J Abnorm Child Psychol (2015) 43:1067–1078
DOI 10.1007/s10802-014-9963-9

Attention Biases Towards and Away from Threat Mark the Relation between Early Dysregulated Fear and the Later Emergence of Social Withdrawal

Santiago Morales · Koraly E. Pérez-Edgar · Kristin A. Buss

Published online: 16 December 2014

Abstract Fearful temperament, mostly studied as behavioral inhibition (BI), has been extensively associated with social withdrawal in childhood and the later emergence of anxiety disorders, especially social anxiety disorder (SAD). Recent studies have characterized a distinct type of fearful temperament marked by high levels of fear in low threat situations – labeled dysregulated fear. Dysregulated fear has been related to SAD over and above risks associated with BI. However, the mechanism by which dysregulated fear is related to SAD has not been studied. Cognitive mechanisms, such as attentional bias towards threat, may be a possible conduit. We examined differences in attentional bias towards threat in six-year-olds who displayed a pattern of dysregulated fear at age two (N= 23) compared with children who did not display dysregulated fear (N=33). Moreover, we examined the concurrent relation between attentional bias and social withdrawal. Results indicated that children characterized by dysregulated fear showed a significant bias away from threat, and that this bias was significantly different from the children without dysregulated fear, who showed no significant bias. Moreover, attentional bias towards threat was positively related to social withdrawal only for the dysregulated fear group. These results are discussed in consideration of the existing knowledge of attentional bias to threat in the developmental and pediatric anxiety literatures, as well as recent studies that find important heterogeneity in attentional bias.

Keywords Temperament · Attentional biases · Social withdrawal · Dysregulated fear

S. Morales (✉) · K. E. Pérez-Edgar · K. A. Buss
Department of Psychology, The Pennsylvania State University, 140 Moore Building, University Park, PA 16802, USA
e-mail: sum260@psu.edu

Anxiety disorders affect approximately 30 % of adolescents in the United States (Kessler et al. 2012). Social anxiety disorder (SAD) is among the most prevalent forms of anxiety, impacting approximately 9 % of children (Kessler et al. 2012; Merikangas et al. 2010). Fearful temperament – particularly in the form of behavioral inhibition (BI)—is one of the strongest early predictors of SAD (Chronis-Tuscano et al. 2009; Clauss and Blackford 2012; Pérez-Edgar and Fox 2005). SAD often first emerges in adolescence but is preceded by elevated levels of social withdrawal in young children. However, recent studies have highlighted a distinct type of fearful temperament marked by high levels of fear in low-threat situations (i.e., dysregulated fear; DF), that is also associated with an increased risk for social wariness (Buss 2011) and SAD symptoms (Buss et al. 2013), over and above risks associated with BI.

The mechanisms linking DF to increased risk for anxiety have not been systematically investigated. One hypothesis is that these children are more likely to detect and attend to the presence of threat and attention to threat, in turn, plays a causal role in the emergence of anxiety. This hypothesis is in line with emerging data, mainly in the adult clinical literature, which suggests that anxious individuals show an attention bias towards threat (Bar-Haim et al. 2007). In addition, experimental manipulation of attention biases modulates anxiety in children (Eldar et al. 2008, 2012) and adults (Hakamata et al. 2010). Finally, healthy children at temperamental risk for anxiety due to BI also show attention bias towards threat, and attention bias moderated the relation between early BI and the presence of social withdrawal (Pérez-Edgar et al. 2010a). Consistent with the attention bias hypothesis and the extant literature, the current study investigated differences in attention bias between children characterized with and without a DF profile, and then examined the

relation between attention bias towards threat and social withdrawal, a common developmental precursor to anxiety.

Fearful Temperament and Anxiety

Children characterized as temperamentally fearful display high levels of fear and wariness to novel situations or unfamiliar people, have elevated physiological reactivity, and are often labeled as shy, as they show increased social withdrawal (i.e., reticence) during childhood (Fox et al. 2005). Fearful temperament shows high stability across development (Caspi et al. 2003; Fox et al. 2005). Several studies have also shown that fearful children are at an increased risk for the development of anxiety disorders in adolescence (Biederman et al. 2001; Hirshfeld et al. 1992; Schwartz et al. 1999), especially SAD (Chronis-Tuscano et al. 2009; Hirshfeld-Becker et al. 2008). For example, Chronis-Tuscano and colleagues (2009) found that stable fearfulness from 14 months to 7 years of age predicted 3.79 increased odds of being diagnosed with SAD by age 15.

However, longitudinal studies have also found significant discontinuity in the trajectories of fearful temperament, as many extremely fearful children display less inhibition and anxiety symptoms later in development (Degnan and Fox 2007) and the majority of children characterized as highly fearful do not develop anxiety problems (e.g., Biederman et al. 2001). Indeed, several studies do not find any association between early fearfulness and later anxiety (e.g., Stifter et al. 2008). It may be that children characterized as having a fearful temperament represent a heterogeneous group containing several sub-groups, some of which are at elevated risk, while others are not.

Numerous studies note specific moderators that help identify children at elevated risk for anxiety above and beyond fearful temperament, highlighting underlying patterns of heterogeneity. These moderators include right frontal EEG asymmetry (Davidson and Rickman 1999; Fox et al. 2001), elevated cortisol (Pérez-Edgar et al. 2008), over-solicitous parenting styles (Rubin et al. 2002; Williams et al. 2009), day care exposure (Almas et al. 2011; Fox et al. 2001), and variations in effortful control (White et al. 2011). In sum, these studies have found that the predictive power of fearful temperament is tied to additional characteristics of the child or external factors, generating several, more homogenous, sub-groups of fearful children.

Buss (2011) addressed the issue of underlying heterogeneity in fearful temperament by characterizing children based on variations in the response to threat across context. The experimental protocol exposed children to multiple contexts and events that varied in the amount of threat (e.g., high, moderate, and low). High threat contexts were novel situations in which most children prototypically display fear (e.g., a mechanical spider) and low threat contexts were novel situations that most children find intriguing and promote engagement rather than displays of fear (e.g., a puppet show). Previous analyses of the children's response to the episodes (Buss 2011) suggest that the children did indeed modulate responses across context. Thus, children were not identified based on how much fear they displayed during a fearful task (a traditional approach), but by the pattern of fear displayed across contexts. At age two, Buss identified children that followed the expected pattern of high fear in high threat situations and a group of children who displayed high fear in all tasks, most notably in low-threat situations.

This last group of children (i.e., DF) were at increased risk for anxiety and social withdrawal at kindergarten entry (Buss 2011). This finding held over and above a traditional characterization of fearful temperament (i.e., BI), suggesting that children who exhibit DF might be a distinct sub-type of fearful children. In addition, children who displayed fear behaviors in low-threat contexts showed higher basal and reactive cortisol and higher sympathetic cardiac activity during baseline (Buss et al. 2004). Recently, Buss and colleagues (2013) found that DF predicted social wariness during a free play with unfamiliar peers in the spring of kindergarten. At the end of kindergarten DF children were almost four times more likely to display SAD symptoms compared to other inhibited children based on a parent interview (Buss et al. 2013).

Even though these studies provide evidence for DF as an important predictor of anxiety and social withdrawal, they do not reveal the underlying mechanism that places these children at increased risk. One possibility is that children who display DF are more prone to detect and attend to the presence of threat, which leads them to evaluate their environment as more threatening and act accordingly with high levels of fear and a heightened physiological response. For example, Kiel and Buss (2011) found that attention towards a threat cue (an angry gorilla mask) in a situation with several other (non-threatening) opportunities for play predicted social inhibition at kindergarten entry, even after controlling for BI.

