



## SHORT REPORT

## Sensitivity to social and non-social threats in temperamentally shy children at-risk for anxiety

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## Abstract

*In the current brief report, we examined threat perception in a group of young children who may be at-risk for anxiety due to extreme temperamental shyness. Results demonstrate specific differences in the processing of social threats: 4- to 7-year-olds in the high-shy group demonstrated a greater bias for social threats (angry faces) than did a comparison group of low-shy children. This pattern did not hold for non-social threats like snakes: Both groups showed an equal bias for the detection of snakes over frogs. The results suggest that children who are temperamentally shy have a heightened sensitivity to social signs of threat early in development. These findings have implications for understanding mechanisms of early threat sensitivity that may predict later socioemotional maladjustment.*

## Introduction

The ability to recognize and detect threatening stimuli has been of interest to researchers for decades. Across countless studies, researchers have shown that adult humans and non-human primates detect threat-relevant stimuli more rapidly than benign control displays. More specifically, when presented with arrays of four or nine photographs, adult humans more quickly detect photographs of threatening stimuli such as snakes, spiders, and angry faces over non-threatening stimuli like flowers, mushrooms, and happy or neutral faces (e.g. Öhman, Flykt & Esteves, 2001a; Öhman, Lundqvist & Esteves, 2001b). Similarly, non-human primates such as Japanese monkeys detect a snake image among flowers more rapidly than a flower image among snakes in 3-by-3 matrices on a touch-screen computer display (Shibasaki & Kawai, 2009).

Until recently, research on threat perception focused almost exclusively on adult participants, making it difficult to study the mechanisms by which humans come to be sensitive to threatening stimuli in the environment. Also left open is the question of how threat sensitivity may come to differentially shape

developmental trajectories. This is a key question for research as early information processing biases associated with threat sensitivity may be linked to long-term patterns of socioemotional functioning (Donnelly, Hadwin, Menneer & Richards, 2010). The gap in the literature is in part due to the fact that the standard visual search paradigm used with adults – which involves pressing one key if all photographs in a matrix are from a single category (e.g. all flowers) and pressing a different key if there is a single discrepant image (e.g. one snake among flowers) – is not suitable for testing young children. As a result, researchers developed an alternative touch-screen paradigm to examine detection in young children (LoBue & DeLoache, 2008). Participants are presented with 3 × 3 matrices of photographs, each containing eight photos from a stimulus category and one photo from a different target category. They are then instructed to find and touch the target on the screen as quickly as possible.

The touch-screen method produces the same results in adults found using the standard visual search paradigm: Adults detect snakes more quickly than flowers, and more quickly than stimuli that strongly resemble snakes, such as frogs and caterpillars (LoBue & DeLoache,

2008). Adults also detect spiders more quickly than both mushrooms and cockroaches (LoBue, 2010), and angry faces more quickly than happy or neutral faces (LoBue, 2009). Most important, the touch-screen paradigm evokes analogous results with preschool children: Just like adults, 3- to 5-year-olds detect snakes more quickly than flowers, frogs, and caterpillars (LoBue & DeLoache, 2008), spiders more quickly than mushrooms and cockroaches (LoBue, 2010), and angry faces more quickly than happy and neutral faces (LoBue, 2009).

Although fewer studies have focused on threat detection in clinical populations, there is work suggesting that some groups of individuals are acutely sensitive to threat-relevant stimuli relative to healthy control groups. Adults with snake or spider phobias, for example, detect the object of their phobia more quickly than non-phobic controls (Öhman *et al.*, 2001a). Adults with clinical anxiety are more sensitive to a variety of threatening stimuli when compared to non-anxious adults, including threatening faces and threatening words (for review, see Bar-Haim, Dominique, Lee, Bakermans-Kranenburg & van Ijzendoorn, 2007). Further, anxious adults are slower to detect non-threatening target stimuli when threatening stimuli are used as distracters (Byrne & Eysenck, 1995). This work suggests that fearful or anxious adults have enhanced threat sensitivities, particularly when linked to idiosyncratic domains of concern.

