response to novel or unfamiliar environments and such caution may be related to their heightened performance on the inhibitory control tasks. Whereas the current results find no direct association between BI and inhibitory control, evidence from a different longitudinal cohort of behaviorally inhibited children supports this explanation. Guyer et al. (2006) and Bar-Haim et al. (2009) found that adolescents characterized as behaviorally inhibited in childhood were more likely to exhibit increased activation in the ventral striatum when performing a task in which they would anticipate receiving monetary reward or punishment based upon their performance. When receiving a reward was not contingent on their motor response, these brain activation effects were not present. The authors interpret these findings as suggesting that behaviorally inhibited participants were more cautious and concerned about their performance than non-inhibited age mates. Future developmental studies could assess a child's level of concern over their performance and cautiousness and associations with inhibitory control.

The current findings may have important implications for prevention and intervention research. Recent research has shown that in children components of cognitive regulatory processes are amenable to improvement through training (Diamond, Barnett, Thomas, & Munro, 2007; Rueda, Rothbart, McCandliss, Saccomanno, & Posner, 2005). As such, it may be possible to help improve attention shifting abilities in behaviorally inhibited children at risk for anxiety symptoms. Such improvements may be directly related to decreases in the amount of anxiety experienced by these children over the course of development.

The results from the current study should be considered in light of several limitations. Correlations between the laboratory measures of inhibitory control or attention shifting and parent-report questionnaire assessments of these constructs were not significant. Such a lack of convergence is quite common in childhood temperament research (Kagan and Fox, 2006), as the questionnaire and laboratory measures of attention shifting and inhibitory control may be tapping different aspects of these cognitive regulatory processes. For example, parental report of effortful control may reflect a child's abilities across a wide range of conditions whereas laboratory assessment of attention shifting and inhibitory control may reflect children's abilities during a mildly stressful situation (e.g., performance in an unfamiliar setting and in the presence of a stranger). Additionally, lack of convergence could indicate that both laboratory and questionnaire assessments are poor measures of the same underlying construct. Furthermore, in a report by Rothbart and colleagues on the reliability and validity of the Child Behavior Questionnaire (2001), the attention shifting items of the questionnaire were not included in the effortful control factor and in fact, in the current version of the CBQ there is no Attention Shifting scale. Therefore, in the current study the lack of correlation between laboratory assessed and parental reports of attention shifting may be as much a result of different methods as reflecting differences in the meaning of attention shifting.

Additionally, the current moderation effects may reflect a combination of cognitive factors, not purely attention shifting or inhibitory control processes, such as working memory.

Recent research in both adults (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000) and children (Garon, Bryson, & Smith, 2008) suggests that inhibitory control, attention shifting, and working memory abilities are three separable, albeit not fully independent, components of an individual's executive function (i.e., effortful control). The utilization of commonly administered tasks to assess both inhibitory control (i.e., Day-Night Stroop and Grass-Snow Stroop) and attention shifting (i.e., DCCS), suggest the findings in the current study are a result of specific differences in the two separable cognitive regulatory processes. Further studies that examine the interactions between temperamental reactivity and other aspects of executive function, such as working memory, on developmental outcomes may clarify the specificity of which components of executive function influence the link between temperamental reactivity and anxious behavior.

Two additional limitations should be considered for the current study: first, the pattern of results detected in the sample may differ as a function of social-economic status or maternal education. The current sample while ethnically diverse was rather homogeneous in SES. Second, there was no clinical assessment of a child's socioemotional functioning during the preschool years. The outcome measure used was a maternal report of anxiety problems and only scores from four children fell within the clinical cut-off range. Thus, the current results are assessing how attention shifting and inhibitory control moderate the link between behavioral inhibition and sub-clinical levels of anxiety. To better understand how attention shifting and inhibitory control serve as protective and/or risk factors for the development of anxiety disorders in behaviorally inhibited children, future work should examine the influence that these cognitive processes have on clinical levels of anxiety.

Given that behaviorally inhibited children are at heightened risk for anxiety problems (Chronis-Tuscano, et al., 2009), the cognitive processes underlying effortful control that contribute to adaptive regulation of negative reactivity play an important role in the developmental link between temperament and psychopathology (Lonigan et al., 2004; Muris et al., 2008; Perez-Edgar & Fox, 2007). The current study offers evidence to support the notions that different cognitive processes underlying effortful control moderate the link between BI and anxiety. As well, it appears that for some children, high levels of cognitive regulation (i.e., inhibitory control) can lead to increased risk for maladaptive developmental outcomes. These findings suggest that the different cognitive regulatory processes that contribute to effortful control may influence relative levels of risk or resilience for maladaptive developmental outcomes depending upon that child's temperamental reactivity.