In an earlier examination of the relation between attention and social behavior, Pérez-Edgar et al. (2010b) measured patterns of sustained attention potentially associated with vigilance at 9 months. They found that levels of sustained attention moderated both the stability of fearful temperament across development and the relation between fearful temperament and social discomfort in adolescence. In particular, infants who spent more time monitoring a distractor showed increases in fearful temperament from 14 months to 7 years. These same infants showed a significant positive relation between fearful temperament during childhood and social discomfort in adolescence (Pérez-Edgar et al. 2010b).

It is worth noting that both Kiel and Buss (2011) and Pérez-Edgar et al. (2010b), used global measures of attention by

scoring observed behavior from a video recording; thus, neither can address which specific components of attention may link attention to threat and social inhibition. In order to extend these findings, the current study employs a standard computer-based task (the dot-probe; MacLeod et al. 1986) that tracks patterns of attention bias to threat and has been associated with levels of social withdrawal and anxiety in children and adults.

Attention Bias Towards Threat, Temperament, and Anxiety

Recently, several studies have found a relation between attention bias towards threat and anxious symptoms and behaviors (Bar-Haim et al. 2007), supporting cognitive models of anxiety development (e.g., Mathews and MacLeod 1994). In general, high levels of anxiety are associated with an attention bias towards threat. For instance, in the first dot-probe study, anxious individuals showed an attentional bias towards threatening words whereas control participants showed a bias away (MacLeod et al. 1986). Many studies have tapped into affect-linked attentional biases using emotion words. While effective, these stimuli are more limited in applicability across samples, particularly when assessing young children. Angry faces are commonly conceptualized as ecologically valid indicators of potential threat (Bar-Haim et al. 2007) – with angry facial expressions signaling a threat from the individual making the expression to the receiver (Adams and Kleck 2003). For children, in particular, facial affect is a salient indicator of emotion that can be systematically varied in an experimental setting to assess sensitivity to threat, allowing for direct comparison across studies and across the lifespan.

Experimental manipulations of attentional biases have trained individuals to attend away or toward threat, leading to reduced or increased anxiety, respectively (e.g., Amir et al. 2008; Eldar et al. 2008), as well as changes in associated biomarkers (e.g., O'Toole and Dennis 2012). These data further support the mechanistic role of attention bias in anxiety. In particular, psychophysiological and neuroimaging studies have linked individual differences in anxiety-related attention patterns to the amygdala, ventrolateral prefrontal cortex (vlPFC), and dorsolateral prefrontal cortex (dlPFC; Hardee et al. 2013; Monk et al. 2006, 2008; Telzer et al. 2008). Because reducing attentional biases towards threat ameliorates anxious thought and behavior, studies have tested attention bias modification (ABM) as a potential treatment for anxiety (Hakamata et al. 2010), targeting and altering previously identified neural networks (Fox and Pine 2012).

It is important to note that just as the phenotype of fearful temperament might reflect subgroups of children who display varying patterns of fear behavior (e.g., BI, DF), studies have found important heterogeneity in attention bias to threat and its relation to anxiety. Although the literature reviewed thus far provides strong evidence for bias towards threat being related to increased anxiety, under certain circumstances, anxious individuals show a bias away from threat (i.e., threat avoidance; Bar-Haim et al. 2010; Shechner et al. 2012b; Wald et al. 2011a). For example, threat avoidance has been positively related with posttraumatic stress disorder (PTSD), anxiety, and depression symptoms (Bar-Haim et al. 2010). Moreover, recent reports in community and clinical samples of children have found that attention bias varies across the recent nosological distinction of anxiety disorders, with distress disorders (generalized anxiety disorder) showing a bias towards threat and fear disorders (including SAD and specific phobias) showing a bias away from threat (Salum et al. 2013; Waters et al. 2014).

Although this growing literature supports the idea that attention biases to threat may play a causal role in the development and maintenance of anxiety, most of this evidence comes from work with adults and cannot provide evidence as to how these biases develop, or if these biases are a precursor to, or symptoms of, anxiety. In order to answer these questions a prospective longitudinal approach is needed, requiring studies that assess attentional biases and their relation to anxiety across development (Field and Lester 2010). As these studies emerge, one initial step toward answering these fundamental questions focuses on evaluating attention biases early in development as well as using populations at risk for anxiety (e.g., fearful children). Although fewer studies have tested attention differences in anxious children, they find the same general pattern of results as in adults – anxious children, or children with higher levels of anxiety, display a larger bias towards threat (Roy et al. 2008; Waters et al. 2008, 2010). Moreover, studies that experimentally manipulate biases by either reducing or augmenting attention bias towards threat in children also find that ABM ameliorates or exacerbates anxiety symptoms and behavior (e.g., Eldar et al. 2012, 2008). Hence, it seems that, like in adults, attention bias towards threat plays a role in the development and maintenance of anxiety.

Similarly, the few studies examining attentional biases in populations at risk for anxiety also find the expected patterns of results – children characterized by laboratory observations and maternal reports as temperamentally fearful exhibited a larger bias towards threat in adolescence than non-fearful children (Pérez-Edgar et al. 2010a). Furthermore, attentional bias towards threat moderated the relation between early temperament and social withdrawal behaviors in adolescence, such that fearful temperament was associated with social withdrawal only when attentional bias towards threat was large (Pérez-Edgar et al. 2010a). In a second sample, Pérez-Edgar and colleagues (2011) found similar results – attentional bias towards threat moderated the relation between early temperament and social withdrawal at age five, such that the

relation between fearful temperament and social withdrawal was strongest for children who displayed a large bias towards threat (Pérez-Edgar et al. 2011).

To our knowledge, there is only one longitudinal study of attentional bias towards threat in temperamentally fearful children. White and colleagues (2014) examined the relation between early fearful temperament, attentional biases towards threat at 5 and 7 years, and anxiety symptoms at age 7. Concurrent attentional biases to both threat and positive stimuli moderated the relation between early fearful temperament and anxiety. Specifically, fearful temperament predicted anxiety only for children who displayed an attentional bias towards threat or those who did not display a bias towards positive stimuli (White et al. 2014). In sum, these studies provide convergent evidence from different developmental periods suggesting that attentional bias towards threat acts as a "developmental tether" that keeps fearful children at risk for later anxiety (Pérez-Edgar et al. 2014).

Current Study

The present study examined differences in attentional bias towards threat at age six in children who displayed a dysregulated pattern of fearful behavior at age two, versus non-dysregulated peers. We hypothesized that children with a history of DF would display a larger bias towards threat and a smaller bias towards positive stimuli compared to non-dysregulated children based on previous findings in temperamentally fearful (Pérez-Edgar et al. 2010a) and clinically anxious (Roy et al. 2008) children. In addition, the current study evaluated whether attentional bias towards threat modulates the documented relation between DF and social withdrawal (Buss 2011). Specifically, we hypothesized that children characterized by DF as toddlers would show increased levels of social withdrawal at age six only if they also show attentional bias towards threat. In other words, attentional bias towards threat would be positively related to social withdrawal only for children characterized as DF.

Method

Participants

Participants in the current study (N=56, 32 boys, $Mean_{age}$= 76.76 months; SD_{age}=3.64) were assessed during kindergarten as part of a larger longitudinal study of toddler's temperament development from 24 months to school entry. Participants were recruited via mailings sent to parents identified by local birth records. Participants were oversampled for fearfulness using parental report between 18 and 20 months on the Infant-Toddler Social and Emotional Assessment (ITSEA; Carter et al. 2003) and a six-item wariness questionnaire asking parents about their child's fearfulness to common novel situations (e.g. meeting a mascot). A hundred and twenty-five toddlers screened via parental report participated in the first laboratory visit ($Mean_{age}$=24.3 months). Subsequent characterization of DF was based solely on laboratory observation of behavior. During the kindergarten year children (N=100) participated in a laboratory visit in the fall and a peer visit in the spring (N=99). The Pennsylvania State University Institutional Review Board approved all procedures and all families consented to participate.