These data are intriguing as biases toward threat have been implicated as a causal mechanism in the emergence of anxiety (Hakamata, Lissek, Bar-Haim, Britton, Fox, Leibenluft, Ernst & Pine, 2010) and are associated with both temperamental (Pérez-Edgar, Bar-Haim, McDermott, Chronis-Tuscano, Pine & Fox, 2010; Pérez-Edgar, Reeb-Sutherland, McDermott, White, Henderson, Degnan, Hane, Pine & Fox, 2011) and genetic (Pergamin-Hight, Bakermans-Kranenburg, van IJzendoorn & Bar-Haim, 2012) markers of risk. The little work that has been done with anxious children (aged 8 to 13) suggests that enhanced threat perception is evident before adulthood (e.g. Muris, Rapee, Meesters, Schouten & Geers, 2003). However, there has been no research examining threat perception in at-risk children under age 8, before children are typically diagnosed with clinical anxiety. Such work could be useful in determining whether heightened sensitivity to threat and enhanced threat detection develops after the onset of anxiety or whether heightened sensitivity might serve as an underlying mechanism in the later emergence of anxious behavior.

In the current brief report, we examined threat detection in healthy preschool and elementary school children who demonstrate early risk factors for anxiety. To date, temperamental shyness stands as one of our strongest predictors of anxiety (Pérez-Edgar & Fox,

2005), with a specific link to social anxiety (Chronis-Tuscano, Degnan, Pine, Pérez-Edgar, Henderson, Diaz, Raggi & Fox, 2009; Rapee & Spence, 2004). As such, children identified as temperamentally shy were asked to detect threatening (snakes and angry faces) and non-threatening (frogs and happy faces) stimuli in a touch-screen visual search paradigm. We had three goals. First, we asked whether children rated high in temperamental shyness, and presumably at increased risk for anxiety, demonstrate heightened threat sensitivity relative to a low-shy comparison group. Second, we asked whether differences in threat sensitivity are specific to social threats, as marked by angry faces, or whether such differences are more global in nature, extending to both social and non-social threats. The generalizability of early threat biases may refine our understanding of the mechanisms that shape developmental patterns in children at temperamental risk for anxiety. Third, we asked whether performance during the detection task predicted patterns of maladjustment above and beyond the risk incurred by early, extreme temperamental shyness.

## Method

### *Participants*

Forty-six children between the ages 4 and 7 years (range: 4.6 to 7.0 years) were recruited for the experiment from a major metropolitan community. The surrounding county of approximately 1.1 million residents has a median household income of \$105,416 and is 62.7% White, Non-Hispanic (US Census Bureau, 2012). Participants were recruited via Experian Marketing Solutions (Schaumburg, IL), a company with access to large databases including the names, addresses, and dates of birth of children within the United States. We requested contact information for households in designated zip codes with children in our age range of interest.

Potential participants ( $N = 183$ ) were screened for a larger study of social behavior in young children using maternal report of temperamental shyness via the Colorado Child Temperament Inventory (CCTI; Buss & Plomin, 1984). Children high in temperamental shyness are at increased risk for exhibiting social anxiety in middle childhood and adolescence (e.g. Pérez-Edgar & Fox, 2005). Much of this work has employed an extreme-groups approach, focusing on children at a qualitatively increased risk for anxiety (Chronis-Tuscano *et al.*, 2009). To mirror this previous work, children with extreme scores were invited to participate and were designated as the high-shy group (see below). Likewise, children with low shyness scores were invited to participate. The

children in the low-shy group were conceptualized to be a comparison group based on our main variable of interest, temperamental shyness. These children were not necessarily high on contrasting temperamental traits, such as exuberance or risk-taking, which are often negatively correlated with, but distinct from, temperamental shyness (Rothbart & Bates, 2007). The final sample consisted of 21 high-shy (10 male, 11 female; Mean<sub>Age</sub> = 5.9), and 25 low-shy (16 male, 9 female; Mean<sub>Age</sub> = 5.8) children. The groups were equivalent in age and gender distribution ( $ps > .26$ ).