However, attention shifting and inhibitory control will likely only show the current pattern of moderation within this specific type of temperamentally reactive population (i.e., children with high levels of behavioral inhibition), and patterns may be different for children displaying greater positive reactivity to novelty or heightened anger to goal blockage. Moreover, the influence that attention shifting and inhibitory control have on the link between temperamental reactivity and socioemotional outcomes may differ throughout development. Future research examining effortful control and psychopathology should explore how inhibitory control and attention shifting, two separable cognitive processes underlying effortful control, lead to optimal regulation and influence psychopathology among different temperamentally reactive populations and during different periods throughout development.

References

- Achenbach TM, Ruffle TM. The Child Behavior Checklist and related forms for assessing behavioral/emotional problems and competencies. *Pediatrics in Review*. 2000; 21(8):265–271. [PubMed: 10922023]

- Bar-Haim Y, Fox NA, Benson B, Guyer AE, Williams A, Nelson EE, Ernst M. Neural Correlates of Reward Processing in Adolescents With a History of Inhibited Temperament. *Psychological Science*. 2009; 20(8):1009–1018.10.1111/j.1467-9280.2009.02401.x [PubMed: 19594857]
- Biederman J, Rosenbaum JF, Hirshfeld DR, Faraone SV, Bolduc EA, Gersten M, Meminger SR, Kagan J, Snidman N, Reznick JS. Psychiatric correlates of behavioral inhibition in young children of parents with and without psychiatric disorders. *Archives of General Psychiatry*. 1990; 47(1):21–26. [PubMed: 2294852]
- Block, JH.; Block, J. The role of ego-control and ego-resiliency in the organization of behavior. In: Collins, WA., editor. *The Minnesota Symposia on Child Psychology*. Vol. 13. Hillsdale, NJ: Erlbaum; 1980. p. 39-101.
- Calkins SD, Fox NA, Marshall TR. Behavioral and physiological antecedents of inhibited and uninhibited behavior. *Child Dev*. 1996; 67(2):523–540.10.1111/j.1467-8624.1996.tb01749.x [PubMed: 8625726]
- Carlson SM. Developmentally sensitive measures of executive function in preschool children. *Developmental Neuropsychology*. 2005; 28(2):595–616.10.1207/s15326942dn2802_3 [PubMed: 16144429]
- Carlson SM, Moses LJ. Individual differences in inhibitory control and children's theory of mind. *Child Development*. 2001; 72(4):1032–1053. [PubMed: 11480933]
- Carver CS. Impulse and constraint: perspectives from personality psychology, convergence with theory in other areas, and potential for integration. *Personality and Social Psychology Review*. 2005; 9(4):312–333.10.1207/s15327957pspr0904_2 [PubMed: 16223354]
- Chronis-Tuscano A, Degnan KA, Pine DS, Perez-Edgar K, Henderson HA, Diaz Y, Fox NA. Stable early maternal report of behavioral inhibition predicts lifetime social anxiety disorder in adolescence. *Journal of the American Academy of Child and Adolescent Psychiatry*. 2009; 48(9): 928–935.10.1097/CHI.0b013e3181ae09dfS0890-8567(09)60148-9 [pii] [PubMed: 19625982]
- Degnan KA, Fox NA. Behavioral inhibition and anxiety disorders: multiple levels of a resilience process. *Developmental Psychopathology*. 2007; 19(3):729–746. S0954579407000363 [pii]. 10.1017/S0954579407000363
- Derryberry D, Rothbart MK. Arousal, affect, and attention as components of temperament. *Journal of Personality and Social Psychology*. 1988; 55(6):958–966.10.1037/0022-3514.55.6.958 [PubMed: 3216290]
- Derryberry D, Rothbart MK. Reactive and effortful processes in the organization of temperament. *Developmental Psychopathology*. 1997; 9(4):633–652.10.1017/S0954579497001375
- Diamond A, Barnett WS, Thomas J, Munro S. Preschool program improves cognitive control. *Science*. 2007; 318(5855):1387–1388. 318/5855/1387 [pii]. 10.1126/science.1151148 [PubMed: 18048670]
- Eisenberg, N.; Fabes, RA.; Guthrie, IK.; Reiser, M. The role of emotionality and regulation in children's social competence and adjustment. In: Caspi, LPA., editor. *Paths to successful development: Personality in the life course*. New York: Cambridge University Press; 2002. p. 46-70.
- Eisenberg N, Sadovsky A, Spinrad TL, Fabes RA, Losoya SH, Valiente C, Shepard SA. The relations of problem behavior status to children's negative emotionality, effortful control, and impulsivity: concurrent relations and prediction of change. *Developmental Psychology*. 2005; 41(1):193–211.10.1037/0012-1649.41.1.193 [PubMed: 15656749]
- Eisenberg N, Shepard SA, Fabes RA, Murphy BC, Guthrie IK. Shyness and children's emotionality, regulation, and coping: contemporaneous, longitudinal, and across-context relations. *Child Development*. 1998; 69(3):767–790.10.1111/j.1467-8624.1998.tb06242.x [PubMed: 9680684]
- Eisenberg, N.; Smith, CL.; Sadovsky, A.; Spinrad, TL. Effortful control: Relations with emotion regulation, adjustment, and socialization in childhood. In: BRF; Vohs, KD., editors. *Handbook of self-regulation: Research, theory, and applications*. New York: Guilford Press; 2004. p. 259-282.
- Eisenberg N, Valiente C, Spinrad TL, Liew J, Zhou Q, Losoya SH, Cumberland A. Longitudinal relations of children's effortful control, impulsivity, and negative emotionality to their externalizing, internalizing, and co-occurring behavior problems. *Developmental Psychology*. 2009; 45(4):988–1008. 2009-09998-024 [pii]. 10.1037/a0016213 [PubMed: 19586175]