From the larger cohort, 99 children participated in the peer visit. From this laboratory visit, only data from the dot-probe were used. Attrition and/or data loss was due to missing this specific assessment, or withdrawal from the study. Of the families who did not participate in this assessment (N=22), eight reported being too busy to participate, three moved out of the area, the rest did not provide a reason. Of the 99 participating children, 72 had behavioral data (fear profiles) at 24 months. Of these 72 children, 56 children (23 DF) completed the dot-probe task. Importantly, there were no significant differences between the children participating in this study and the rest of the larger sample in any of the core study variables (all p's>0.14).

Among this final sample, 49 children were Caucasian (87.5 %), 5 were Asian (8.9 %), and the rest were other ethnicities (African American and American Indian). Most families reported being middle class (Hollingshead mean= 51.7, SD=9.29) reflected in the fact that children lived with married (96.4 %) biological (96.4 %) parents with high levels of education (13+ years; Fathers: 87.5 %; Mothers: 92.6 %). With respect to sibling status, 33.9 % were single children and the rest had 1 to 5 siblings. None of these demographic variables were associated with any of the variables in this study (p's>0.06).

Although most children were able to successfully complete the dot-probe, six children (10.7 %) were excluded due to poor performance (<75 % accuracy). The remaining sample had an average accuracy rate of 89.5 %. The six children excluded due to poor performance did not differ in fear profile (2 DF), gender (3 males), or social withdrawal (p=0.68).

Procedures and Measures

Laboratory Visit at 24 months Upon arrival to the laboratory, parents provided written consent and completed several questionnaires. Toddlers and their mothers participated in a neutral baseline task and six emotional challenge tasks meant to elicit a targeted emotional response. All tasks were based on the Laboratory Temperament Assessment Battery (Lab-TAB; Buss and Goldsmith 2000). Video and sound were recorded for later scoring. All episodes took place in one experimental room with a one-way mirror. Mothers remained with their

toddlers during the visit. However, they were asked to remain as uninvolved in the tasks as possible, except if they thought their toddler needed to be soothed (e.g. high distress). Families were compensated $40 for their participation, and the child was given a small prize (e.g., toy).

Episodes Six episodes were used to measure fearful behavior. Two episodes, Puppet Show and Clown, were designed to be novel yet to be engaging by inviting the child to play. In the *Clown* episode, a different female experimenter dressed as a clown entered the room and invited the child to play with a variety of toys (e.g., bubbles, beach balls, musical instruments). For the *Puppet Show* episode, the same female experimenter as in the clown episode acted out a puppet show from behind a puppet theatre, inviting the child to interact with the puppets (a lion and an elephant). In addition, there were two stranger episodes designed to assess social wariness. In *Stranger Working*, a female experimenter entered the room where the child was already playing and sat at a desk in the corner, ignoring the child as she pretended to work. In the *Stranger Approach* episode, a male experimenter came into the room and verbally interacted with the child for 1.5 min. The remaining two episodes examined fear of novelty and object fear by exposing the child to novel objects controlled by remote control from the control room. In the *Robot* episode, a one-foot-tall remote control robot moved and made noises randomly on a wooden platform in the corner of the room. In the *Spider* episode, a large stuffed animal spider (placed on top of a remote control car) was driven toward the child and then withdrew to the opposite corner of the room. Episodes are described in more detail in Buss (2011). The episodes were presented in a set order to avoid the two most threatening episodes occurring back to back: Puppet Show, Stranger Approach, Robot, Clown, Stranger Working, and Spider. In addition, a non-threat episode, in which no threat was present (e.g., a three-minute free play), was administered between each of the mentioned episodes.

Behavioral Coding Behavior in each of the six episodes was reliably (K>0.82 and percentage agreement above 95 % coded on 20 % of cases) coded second-by-second for fearful behaviors. These behaviors included facial fear, bodily fear, freezing, and time spent in proximity to caregiver. Facial fear was coded using the AFFEX system, which differentiates emotion expressions based on three regions of the face (Izard et al. 1983). Fear was coded when brows were straight or raised and drawn together, eyes were open wide, and mouth open with corners pulled back. Bodily expressions of fear were indicated when the child froze, play was diminished, or decreased activity suddenly, and/or when muscle tension increased or trembling occurred. Freezing behavior was also scored when the child did not move or remained rigid for two or more seconds. Proximity to caregiver was scored when the child was within one arm's-length reach of caregiver. A full description of analytic procedures to determine the threat and engagement ordering can be found in Buss (2011). Variables representing the duration or timing of each behavior (i.e., duration of facial fear, bodily fear and freezing, time spent in proximity to caregiver, and latency to freeze) were combined using an exploratory Principal Component Analysis into a fear composite for each episode, accounting for approximately 20–42 % of the variance. This variable indexed the proportion of time children engaged in fear behaviors during the episode.

Latent Profiles of Fear Behavior Latent profile analysis (LPA) employing the full sample at age two (N=125) was completed in Mplus version 5.1 (Muthén and Muthén 2007) to identify latent groups of participants based on patterns of observed behaviors across the six episodes by estimating the probability of profile membership and the profiles within the same model. Two, three, and four profile solutions were estimated and compared based on model fit before the three-profile solution was selected. Examination of traditional fit statistics (i.e., lower BIC & AIC), bootstrapping likelihood ratio tests, and entropy (Entropy=0.814) were used to assess the model fit. Both Indices showed that the three-profile solution was the best fit to this data. The first profile, the normative profile (51.6 % of sample), showed the hypothesized pattern of high fear in high-threat situations (spider and robot episodes) and low fear in low-threat situations. The second profile, the low reactive profile (12.9 %), was comprised of toddlers who displayed low levels of fear across all episodes. The third profile, the DF profile (35.5 %), was composed of toddlers who displayed higher levels of fear in the lower threat episodes relative to the moderate to high threat episodes.

All of the ANOVAs comparing the three profiles across the episodes were significant (F's >10.7). The normative and the DF profiles closely parallel the profiles found by Buss (2011), and the addition of the low fear profile was marked by low fear across contexts, especially high-threat episodes. Given that not all children with a fear profile had the other measures of the study (i.e., the dot-probe and parental report of social withdrawal), the normative (N=28) and the low reactive profiles (N=5) were analyzed as one group (heretofore called the non-dysregulated group). Supporting the validity of the profiles used in this study, the DF group (M=1.30, SD=0.53) was significantly higher in maternal reported inhibition, $t(54)=2.4$, $p=0.02$, $d=0.698$, compared to the non-DF group (M=0.94, SD=0.48) as measured by the ITSEA at 24 months. For more details regarding the nature of the profiles, see Buss et al. (2014).

The Dot-Probe Task The dot-probe task was administered at the end of the peer visit during the spring of kindergarten. The dot-probe task consisted of 8 practice trials and 100

experimental trials randomly presented in four blocks of 25 trials. Each trial began with the presentation of a central fixation cross for 500 ms followed by a pair of faces presented side-by-side for 500 ms. One of the faces was replaced by an asterisk, which appeared for 2500 ms. Using a computer mouse, children were asked to indicate, as quickly and accurately as possible, the side of the screen the asterisk appeared. The inter-trial interval was 1800 ms. Children were seated 60 cm from a 20 in. LCD color monitor. Stimuli were presented with E-Prime 2.0 (Psychology Software Tools, Pittsburgh, PA).