The final sample was predominantly Caucasian (76.1%) with an additional 13.0% self-identifying as Asian-American, African-American, or Hispanic. The final 10.9% self-identified as multi-racial. All families reported English as the primary language spoken at home and all but one child (low-shy) was residing with his or her biological parent. All children were born within two weeks of their due date and had adequate birth weight ( $> 2500$  g). There were no group differences in age for achieving major motor milestones (e.g. sitting, crawling, walking,  $ps > .50$ ). All children were currently enrolled in either preschool ( $N = 10$ ) or elementary school (Kindergarten through 2nd grade), with no difference across groups,  $p = .72$ .

As noted above, selection was based on shyness levels reported on the CCTI and exclusionary criteria focused exclusively on prior medical and developmental milestone history. As such, the participants were not formally screened for current psychiatric status. However, in characterizing our current sample we reviewed levels of maladjustment, as reported on the Child Behavior Checklist (CBCL; Achenbach, 1991). As expected, children in the high-shy group were higher on continuous ratings from the emotional reactivity, anxiety/depression, and social withdrawal subscales as well as the internalizing scale (all  $ps < .001$ ) relative to the low-shy group. The groups did not differ on the remaining subscales or on the externalizing scale ( $ps > .11$ ). When examining T-score cutoffs, the children were broadly healthy. High-shy children did show more elevated scores on the broadband scales (Internalizing: 2 Borderline, 6 Clinical; Externalizing: 2 Borderline, 1 Clinical) than the low-shy children (Internalizing: 0 Borderline, 1 Clinical; Externalizing: 0 Borderline, 2 Clinical).

### Materials

The stimuli for each experiment consisted of four sets of 24 images: 24 snakes and 24 frogs from LoBue and DeLoache (2008), and 24 angry and 24 happy faces from LoBue (2009; originally obtained from the NimStim face set, Tottenham, Tanaka, Leon, McCarry, Nurse, Hare,

Marcus, Westerlund, Casey & Nelson, 2009). Each stimulus category contained 24 color photographs that were arranged in  $3 \times 3$  matrices, with one target picture from one category and eight distracter pictures from the paired category (e.g. snakes vs. frogs or angry vs. happy faces).

A color touch-screen monitor was used to present each picture matrix on a 61 cm screen. The overall matrix was  $39.4$  cm  $\times$   $39.4$  cm, with  $1.27$  cm between rows and  $0.64$  cm between columns. The individual projected pictures measured  $11.47 \times 8.64$  cm. Each of the 24 pictures in the target category served as the target once, appearing in each of the nine positions in the matrix two or three times. The 24 pictures from the distracter category appeared approximately the same number of times across trials. One stimulus order was created by randomly arranging matrices, and the second order was the reverse of the first. An outline of a child's handprints was located on the table immediately in front of the monitor.

### Procedure

#### Screening measure

As part of the screening process for the larger study, parents were asked to complete a standard temperament measure. The CCTI is a 30-item measure that asks parents to rate their child with a 5-point Likert scale ranging from 1 (Not at all/Strongly disagree) to 5 (A lot/Strongly agree) on six factors pertaining to different dimensions of child temperament, including emotionality, activity, sociability, shyness, attention, and persistence. As temperamental shyness has been identified as one of our strongest predictors of later anxiety, scores on the shyness dimension were used as our main screening measure. For the full sample the mean CCTI shyness score was  $2.34$  ( $SD = 1.06$ ) with a Cronbach's alpha of  $0.915$ .