- Fox, NA.; Henderson, HA. Temperament, emotion, and executive function: Influences on the development of self-regulation. Paper presented at the Annual Meeting of the Cognitive Neuroscience Society; San Francisco. 2000.
- Fox NA, Henderson HA, Marshall PJ, Nichols KE, Ghera MM. Behavioral inhibition: linking biology and behavior within a developmental framework. *Annual Review of Psychology*. 2005; 56:235–262.
- Fox NA, Henderson HA, Rubin KH, Calkins SD, Schmidt LA. Continuity and discontinuity of behavioral inhibition and exuberance: psychophysiological and behavioral influences across the first four years of life. *Child Development*. 2001; 72(1):1–21.10.1111/1467-8624.00262 [PubMed: 11280472]
- Frye D, Zelazo PD, Palfai T. Theory of mind and rule-based reasoning. *Cognitive Development*. 1995; 10:483–527.10.1016/0885-2014(95)90024-1
- Gerardi-Caulton G. Sensitivity to spatial conflict and the development of self-regulation in children 24–26 months of age. *Developmental Science*. 2000; 3(4):397–404.
- Gerstadt CL, Hong YJ, Diamond A. The relationship between cognition and action: performance of children 3 1/2–7 years old on a Stroop-like day-night test. *Cognition*. 1994; 53(2):129–153.10.1016/0010-0277(94)90068-X [PubMed: 7805351]
- Guyer AE, Nelson EE, Perez-Edgar K, Hardin MG, Roberson-Nay R, Monk CS, Ernst M. Striatal functional alteration in adolescents characterized by early childhood behavioral inhibition. *Journal of Neuroscience*. 2006; 26(24):6399–6405.10.1523/JNEUROSCI.0666-06.2006 [PubMed: 16775126]
- Hane AA, Fox NA, Henderson HA, Marshall PJ. Behavioral reactivity and approach-withdrawal bias in infancy. *Developmental Psychology*. 2008; 44(5):1491–1496. 2008-12114-026 [pii]. 10.1037/a0012855 [PubMed: 18793079]
- Henderson HA. Neural correlates of cognitive control and the regulation of shyness in children. *Developmental Neuropsychology*. 2010; 35(2):177–193.10.1080/87565640903526538 [PubMed: 20390601]
- Kagan, J.; Fox, NA. Biology, culture, and temperamental biases. In: Damon, W.; Eisenberg, N., editors. *Handbook of child psychology: Social, emotional, and personality development*. Vol. 3. New York: Wiley; 2006.
- Kagan J, Reznick JS, Clarke C, Snidman N, Garcia-Coll C. Behavioral Inhibition to the Unfamiliar. *Child Development*. 1984; 55:2212–2225.
- Kagan J, Reznick JS, Snidman N. The physiology and psychology of behavioral inhibition in children. *Child Development*. 1987; 58:1459–1473. [PubMed: 3691195]
- Kieras JE, Tobin RM, Graziano WG, Rothbart MK. You can't always get what you want: effortful control and children's responses to undesirable gifts. *Psychological Science*. 2005; 16(5):391–396. [PubMed: 15869699]
- Lonigan, CJ.; Phillips, BM. Temperamental basis of anxiety disorders in children. In: Vasey, MW.; Dadds, M., editors. *The developmental psychopathology of anxiety*. New York: Oxford University Press; 2001. p. 60-91.
- Lonigan CJ, Vasey MW. Negative affectivity, effortful control, and attention to threat-relevant stimuli. *Journal of Abnormal Child Psychology*. 2009; 37(3):387–399.10.1007/s10802-008-9284-y [PubMed: 19043783]
- Lonigan CJ, Vasey MW, Phillips BM, Hazen RA. Temperament, anxiety, and the processing of threat-relevant stimuli. *Journal of Clinical Child and Adolescent Psychology*. 2004; 33(1):8–20.10.1207/S15374424JCCP3301_2 [PubMed: 15028537]
- MacLeod C, Rutherford E, Campbell L, Ebworthy G, Holker L. Selective attention and emotional vulnerability: assessing the causal basis of their association through the experimental manipulation of attentional bias. *Journal of Abnormal Psychology*. 2002; 111(1):107–123.10.1037/0021-843X.111.1.107 [PubMed: 11866165]
- McDermott, JM.; Fox, NA. Exploring response-monitoring: Developmental differences and contributions to self-regulation. In: Hoyle, RH., editor. *Handbook of Self-Regulation and Personality*. Oxford, UK: Wiley-Blackwell Publishing; 2010. p. 91-113.