Three combinations of faces were presented: Angry-Neutral (40 trials), Happy-Neutral (40 trials), and Neutral-Neutral (20 trials). Ten different actors (5 male) were used from the NimStim face stimulus set (Tottenham et al. 2009). Each face was presented ten times. Congruent trials were those in which the probe replaced the affective face (i.e., angry or happy). Incongruent trials were those in which the probe replaced the neutral face. Response accuracy and reaction times were recorded for each trial.

Social Withdrawal In the spring of kindergarten, mothers and fathers reported on the child's adjustment to kindergarten by using the MacArthur Health Behavior Questionnaire (HBQ; Armstrong et al. 2003). This measure is designed to assess the mental and physical health and functioning of children (4–8 years-old). The HBQ has been widely used as a measure of behavior problems in young children (e.g., Buss 2011; Essex et al. 2006; Lemery et al. 2002; Obradović et al. 2011). A study comparing the reliability of the HBQ as a screening measure for psychopathology in young children versus the DISC-IV found strong convergence between these two screening measures. Moreover, the HBQ was more sensitive to internalizing difficulties, compared to the DISC-IV, making it a more effective tool for evaluating psychopathology in early childhood (Lemery-Chalfant et al. 2007).

The parent version of the HBQ contains 172 items. These items are grouped into four domains: Emotion and Behavioral Symptoms, Physical Health, School Adjustment, and Social Adjustment. In the HBQ, the reporter responds in a dichotomous (*yes* or *no*) or 3-point Likert scale of 0 (*never or not true*), 1 (*sometimes or somewhat true*), and 2 (*often or very true*). The present study used the Social Withdrawal composite, which is composed of the Social Inhibition and Asocial with Peers scales. Both of the scales used in the study belong to the Social Functioning domain. Sample items from these scales are "avoids peers" or "withdraws from peer activities" (Asocial Scale), and "shy with other children" or "is afraid of strangers" (Social Inhibition Scale). The Social Withdrawal composites for mothers (α=0.77) and fathers (α=0.65) during the spring were averaged (r=0.61), yielding one measure of social withdrawal.

Statistical Analyses

Incorrect dot-probe trials or trials with RTs of less 150 ms or more than 2000 ms were removed before analyses. In addition, trials were filtered by removing responses that had RTs +/− 2.5 SDs from an individual's mean. Attentional bias scores towards the emotional faces were calculated as in previous dot-probe studies (O'Toole and Dennis 2012; Pérez-Edgar et al. 2011) by subtracting the mean RT for congruent trials from the mean RT for incongruent trials. Positive values denote a bias/vigilance towards the emotional stimuli whereas negative scores indicate bias away/avoidance of the emotional stimuli. The Neutral-Neutral trials served as controls and "catch trials" during testing to ensure that the child did not expect or seek out an emotion face on every trial.

Based on the clinical (Roy et al. 2008) and developmental (Pérez-Edgar et al. 2010a; Pérez-Edgar et al. 2011) literature, a 2×2 repeated measures ANOVA was used to examine the effect of the fear profile group (Dysregulated vs. Non-Dysregulated) and emotion (happy vs. angry) on the attentional bias patterns to compare performance across the two emotion conditions. Post hoc independent-sample and one-sample t-tests versus zero were used to assess individual patterns of attentional biases.

In line with previous work (Pérez-Edgar et al. 2010a; Pérez-Edgar et al. 2011), the role of attentional bias in the relation between fear profiles and social withdrawal was then tested using a moderated mediation model based on the work of Preacher et al. (2007). This analysis (SPSS Macro) provides the same information as a traditional regression model, while allowing us to simultaneously examine both the moderation and mediation relations. Given the constraints of the model, we ran the analysis separately for each of the faces (Angry and Happy). See Fig. 1 for a graphical representation of the analyses for attentional bias to angry faces.

Results

Differences in Attentional Bias Towards Threat

Table 1 depicts the means and standard deviations for the measures of interest for the whole sample and Table 2 by each profile group. The repeated-measures ANOVA revealed no significant effects for either the main effect of emotion or the fear profiles by emotion interaction. However, we found a significant between-subjects effect, $F(1, 47)=5.42$, $p=0.02$, $\eta^2=0.10$. Given the a priori hypotheses of differences in attentional bias between children with and without DF, post hoc independent sample t-tests found a significant difference between profiles in angry bias, $t(48)=2.22$, $p=0.03$, $d=0.613$, but not happy bias, $t(47)=0.51$, $p=0.60$, $d=0.149$.

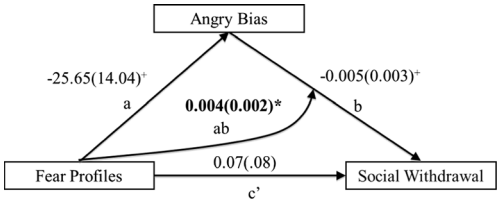

Fig. 1 Path results for the model examining the moderated mediation of attention bias towards angry in the relation between fear profiles and social withdrawal. Noted are the coefficients with standard errors in parenthesis. *=$p<0.05$; $^{+}$=$p<0.10$

In order to test the specificity of the bias scores, one sample *t*-tests were performed for each emotion and for each profile. As illustrated in Fig. 2, the t-tests revealed only one significant difference from zero, angry bias in the DF profile, $t(20)=-2.27$, $p=0.03$, $d=1.02$, indicating a significant bias away from threat. All the other *t*-tests were not significant (*p's*>=0.20; *d's*=0.19–0.50). Figure 3 illustrates the distribution of attention bias towards threat scores by profile.

The Relation between DF, Attentional Biases, and Social Withdrawal

The simple correlations between the fear profiles, attentional biases, and social withdrawal are illustrated in Table 1 for the whole sample and in Table 2 for each profile group. The correlation between the profiles and angry bias was the only significant correlation, as previously discussed. Unexpectedly, the zero-order relation between dysregulation profiles and social withdrawal was not significant. Previous reports (Pérez-Edgar et al. 2010a; Pérez-Edgar et al. 2011; White et al. 2014) have shown a non-linear relation between fearful temperament and social withdrawal; hence, it was hypothesized that the interaction between the fear profiles and angry bias would predict social withdrawal. Figure 1 illustrates the moderated mediation analysis for the angry faces. None of the direct or mediated paths reached significance. However, as predicted, the interaction between fear profiles and attentional bias was significant ($t=2.33$, $p=0.03$). To interpret the interaction, the relation between social withdrawal and angry bias was compared for the two profiles separately. As shown in Table 2, angry bias predicted social withdrawal for the DF profile, $r(17)=0.60$, $p=0.01$, but not for the non-dysregulated profile, $r(26)=-0.13$, $p=0.51$. The two correlations were significantly different from each other, $Z=2.61$, $p=0.01$. For illustrative purposes, Fig. 4 depicts the simple slopes analysis (Aiken and West 1991) where only for the DF profile attention bias towards threat was positively related to social withdrawal ($b=0.002$, $SE=0.001$, $p=0.05$), whereas there was no relation for the non-dysregulated profile ($b=-0.0006$, $SE=0.0006$, $p=0.35$). In the moderated mediation with happy faces, none of the paths were significant (all *t*'s <0.6, *p*'s>0.55).