Cut-off scores from the five-item shyness subscale were derived from previous longitudinal studies (e.g. Fox, Henderson, Marshall, Nichols & Ghera, 2005) to identify children who are temperamentally shy. The top 20% of the normative population distribution were expected to have scores  $> 3.10$  on the shyness scale. Conversely, children at the other end of the distribution were expected to have scores  $< 1.70$ . As such, children with scores in these two ranges were selected for the current study and invited to participate. This resulted in two groups of children designated as high-shy (Mean<sub>CCTI</sub> =  $3.92$ ,  $SD = 0.46$ , Range<sub>CCTI</sub> =  $3.20$ – $4.80$ ) and low-shy (Mean<sub>CCTI</sub> =  $1.31$ ,  $SD = 0.24$ , Range<sub>CCTI</sub> =  $1.00$ – $1.60$ ).

### Child maladjustment measure

The CBCL (Achenbach, 1991) provided a measure of concurrent behavioral and emotional problems among the children. Parents reported on the frequency with which an item was true for their child on a 3-point scale from 0 'not true' to 2 'very true or often true'. The CBCL yields eight narrow-band factors, two broadband factors (internalizing and externalizing behavior problems) and a total problems score.

### General detection procedure

Each child was seated in front of the touch-screen monitor (approximately 40 cm from the base of the screen) and told to place his or her hands on the handprints. This ensured that the child's hands were in the same place at the start of each trial, making it possible to collect reliable reaction time data. The experimenter stood alongside the monitor to instruct the child throughout the procedure.

First, a set of seven practice trials (using the same pictures from the experimental set) was given to teach the child how to use the touch screen. On the first two trials, a single picture appeared on the screen, and the child was asked to verbally label it and touch it on the screen. The first picture was from the target category and the second from the distracter category. Next, the child was presented with two trials employing one target and one distracter picture and asked to touch only the target picture. Finally, three practice trials followed, each involving a different nine-picture matrix. The child was told that for each trial, his or her task was always to find the 'X' (target) among 'Ys' (distracters) as quickly as possible, touch it on the screen, and then return his or her hands to the handprints. All the children readily learned the procedure.

A series of 24 test trials followed. A different picture matrix containing one target and eight distracters was presented on each trial. In between all trials, a large smiley face appeared on the screen. To ensure that the child's full attention was on the screen before each matrix appeared, the experimenter pressed the face when she judged that the child was looking at it, causing the next matrix to appear. Latency was automatically recorded from the onset of the matrix to when the child touched one of the pictures on the screen.

Children participated in this procedure four times, in which they were asked to detect: (1) Angry targets among happy distracters, (2) Happy targets among angry distracters, (3) Snake targets among frog distracters, and (4) Frog targets among snake distracters. Children were randomly assigned to one of eight task

orders that were created to account for potential practice effects.

## Results

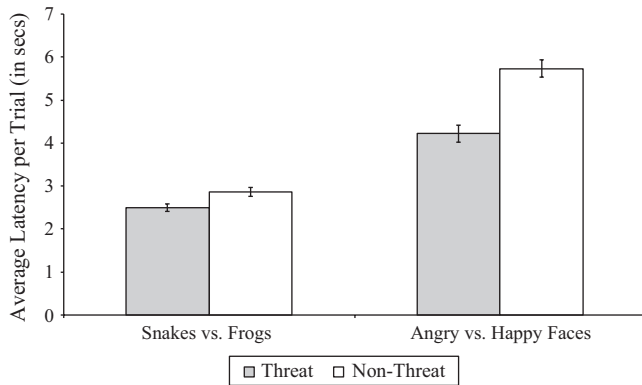
### *Detection of threat versus non-threat*

Based on previous work (LoBue & DeLoache, 2008; LoBue, 2009), we predicted that all children would detect snakes more quickly than frogs, and angry faces more quickly than the happy faces. Thus, as a manipulation check, we first sought to examine whether we were able to replicate previous findings using the touch-screen detection method. We ran two Mixed Effects ANOVAs to examine the detection of snakes versus frogs, and angry versus happy faces. Following standard procedures for visual search tasks, only trials in which the correct target was selected were counted. Participants rarely erred and errors did not vary by target or group (< 3% of the data).