- McDermott JM, Perez-Edgar K, Henderson HA, Chronis-Tuscano A, Pine DS, Fox NA. A history of childhood behavioral inhibition and enhanced response monitoring in adolescence are linked to clinical anxiety. *Biological Psychiatry*. 2009; 65(5):445–448.10.1016/j.biopsych.2008.10.043 [PubMed: 19108817]
- Muris P, Mayer B, van Lint C, Hofman S. Attentional control and psychopathological symptoms in children. *Personality and Individual Differences*. 2008; 44:1495–1505.10.1016/j.paid.2008.01.006
- Nolen-Hoeksema S. The role of rumination in depressive disorders and mixed anxiety/depressive symptoms. *Journal of Abnormal Psychology*. 2000; 109(3):504–511. doi: 101037/10021-843X.109.3.504. [PubMed: 11016119]
- Perez-Edgar K, Fox NA. A behavioral and electrophysiological study of children's selective attention under neutral and affective conditions. *Journal of Cognition and Development*. 2005; 6(1):89–118.10.1207/s15327647jcd0601_6
- Perez-Edgar K, Fox NA, Bar-Haim Y, Martin McDermott J, Pine DS. Attention bias to threat link behavioral inhibition in early childhood to adolescent social withdrawal. *Emotion*. 2010; 10(3):349–357.10.1037/a0018486, [PubMed: 20515224]
- Posner MI, Rothbart MK. Developing mechanisms of self-regulation. *Development and Psychopathology*. 2000; 12:427–441.10.1017/S0954579400003096 [PubMed: 11014746]
- Price RB, Mohlman J. Inhibitory control and symptom severity in late life generalized anxiety disorder. *Behaviour Research and Therapy*. 2007; 45(11):2628–2639.10.1016/j.brat.2007.06.007 [PubMed: 17662240]
- Rothbart MK, Ahadi SA, Hershey KL, Fisher P. Investigations of temperament at three to seven years: the Children's Behavior Questionnaire. *Child Development*. 2001; 72(5):1394–1408. [PubMed: 11699677]
- Rothbart MK, Ellis LK, Rueda MR, Posner MI. Developing mechanisms of temperamental effortful control. *Journal of Personality*. 2003; 71:1113–1143.10.1111/1467-6494.7106009 [PubMed: 14633060]
- Rothbart, MK.; Posner, MI.; Hershey, KL. Temperament, attention, and developmental psychopathology. In: Cohen, DCD., editor. *Developmental Psychopathology: Vol. 2: Developmental Neuroscience*. 2. New York: Wiley; 1995. p. 465-501.
- Rothbart, MK.; Sheese, BE. Temperament and Emotion Regulation. In: Gross, JJ., editor. *Handbook of emotion regulation*. New York: Guilford Press; 2007. p. 331-350.
- Rothbart MK, Ziaie H, O'Boyle CG. Self-regulation and emotion in infancy. *New Directions for Child and Adolescent Development*. 1992; 55:7–23.10.1002/cd.23219925503
- Rueda MR, Rothbart MK, McCandliss BD, Saccomanno L, Posner MI. Training, maturation, and genetic influences on the development of executive attention. *Proceedings of the National Academy of Sciences of the United States of America*. 2005; 102(41):14931–14936. 0506897102 [pii]. 10.1073/pnas.0506897102 [PubMed: 16192352]
- Schwartz CE, Snidman N, Kagan J. Adolescent social anxiety as an outcome of inhibited temperament in childhood. [Article]. *Journal of the American Academy of Child and Adolescent Psychiatry*. 1999; 38(8):1008–1015.10.1097/00004583-199908000-00017 [PubMed: 10434493]
- Thorell L, Bohlin G, Rydell A. Two types of inhibitory control: Predictive relations to social functioning. *International Journal of Behavioral Development*. 2004; 28(3):193–203.10.1080/01650250344000389
- Wechsler, D. *WPPSI-III administration and scoring manual*. San Antonio, TX: 2002.
- White, LK.; Helfinstein, SM.; Fox, NA. Temperamental Factors Associated with the Acquisition of Information Processing Biases and Anxiety. In: Hadwin, JA.; Field, AP., editors. *Information Processing Biases and Anxiety: A Developmental Perspective*. Wiley-Blackwell; 2010.
- White LK, Helfinstein SM, Reeb-Sutherland BC, Degnan KA, Fox NA. Role of attention in the regulation of fear and anxiety. *Developmental Neuroscience*. 2009; 31(4):309–317. 000216542 [pii]. 10.1159/000216542 [PubMed: 19546568]
- Zelazo PD. The dimensional change card sort (DCCS): A method of assessing executive function in children. *Nature Protocols*. 2006; 1:297–301.10.1038/nprot.2006.46