Discussion

Previous studies have shown that DF in toddlerhood predicted social withdrawal and internalizing behaviors during preschool and during the transition to kindergarten (Buss 2011), as well as social wariness and SAD symptoms (Buss et al. 2013). However, why this group of children is at an increased risk is still an open question. The current study looked to see if children characterized by the DF profile would display different patterns of attentional bias towards threat compared with children not characterized by this profile. Contrary to our hypotheses, children who showed a pattern of DF at 24 months exhibited a bias away from threat approximately 4 years later, whereas children who did not manifest this pattern of fear did not show a significant bias towards or away from threat. However, attentional bias to threat was positively related with social withdrawal during kindergarten for children in the DF profile.

Our finding of significant bias away from threat is contrary to the existing developmental literature (Pérez-Edgar et al. 2010a, 2011), in which fearful (as indexed by BI) children and adolescents display a bias towards threat. However, findings in the clinical literature are mixed as there is evidence indicating an attentional bias towards threat (Roy et al. 2008) and away from threat (Stirling, Eley, and Clark 2006) in children with elevated social anxiety. Thus the overarching pattern of bias towards threat, evident across studies and meta-analyses, may also shift with variations in population, context,

Table 1 Means, standard deviations, and intercorrelations gender, fear profile, angry bias, happy bias, and social withdrawal

	Variable	Mean	SD	1	2	3	4
1	Gender	**	**	–			
2	Fear Profile	***	***	0.084	–		
3	Angry Bias	−2.32	48.88	0.187	**-0.288**	–	
4	Happy Bias	7.42	40.46	−0.176	−0.075	−0.086	–
5	Social Withdrawal	0.43	0.27	−0.140	0.003	0.070	0.139

Note: Bolded=$p<0.05$. *SD* Standard Deviation. **Gender=32 boys and 24 girls. ***33 non-dysregulated and 23 dysregulated children. Boys=0 and girls=1

Table 2 Means, standard deviations, and intercorrelations angry bias, happy bias, and social withdrawal by fear behavior profiles

	Variable	DF Mean (SD)	Non-DF Mean (SD)	1	2	3
1	Angry Bias	−18.69 (37.68)	9.54 (53.11)	–	−0.293	−0.130
2	Happy Bias	3.93 (41.63)	10.04 (40.12)	0.176	–	0.088
3	Social Withdrawal	0.44 (0.23)	0.43 (0.29)	**0.607**	0.241	–

Note: Bolded=$p<0.05$. *SD* Standard Deviation, *DF* Dysregulated Fear Profile, *Non-DF* Non-dysregulated fear profile. Below the diagonal, correlations for the dysregulated profile. Above the diagonal, correlations for the non-dysregulated profile

and current affective state. For example, Salum and colleagues (2013) found that children with a fear disorder showed bias away from threat while children with a distress disorder presented with a bias towards threat.

It is possible that a similar distinction can be made for different sub-groups of temperamental fear where DF leads to avoidance of threatening stimuli while sensitivity towards novelty (BI) leads to orientation towards threat. Clearly, the distribution of attention bias scores is more homogenous in our DF sample, versus non-DF peers. Our characterization of more homogenous fear profiles could help shed light on the inconsistencies in the literature among studies employing broader groupings across anxiety disorders or temperament groups. Future work directly comparing across risk groups will be needed to test this assumption. Our data also contribute to the emerging argument that attention bias, rather than acting as trait marker of risk, also indexes current functioning and the individual's overall response style when confronted with threat. Again, future work will need to see how attentional bias patterns in children with a history of DF shift as a function of context (high and low threat) and development (periods of greater risk, such as adolescence) and document if these shifts track changes in level of anxiety and social withdrawal.

Indeed, in the DF group only, there was a positive relation between attentional bias to threat and concurrent social withdrawal. This relation replicates previous findings from the developmental literature, in which bias towards threat was related to social withdrawal (Pérez-Edgar et al. 2010a, 2011). Moreover, a parallel relation is present in the clinical literature where a bias towards threat has been positively related with anxiety symptoms (Waters et al. 2008). This suggests that even though DF was associated with threat avoidance, attentional bias towards threat seems to operate in a similar manner as in other fearful temperament types (i.e., BI).

Fig. 2 Means and standard errors (*error bars*) of attention bias score by emotion and profile

Importantly, the current study replicates previous studies by finding a profile of children who displayed a pattern of fear characterized by high levels of fear across contexts, including low-threat contexts. The DF profile was associated with concurrent maternal-reported social inhibition (current study) and social inhibition at age 3 and 4 (Buss et al. 2014). However, we did not find this prediction of higher levels of social withdrawal during kindergarten. It is possible that children characterized by the DF profile were not higher in social withdrawal as most of them, 17 out of 21 (~81 %), displayed a bias away from threat. This suggests that at least in this time point (kindergarten), bias away from threat might be an adaptive response, which might explain the lack of differences in social withdrawal between the DF group and the non-DF group.

The absence of a relation between fear profiles and social withdrawal in kindergarten may also stem from the time point at which social withdrawal was assessed in the current study. It is possible that in the short term, threat avoidance is adaptive; however, this might not be the case later in development. Recent studies are beginning to show important plasticity in attentional bias patterns (Bar-Haim et al. 2010; Shechner et al. 2012b; Wald et al. 2011a, b). This growing literature finds that in a stressful circumstance, anxious individuals shift to an avoidant pattern of attention (bias away from threat). Experimental studies using the dot-probe have found that in the presence of imminent threat or stress, attentional bias towards threat disappears (Helfinstein et al. 2008) or shifts to bias away from threat (Shechner et al. 2012b). Notably, the same pattern of results was found in field studies of soldiers in combat contexts (Bar-Haim et al. 2010; Wald et al. 2011a, b). For instance, Bar-Haim and colleagues (2010) found bias away from threat when war-related threat was high. Furthermore, the magnitude of bias away from threat predicted concurrent PTSD, anxiety, and depression symptoms (Bar-Haim

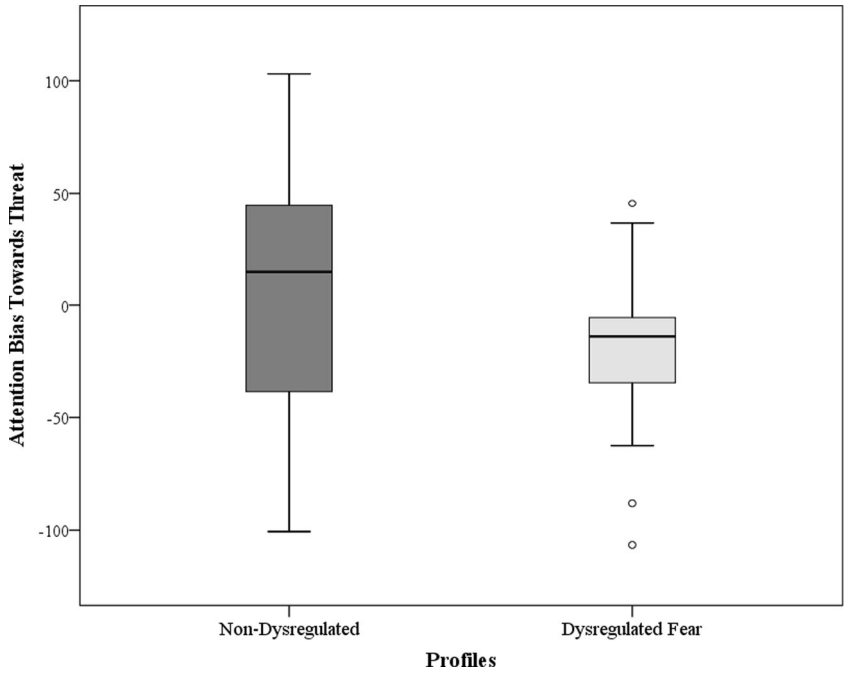

Fig. 3 Box plot of attention bias towards threat by fear profile

et al. 2010) as well as PTSD symptoms a year later (Wald et al. 2011b), such that as threat avoidance increased (bias score became more negative) the symptoms became greater. Together, these findings suggest a more complicated relation between threat vigilance or avoidance, stress, and stress responding than the one expected – where threat avoidance might be the normative response in the presence of threat, but might come with an increased risk for psychopathology (i.e., PTSD, depression, and anxiety; Bar-Haim et al. 2010). Future studies should evaluate the prospective implications of threat avoidance in children.