Across analyses, there were no relevant effects of age; this factor was therefore removed from the analyses presented. Task order was included in each model, as young children are susceptible to practice effects and we wanted to control for any variance caused by such effects. Gender was included in each model based on previous work showing gender differences in threat detection tasks (LoBue & DeLoache, 2009). Preliminary analyses indicate that there were no significant three-way interactions, so they were removed from all Mixed Effects models.

In a 2 (Target: snakes versus frogs) by 2 (Gender: male versus female) by 8 (Task Order) Mixed Effects ANOVA on average latency to detect the target, we found a main effect of target,  $F(1, 59) = 6.22, p < .05, d = 0.65$ . As predicted, the snake targets (Mean<sub>Snakes</sub> = 2.50 s) were detected more quickly than the frog targets (Mean<sub>Frogs</sub> = 2.86 s). In a second 2 (Target: angry versus happy faces) by 2 (Gender: male versus female) by 8 (Task Order) Mixed Effects ANOVA on average latency to detect the target, there was again a main effect of target,  $F(1, 60) = 32.52, p < .05, d = 1.47$ . As predicted, the angry targets (Mean<sub>Angry</sub> = 4.22 s) were detected more quickly than the happy targets (Mean<sub>Happy</sub> = 5.73 s). These results thus replicate previous work using the touch-screen method, demonstrating rapid detection of both social (faces) and non-social threats across participants (see Figure 1). A gender by order interaction,  $F(1, 60) = 2.42, p < .05, d = 0.40$ , was also found. According to post-hoc comparisons (Tukey HD), the interaction indicates that for girls, detection of faces in one of the eight task orders (Order 7) was marginally slower ( $m = 6.4$  s) than detection in another task order (Order 5) ( $m = 4.0$  s),  $p = .067$ .



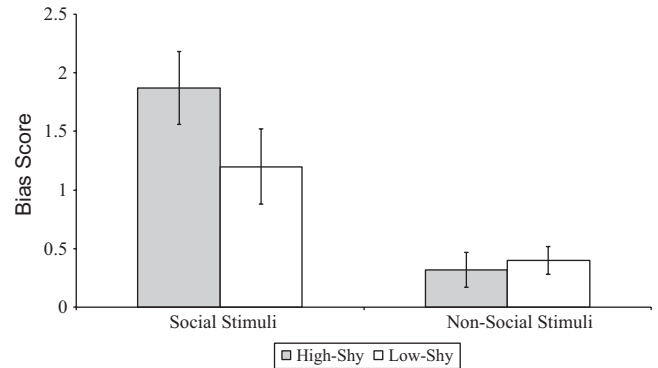


**Figure 1** Average latency in seconds to detect threatening and benign targets across participants. Error bars reflect the standard errors of the mean.

### Individual differences in shyness

Our central question examined whether children who are temperamentally shy would demonstrate heightened threat sensitivity relative to a comparison group. We also asked whether differences in threat sensitivity are relatively specific, holding only for social threats as marked by angry faces, or are global in nature, extending to both social and non-social threats. In order to test these hypotheses, we created a difference score to represent a bias for social threats (angry faces) and a second difference score to represent a bias for non-social threats (snakes). Previous work indicates that adults with anxiety not only detect social threats more quickly than do non-anxious controls, but they are also slower to detect non-threatening targets when social threats are used as the distracters (Bar-Haim *et al.*, 2007; Byrne & Eysenck, 1995; Gilboa-Schechtman, Foa & Amir, 1999; Mogg & Bradley, 2002; Waters & Valvoi, 2009). The conditions we are contrasting are threatening targets among non-threatening distracters and non-threatening targets among threatening distracters. A difference score captures in one dependent measure the effect of threat when functioning as both target and distracter. This method for calculating biases is commonly used in other attentional tasks, such as the classic dot-probe task (e.g. Pérez-Edgar *et al.*, 2010).