Figure 1.
Joint effect of behavioral inhibition and attention shifting on preschool anxiety symptoms

Figure 2.
Joint effect of behavioral inhibition and inhibitory control on preschool anxiety symptoms

Table 1

Descriptive statistics of predictor and outcome variables

Variable	<i>n</i>	<i>M (SD)</i>
24 month BI	152	.001 (.52)
Day/Night Stroop ^a	137	67.06 (24.07)
Grass/Snow Stroop ^a	144	77.77 (28.96)
DCCS	136	55.00 (44.32)
CBQ Inhibitory Control	141	4.86 (0.64)
CBQ Attentional Control	141	4.47 (0.64)
Preschool anxiety problems	152	2.92 (2.30)

^a Means for cognitive tasks are reported in percent accuracy rates.

Table 2

Correlations of predictor and outcome variables

	Attention Shifting	Behavioral Inhibition	Anxiety Problems
Inhibitory Control	.06	.04	.01
Attention Shifting	—	.03	.07
Behavioral Inhibition	—	—	.22*

*
 $p < .01$

Table 3

24-month behavioral inhibition by 4-year attention shifting and inhibitory control predicting preschool anxiety symptoms

Attention Shifting				
Variable	R²	B	SE B	B
<i>Step 1 (df 4/130)</i>	.06			
Sex		.09	.41	.02
IQ		.006	.01	.05
BI		1.07	.39	.24**
AS		.11	.20	.05
<i>Step 2 (df 1/129)</i>	.09			
BIxAS		-.71	.38	-.16*
Inhibitory Control				
<i>Step 1 (df 4/126)</i>	.07			
Sex		-.08	.43	-.02
IQ		.005	.01	.04
BI		1.20	.39	.26**
IC		-.005	.26	-.002
<i>Step 2 (df 1/125)</i>	.10			
BIxIC		1.09	.49	.20*

* $p < .07$,

** $p < .01$