In addition, this plasticity or heterogeneity in attentional bias towards threat complicates the interpretation of findings as well as the development of treatment opportunities for anxiety based on biased attention mechanisms (Shechner et al. 2012a). For instance, O'Toole and Dennis (2012) found significant effects for ABM only in individuals who displayed a bias towards threat during baseline, suggesting that training individuals who display a bias away from threat might not be as effective in reducing anxiety. Future work will need to systematically examine the relation between initial biases, the form of attention manipulation, and specific outcomes, rather than rely on the current assumption that attention training away from threat, for all participants, is necessarily the most efficacious intervention.

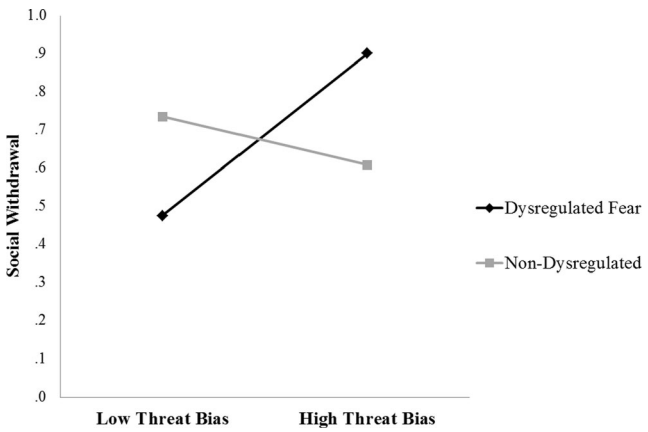

Fig. 4 Simple slopes of the interaction between fear profile and attention bias towards threat predicting social withdrawal. The relation is only significant for the dysregulated fear profile (*black*)

The findings of the current study and their interpretation should be considered in light of important limitations. First, the relatively small sample size limits the power of the study to address potential additional moderators. Moreover, the current sample was mostly Caucasian and middle class, limiting the generalizability of the results. This study is part of a larger longitudinal study and only a subset of the children in the larger study completed the dot-probe and parental reports of social withdrawal, potentially biasing the results. However, the fact that there are no significant differences between children who did and did not complete the dot-probe for any of the study variables helps ameliorate this concern. Social withdrawal was evaluated with the HBQ scale via parental reports. However, this measure does not distinguish among different forms of social withdrawal (e.g., Coplan et al. 1994). Future studies should consider the relations between DF, attentional bias, and the different types of social withdrawal (often measured via observational data). Social withdrawal and attentional bias were measured concurrently preventing analyses that would provide insight into the developmental

timing of this relation. Longitudinal studies such as White et al. (2014) that assess attentional biases and socioemotional adjustment over time are therefore necessary.

Furthermore, the outcome variables were measured at a relatively early age – before the upsurge of anxiety observed in adolescence. Forthcoming investigations will have to evaluate the longitudinal predictive power of DF and attentional biases to anxiety disorders. Finally, attentional bias away from threat (as captured by the dot-probe via reaction times) might indicate an initial orientation towards the threatening stimulus, followed by active disengagement and orientation to the neutral stimulus, namely threat avoidance. To evaluate if this is the case, future studies employing a different methodology (e.g., eye tracking) will be required as the method used in the current study is not able to discern between attention components (i.e., orientation and disengagement).

Conclusion

The present study increases our understanding of the role of attentional biases in young children at risk for anxiety. This study suggests that a pattern of biased attention away from threat might be a factor that characterizes fearful children marked by a DF profile as opposed to other temperament profiles, such as behavioral inhibition. Furthermore, this study provides data similar to other studies (Pérez-Edgar et al. 2010a, 2011) that identifies attentional bias as a moderator of the relation between fearful temperament and social withdrawal. Future studies will have to evaluate the stability of the results presented as well as the longitudinal risk of DF and early attentional bias towards threat.

Acknowledgments This work was supported by NIMH R01MH75750 to Kristin A. Buss.

Conflicts of interest The authors declare that they have no conflict of interest.

References

Adams, R. B., & Kleck, R. E. (2003). Perceived gaze direction and the processing of facial displays of emotion. *Psychological Science, 14*(6), 644–647. doi:10.1046/j.0956-7976.2003.psci_1479.x.

Aiken, L. S., & West, S. G. (1991). *Multiple Regression: Testing and Interpreting Interactions*. SAGE.

Almas, A. N., Degnan, K. A., Fox, N. A., Phillips, D. A., Henderson, H. A., Moas, O. L., & Hane, A. A. (2011). The relations between infant negative reactivity, non-maternal childcare, and children's interactions with familiar and unfamiliar peers. *Social Development, 20*(4), 718–740. doi:10.1111/j.1467-9507.2011.00605.x.

Amir, N., Weber, G., Beard, C., Bomyea, J., & Taylor, C. T. (2008). The effect of a single-session attention modification program on response to a public-speaking challenge in socially anxious individuals. *Journal of Abnormal Psychology, 117*(4), 860–868. doi:10.1037/a0013445.

Armstrong, J. M., Goldstein, L. H., & The MacArthur Working Group on Outcome Assessment. (2003). *The MacArthur health and behavior questionnaire (HBQ 1.0)*. (D. J. Kupfer, Ed.). University of Pittsburgh: MacArthur Foundation Research Network on Psychopathology and Development.

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

Bar-Haim, Y., Holoshitz, Y., Eldar, S., Frenkel, T. I., Muller, D., Charney, D. S., & Wald, I. (2010). Life-threatening danger and suppression of attention bias to threat. *The American Journal of Psychiatry, 167*(6), 694–698. doi:10.1176/appi.ajp.2009.09070956.

Biederman, J., Hirshfeld-Becker, D. R., Rosenbaum, J. F., Hérot, C., Friedman, D., Snidman, N., & Faraone, S. V. (2001). Further evidence of association between behavioral inhibition and social anxiety in children. *American Journal of Psychiatry, 158*(10), 1673–1679. doi:10.1176/appi.ajp.158.10.1673.

Buss, K. A. (2011). Which fearful toddlers should we worry about? Context, fear regulation, and anxiety risk. *Developmental Psychology, 47*(3), 804–819. doi:10.1037/a0023227.

Buss, K.A., & Goldsmith, H.H. (2000). Manual and normative data for the laboratory temperament assessment battery toddler version. Psychology Department Technical Report, University of Wisconsin Madison.

Buss, K. A., Davidson, R. J., Kalin, N. H., & Goldsmith, H. H. (2004). Context-specific freezing and associated physiological reactivity as a dysregulated fear response. *Developmental Psychology, 40*(4), 583–594. doi:10.1037/0012-1649.40.4.583.

Buss, K. A., Davis, E. L., Kiel, E. J., Brooker, R. J., Beekman, C., & Early, M. C. (2013). Dysregulated fear predicts social wariness and social anxiety symptoms during kindergarten. *Journal of Clinical Child & Adolescent Psychology, 42*(5), 603–616. doi:10.1080/15374416.2013.769170.