Thus, for each participant, we subtracted average latency to detect angry faces from average latency to detect happy faces (bias for social threats), and subtracted average latency to detect snake targets from average latency to detect frog targets (bias for non-social threats). Positive scores indicate a bias for threats, while negative scores indicate a bias for non-threats. Larger scores indicate a stronger bias than do lower scores. As expected, mean reaction times to detect angry and happy faces were significantly correlated ( $r = 0.341$ ,  $p = .009$ ) and the



**Figure 2** Bias scores for detecting social and non-social threats for the at-risk and comparison groups. Higher scores indicate increased bias for threat and the error bars reflect the standard errors of the mean.

calculated bias score was associated with faster threat detection ( $r = -0.362$ ,  $p = .006$ ) and slower detection of happy faces ( $r = 0.743$ ,  $p < .001$ ). The pattern was similar for the frog and snake trials ( $ps < .01$ ). There were no significant differences in latency as a function of shyness group ( $ps > .15$ ).

To examine our experimental question, we conducted a 2 (Shyness: high versus low) by 2 (Target: social versus non-social) by 2 (Gender: male versus female) by 8 (Task Order) Mixed Effects ANOVA on the bias scores. The results yielded a main effect of target,  $F(1, 56) = 33.83$ ,  $p < .05$ ,  $d = 1.55$ , and a shyness by target interaction,  $F(1, 56) = 4.29$ ,  $p < .05$ ,  $d = 0.55$ . The main effect of target indicates that the difference score for social threats (Mean<sub>Social</sub> = 1.51;  $SD = 1.54$ ; Range =  $-2.25$ – $5.22$ ) was significantly larger than the difference score for non-social threats (Mean<sub>Non-social</sub> = 0.36;  $SD = 0.62$ ; Range =  $-1.31$ – $2.32$ ). Most importantly, the significant shyness by target interaction indicates that there was only an effect of shyness for the detection of social threats, with a greater bias score for angry faces for children in the high-shy (Mean<sub>High-shy</sub> = 1.87;  $SD = 1.42$ ; Range =  $-0.57$ – $5.22$ ) group when compared to children in the comparison group (Mean<sub>Low-shy</sub> = 1.20;  $SD = 1.60$ ; Range =  $-2.25$ – $3.98$ ) (see Figure 2). These results suggest that children who are temperamentally shy are indeed more sensitive to the detection of threats than children who are not shy, and that this sensitivity is particular to social threats, such as angry faces. A target by order interaction was also found,  $F(1, 56) = 5.16$ ,  $p < .05$ ,  $d = 0.61$ , indicating significant differences in bias scores for faces based on the order of the tasks. According to post-hoc comparisons (Tukey HD), Order 7 ( $m = -0.01$ ) was significantly different from Order 6 ( $m = 2.5$ ) and Order 8 ( $m = 2.8$ ), and Order 8 was

significantly different from Order 3 ( $m = 0.30$ ),  $p < .05$ . However, the order did not impact the non-shy and high-shy groups differentially.

A non-significant trend in the opposite direction was found for non-social stimuli, with the children in the comparison group demonstrating a greater bias for snakes (Mean<sub>Low-shy</sub> = 0.40;  $SD = 0.58$ ; Range =  $-0.35$ – $2.32$ ) than children in the high-shy group (Mean<sub>High-shy</sub> = 0.32;  $SD = 0.67$ ; Range =  $-1.31$ – $1.84$ ). Further, there was a significant negative correlation between the difference scores for social and non-social stimuli ( $r = -0.439$ ,  $p < .01$ ), suggesting that a larger bias for angry faces was accompanied by a smaller bias for snakes. A non-significant moderate correlation in this direction was found in the high-shy group ( $r = -0.285$ , *ns*), with a larger significant correlation in the comparison group ( $r = -0.556$ ,  $p < .01$ ). It is possible that the correlation would have reached significance in the high-shy group if the sample size had been larger. These additional findings suggest that a heightened bias for social threats might come at the expense of a bias for non-social threats. However, because of the small sample size, future research is needed to further examine this possibility.