Buss, K. A., Ram, N., Davis, E. L., & Coccia, M. (2014). Dysregulated fear, RSA dysregulation, and social inhibition: A replication and extension. Manuscript in preparation.

Carter, A. S., Briggs-Gowan, M. J., Jones, S. M., & Little, T. D. (2003). The infant-toddler social and emotional assessment (ITSEA): factor structure, reliability, and validity. *Journal of Abnormal Child Psychology, 31*(5), 495–514. doi:10.1023/A:1025449031360.

Caspi, A., Harrington, H., Milne, B., Amell, J. W., Theodore, R. F., & Moffitt, T. E. (2003). Children's behavioral styles at age 3 are linked to their adult personality traits at age 26. *Journal of Personality, 71*(4), 495–514. doi:10.1111/1467-6494.7104001.

Chronis-Tuscano, A., Degnan, K. A., Pine, D. S., Perez-Edgar, K., Henderson, H. A., Diaz, Y., & Fox, N. A. (2009). Stable early maternal report of behavioral inhibition predicts lifetime social anxiety disorder in adolescence. *Journal of the American Academy of Child and Adolescent Psychiatry, 48*(9), 928–935. doi:10.1097/CHI.0b013e3181ae09df.

Clauss, J. A., & Blackford, J. U. (2012). Behavioral inhibition and risk for developing social anxiety disorder: a meta-analytic study. *Journal of the American Academy of Child and Adolescent Psychiatry, 51*(10), 1066–075.e1. doi:10.1016/j.jaac.2012.08.002.

Coplan, R. J., Rubin, K. H., Fox, N. A., Calkins, S. D., & Stewart, S. L. (1994). Being alone, playing alone, and acting alone: distinguishing among reticence and passive and active solitude in young children. *Child Development, 65*(1), 129–137.

Davidson, R. J., & Rickman, M. (1999). Behavioral inhibition and the emotional circuitry of the brain: stability and plasticity during the early childhood years. In L. Schmidt & J. Schulkin (Eds.), *Extreme fear, shyness, and social phobia: origins, biological mechanisms, and clinical outcomes* (pp. 67–77). New York: Oxford.

Degnan, K. A., & Fox, N. A. (2007). Behavioral inhibition and anxiety disorders: multiple levels of a resilience process. *Development and Psychopathology, 19*(03), 729–746. doi:10.1017/S0954579407000363.

Eldar, S., Ricon, T., & Bar-Haim, Y. (2008). Plasticity in attention: implications for stress response in children. *Behaviour Research and Therapy, 46*(4), 450–461. doi:10.1016/j.brat.2008.01.012.

Eldar, S., Apter, A., Lotan, D., Pérez-Edgar, K., Naim, R., Fox, N. A., & Bar-Haim, Y. (2012). Attention bias modification treatment for pediatric anxiety disorders: a randomized controlled trial. *The American Journal of Psychiatry, 169*(2), 213–220.

Essex, M. J., Kraemer, H. C., Armstrong, J. M., Boyce, W. T., Goldsmith, H. H., Klein, M. H., & Kupfer, D. J. (2006). Exploring risk factors for the emergence of children's mental health problems. *Archives of General Psychiatry, 63*(11), 1246. doi:10.1001/archpsyc.63.11.1246.

Field, A. P., & Lester, K. J. (2010). Is there room for "development" in developmental models of information processing biases to threat in children and adolescents? *Clinical Child and Family Psychology Review, 13*(4), 315–332. doi:10.1007/s10567-010-0078-8.

Fox, N. A., & Pine, D. S. (2012). Temperament and the emergence of anxiety disorders. *Journal of the American Academy of Child and Adolescent Psychiatry, 51*(2), 125–128. doi:10.1016/j.jaac.2011.10.006.

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

Fox, N. A., Henderson, H. A., Marshall, P. J., Nichols, K. E., & Ghera, M. M. (2005). Behavioral inhibition: linking biology and behavior within a developmental framework. *Annual Review of Psychology, 56*(1), 235–262. doi:10.1146/annurev.psych.55.090902.141532.

Hakamata, Y., Lissek, S., Bar-Haim, Y., Britton, J. C., Fox, N. A., Leibenluft, E., & Pine, D. S. (2010). Attention bias modification treatment: a meta-analysis toward the establishment of novel treatment for anxiety. *Biological Psychiatry, 68*(11), 982–990. doi:10.1016/j.biopsych.2010.07.021.

Hardee, J. E., Benson, B. E., Bar-Haim, Y., Mogg, K., Bradley, B. P., Chen, G., & Pérez-Edgar, K. (2013). Patterns of neural connectivity during an attention bias task moderates associations between early childhood temperament and internalizing symptoms in young adulthood. *Biological Psychiatry*. doi:10.1016/j.biopsych.2013.01.036.

Helfinstein, S. M., White, L. K., Bar-Haim, Y., & Fox, N. A. (2008). Affective primes suppress attention bias to threat in socially anxious individuals. *Behaviour Research and Therapy, 46*(7), 799–810. doi:10.1016/j.brat.2008.03.011.

Hirshfeld, D. R., Rosenbaum, J. F., Biederman, J., Bolduc, E. A., Faraone, S. V., Snidman, N., & Kagan, J. (1992). Stable behavioral inhibition and its association with anxiety disorder. *Journal of the American Academy of Child and Adolescent Psychiatry, 31*(1), 103–111. doi:10.1097/00004583-199201000-00016.

Hirshfeld-Becker, D. R., Micco, J., Henin, A., Bloomfield, A., Biederman, J., & Rosenbaum, J. (2008). Behavioral inhibition. *Depression and Anxiety, 25*(4), 357–367. doi:10.1002/da.20490.

Izard, C. E., Dougherty, L. M., & Hembree, E. A. (1983). *A system for identifying affect expressions by holistic judgments (AFFEX)*. Instructional Resources Center, University of Delaware.

Kessler, R. C., Petukhova, M., Sampson, N. A., Zaslavsky, A. M., & Wittchen, H.-U. (2012). Twelve-month and lifetime prevalence and lifetime morbid risk of anxiety and mood disorders in the United States. *International Journal of Methods in Psychiatric Research, 21*(3), 169–184. doi:10.1002/mpr.1359.

Kiel, E. J., & Buss, K. A. (2011). Toddlers' duration of attention toward putative threat. *Infancy, 16*(2), 198–210. doi:10.1111/j.1532-7078.2010.00036.x.

Lemery, K. S., Essex, M. J., & Smider, N. A. (2002). Revealing the relation between temperament and behavior problem symptoms by eliminating measurement confounding: expert ratings and factor analyses. *Child Development, 73*(3), 867–882. doi:10.1111/1467-8624.00444.

Lemery-Chalfant, K., Schreiber, J. E., Schmidt, N. L., Van Hulle, C. A., Essex, M. J., & Goldsmith, H. H. (2007). Assessing internalizing, externalizing, and attention problems in young children: Validation of the MacArthur HBQ. *Journal of the American Academy of Child and Adolescent Psychiatry, 46*(10), 1315–1323. doi:10.1097/chi.0b013e3180f616c6.

MacLeod, C., Mathews, A., & Tata, P. (1986). Attentional bias in emotional disorders. *Journal of Abnormal Psychology, 95*(1), 15–20. doi:10.1037/0021-843X.95.1.15.

Mathews, A., & MacLeod, C. (1994). Cognitive approaches to emotion and emotional disorders. *Annual Review of Psychology, 45*(1), 25–50. doi:10.1146/annurev.ps.45.020194.000325.