### Regression analyses

The findings thus far suggest that children who are temperamentally shy are particularly sensitive to social

(angry faces) but not non-social (snakes) threats. To further examine the relation between the detection of social threat and socioemotional functioning, we conducted a set of exploratory hierarchical regression analyses. In particular we looked to see if performance during the detection task predicted patterns of maladjustment above and beyond the risk incurred by early, extreme temperamental shyness. We did not wish to carry out a large number of analyses as this increases the potential for spurious findings. Given the importance of social stimuli in characterizing both temperamental shyness (Pérez-Edgar & Fox, 2005) and threat processing (LoBue, 2013), we therefore focused on performance during the trials incorporating happy and angry faces. The difference score calculated for the Mixed Effect ANOVA analysis served as a predictor. Recent work suggests that children with internalizing problems often exhibit a general slowing in behavior and task performance (Cataldo, Nobile, Lorusso, Battaglia & Molteni, 2005). Thus, raw RTs for detecting angry and happy faces also served as separate predictors. CBCL internalizing, externalizing, and total problem scores served as the dependent measures. Thus, a total of nine regressions (three sets of predictors and three sets of outcomes) are presented (Table 1).

In each regression two steps were employed and the predictors were added in the following order: (1) Age (entered as a continuous variable), (2) Shyness group

**Table 1** Prediction of parent-report CBCL Internalizing, Externalizing, and Total Problem scores. Age, shyness group, and task performance served as predictors. A-Raw RTs from the angry face detection condition served as the predictor. B-Happy face detection served as the predictor. C-The threat bias difference score served as the predictor

		Internalizing				Externalizing				Total			
		$\beta$	Partial $r$	$\Delta R^2$	$\Delta F$	$\beta$	Partial $r$	$\Delta R^2$	$\Delta F$	$\beta$	Partial $r$	$\Delta R^2$	$\Delta F$
<b>(A)</b>													
Step 1	Age	0.096		0.000	0.001	-0.006		0.020	0.728	0.040		0.011	0.354
Step 2	Shyness group	0.593**	0.676	0.512	11.193	0.119	0.197	0.149	1.916	0.338*	0.453	0.315	4.663
	Detection of Anger	0.420*	0.303			0.443 <sup>+</sup>	0.195			0.455*	0.242		
	Shy by Detection	-0.118	-0.048			-0.112	-0.042			-0.043	0.056		
		$F(4,41)=8.40$ , $p < 0.001$				$F(4,41)=1.63$ , $p = 0.19$				$F(4,41)=3.62$ , $p = 0.02$			
<b>(B)</b>													
Step 1	Age	-0.030		0.000	0.001	-0.150		0.020	0.728	-0.098		0.011	0.354
Step 2	Shyness group	0.614**	0.643	0.410	7.420	0.116	0.163	0.063	0.733	0.335 <sup>+</sup>	0.390	0.196	2.475
	Detection of Happy	0.108	0.022			0.304	0.176			0.274	0.169		
	Shy by Detection	-0.060	-0.008			-0.225	-0.146			-0.106	-0.087		
		$F(4,41)=5.57$ , $p = 0.002$				$F(4,41)=0.73$ , $p = 0.58$				$F(4,41)=1.96$ , $p = 0.13$			
<b>(C)</b>													
Step 1	Age	-0.011		0.000	0.001	-0.152		0.020	0.728	-0.109		0.011	0.354
Step 2	Shyness group	0.671**	0.683	0.431	8.065	0.187	0.221	0.040	0.451	0.415*	0.449	0.165	2.005
	Difference score	-0.210	-0.199			-0.052	0.009			-0.093	-0.027		
	Shy by Difference	0.081	0.065			-0.062	-0.084			0.026	-0.032		
		$F(4, 41)=6.05$ , $p = .001$				$F(4, 41)=0.511$ , $p = .73$				$F(4, 41)=1.60$ , $p = .20$			

Note: <sup>+</sup> $p < .10$ ; \* $p < 0.05$ ; \*\* $p < 0.01$ .

(entered as a categorical variable), performance on the touch screen task (RT to detect an angry face, RT to detect a happy face, or the RT difference score of happy minus angry), and the interaction between shyness group and the performance measure. Age and the performance measures were mean centered before being entered into the regression.

Results are presented in Table 1. To summarize, temperamental shyness, as expected, was associated with increased levels of internalizing problems (and, as a consequence, total problems) across the regressions. The bias score was unrelated to behavior problem scores. Reaction time in detecting angry faces was associated with higher internalizing (and total) problem scores. Although non-significant, reaction time in detecting a happy face was also positively associated with internalizing difficulties. The processes linking overall slowing of responses with internalizing difficulties may act independently of temperament as the interaction was not significant.

## General discussion

In the current work, we sought to examine whether children who show early risk factors for anxiety would demonstrate heightened sensitivity to social and non-social threats in a visual search task. There are several noteworthy findings. First, we replicated previous work, finding faster detection of threatening (snakes and angry faces) than non-threatening (frogs and happy faces) stimuli across groups of preschool and elementary school children (LoBue & DeLoache, 2008). Most importantly, we found differences in threat detection biases between children who are temperamentally shy when compared to a low-shy comparison group. Namely, children at-risk for anxiety showed a greater bias for the detection of social threats such as angry faces than did low-shy comparison children. This pattern was not evident for non-social threats – both groups of children demonstrated an equal bias for the detection of non-social threats such as snakes. Further, we found that overall slowing in the detection of angry faces (in contrast to the relative bias in detecting threat versus non-threat) predicted children's internalizing and total problem scores on the CBCL.

Longitudinal studies of temperament suggest that infants with extreme temperamental reactivity are sensitive to salient or novel stimuli (Fox, Henderson, Rubin, Calkins & Schmidt, 2001). However, with time this sensitivity narrows to focus on socially relevant stimuli. This specificity is evident at the behavioral (Fox *et al.*, 2001), cognitive (Pérez-Edgar *et al.*, 2010), and neural (Pérez-Edgar, Roberson-Nay, Hardin, Poeth, Guyer,

Nelson, McClure, Henderson, Fox, Pine & Ernst, 2007) levels. A unique sensitivity to social stimuli (indexed here as threat perception) may therefore go hand-in-hand with early temperament traits to bias the selection, processing, and response to environmental cues. In this way, sensitivity to social threat may act as a developmental tether linking early risk to the eventual manifestation of maladaptation.

We indeed found that task performance predicted levels of maladaptation, particularly for internalizing problems, above and beyond that accounted for by temperament. Our analyses suggest that shyness was associated with both faster detection of threat relative to non-threat in the task and increased internalizing problems. Independent of temperament, a general slowing in response was associated with increased internalizing levels as well. Although strong interpretations cannot be made given the sample size and exploratory analyses, the pattern across the regressions suggests that the main effect of detection may reflect an overall slowing of response often seen in children with internalizing problems (Cataldo *et al.*, 2005). Follow-up studies will be able to systematically examine this possibility. Future work may also examine the specificity of our findings given work linking early temperament most strongly to social anxiety as adolescents and young adults (Chronis-Tuscano *et al.*, 2009). Our current focus on internalizing problems reflects the fact that young children often manifest early disturbances in a diffuse manner (Gazelle & Rubin, 2010), that later differentiate into more distinct behavioral patterns or clinical diagnoses. Broad patterns of maladjustment may also be more evident in a healthy, albeit at-risk, sample as in the current study. A larger sample with a broader age range will allow us to examine the potential for differentiation of risk over the course of development.

In conclusion, this study is the first to show that children as young as 4 who are at-risk for anxiety demonstrate a heightened and specific sensitivity to angry faces – an ecologically relevant social threat cue – before the emergence of anxiety. A similar sensitivity has been found in adults and older children who have been diagnosed with clinical anxiety (see Bar-Haim *et al.*, 2007, for review). This suggests that social threat sensitivity might be used as an early marker for the later emergence of socioemotional and behavioral maladjustment.

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