Merikangas, K. R., He, J., Burstein, M., Swanson, S. A., Avenevoli, S., Cui, L., & Swendsen, J. (2010). Lifetime prevalence of mental disorders in u.s. adolescents: results from the national comorbidity survey replication–adolescent supplement (NCS-A). *Journal of the American Academy of Child and Adolescent Psychiatry, 49*(10), 980–989. doi:10.1016/j.jaac.2010.05.017.

Monk, C. S., Nelson, E. E., McClure, E. B., Mogg, K., Bradley, B. P., Leibenluft, E., & Pine, D. S. (2006). Ventrolateral prefrontal cortex activation and attentional bias in response to angry faces in adolescents with generalized anxiety disorder. *The American Journal of Psychiatry, 163*(6), 1091–1097. doi:10.1176/appi.ajp.163.6.1091.

Monk, C. S., Telzer, E. H., Mogg, K., Bradley, B. P., Mai, X., Louro, H. M. C., & Pine, D. S. (2008). Amygdala and ventrolateral prefrontal cortex activation to masked angry faces in children and adolescents with generalized anxiety disorder. *Archives of General Psychiatry, 65*(5), 568–576. doi:10.1001/archpsyc.65.5.568.

Muthén, L. K., & Muthén, B. O. (2007). *Mplus user's guide* (6th ed.). Los Angeles: Muthén & Muthén.

O'Toole, L., & Dennis, T. A. (2012). Attention training and the threat bias: an ERP study. *Brain and Cognition, 78*(1), 63–73. doi:10.1016/j.bandc.2011.10.007.

Obradović, J., Bush, N. R., & Boyce, W. T. (2011). The interactive effect of marital conflict and stress reactivity on externalizing and internalizing symptoms: The role of laboratory stressors. *Development and Psychopathology, 23*(01), 101–114. doi:10.1017/S0954579410000672.

Pérez-Edgar, K., & Fox, N. A. (2005). Temperament and anxiety disorders. *Child and Adolescent Psychiatric Clinics of North America, 14*(4), 681–706. doi:10.1016/j.chc.2005.05.008.

Pérez-Edgar, K., Schmidt, L. A., Henderson, H. A., Schulkin, J., & Fox, N. A. (2008). Salivary cortisol levels and infant temperament shape developmental trajectories in boys at risk for behavioral maladjustment. *Psychoneuroendocrinology, 33*(7), 916–925. doi:10.1016/j.psyneuen.2008.03.018.

Pérez-Edgar, K., Bar-Haim, Y., McDermott, J. M., Chronis-Tuscano, A., Pine, D. S., & Fox, N. A. (2010a). Attention biases to threat and behavioral inhibition in early childhood shape adolescent social withdrawal. *Emotion, 10*(3), 349–357. doi:10.1037/a0018486.

Pérez-Edgar, K., McDermott, J. N. M., Korelitz, K., Degnan, K. A., Curby, T. W., Pine, D. S., & Fox, N. A. (2010b). Patterns of sustained attention in infancy shape the developmental trajectory of social behavior from toddlerhood through adolescence. *Developmental Psychology, 46*(6), 1723–1730. doi:10.1037/a0021064.

Pérez-Edgar, K., Reeb-Sutherland, B. C., McDermott, J. M., White, L. K., Henderson, H. A., Degnan, K. A., & Fox, N. A. (2011). Attention biases to threat link behavioral inhibition to social withdrawal over time in very young children. *Journal of Abnormal Child Psychology, 39*(6), 885–895. doi:10.1007/s10802-011-9495-5.

Pérez-Edgar, K., Taber-Thomas, B., Auday, E., & Morales, S. (2014). Temperament and attention as core mechanisms in the early emergence of anxiety. In K. H. Lagattuta (Ed.), *Contributions to Human Development* (Vol. 26, pp. 42–56). Basel: S. KARGER AG.

Preacher, K. J., Rucker, D. D., & Hayes, A. F. (2007). Addressing moderated mediation hypotheses: theory, methods, and prescriptions. *Multivariate Behavioral Research, 42*(1), 185–227. doi:10.1080/00273170701341316.

Roy, A. K., Vasa, R. A., Bruck, M., Mogg, K., Bradley, B. P., Sweeney, M., & Pine, D. S. (2008). Attention bias toward threat in pediatric anxiety disorders. *Journal of the American Academy of Child and Adolescent Psychiatry, 47*(10), 1189–1196. doi:10.1097/CHI.0b013e3181825ace.

Rubin, K. H., Burgess, K. B., & Hastings, P. D. (2002). Stability and social–behavioral consequences of toddlers' inhibited temperament and parenting behaviors. *Child Development, 73*(2), 483–495. doi:10.1111/1467-8624.00419.

Salum, G. A., Mogg, K., Bradley, B. P., Gadelha, A., Pan, P., Tamanaha, A. C., & Pine, D. S. (2013). Threat bias in attention orienting: evidence of specificity in a large community-based study. *Psychological Medicine, 43*(4), 733–745. doi:10.1017/S0033291712001651.

Schwartz, C. E., Snidman, N., & Kagan, J. (1999). Adolescent social anxiety as an outcome of inhibited temperament in childhood. *Journal of the American Academy of Child and Adolescent Psychiatry, 38*(8), 1008–1015. doi:10.1097/00004583-199908000-00017.

Shechner, T., Britton, J. C., Pérez-Edgar, K., Bar-Haim, Y., Ernst, M., Fox, N. A., & Pine, D. S. (2012a). Attention biases, anxiety, and development: toward or away from threats or rewards? *Depression and Anxiety, 29*(4), 282–294. doi:10.1002/da.20914.

Shechner, T., Pelc, T., Pine, D. S., Fox, N. A., & Bar-Haim, Y. (2012b). Flexible attention deployment in threatening contexts: an instructed fear conditioning study. *Emotion, 12*(5), 1041–1049. doi:10.1037/a0027072.

Stifter, C. A., Putnam, S., & Jahromi, L. (2008). Exuberant and inhibited toddlers: stability of temperament and risk for problem behavior. *Development and Psychopathology, 20*(02), 401–421. doi:10.1017/S0954579408000199.

Stirling, L. J., Eley, T. C., & Clark, D. M. (2006). Preliminary evidence for an association between social anxiety symptoms and avoidance of negative faces in school-age children. *Journal of Clinical Child & Adolescent Psychology, 35*(3), 431–439. doi:10.1207/s15374424jccp3503_9.

Telzer, E. H., Mogg, K., Bradley, B. P., Mai, X., Ernst, M., Pine, D. S., & Monk, C. S. (2008). Relationship between trait anxiety, prefrontal cortex, and attention bias to angry faces in children and adolescents. *Biological Psychology, 79*(2), 216–222. doi:10.1016/j.biopsycho.2008.05.004.

Tottenham, N., Tanaka, J. W., Leon, A. C., McCarry, T., Nurse, M., Hare, T. A., & Nelson, C. (2009). The NimStim set of facial expressions: Judgments from untrained research participants. *Psychiatry Research, 168*(3), 242–249. doi:10.1016/j.psychres.2008.05.006.

Wald, I., Lubin, G., Holoshitz, Y., Muller, D., Fruchter, E., Pine, D. S., & Bar-Haim, Y. (2011a). Battlefield-like stress following simulated combat and suppression of attention bias to threat. *Psychological Medicine, 41*(4), 699–707. doi:10.1017/S0033291710002308.

Wald, I., Shechner, T., Bitton, S., Holoshitz, Y., Charney, D. S., Muller, D., & Bar-Haim, Y. (2011b). Attention bias away from threat during life threatening danger predicts PTSD symptoms at one-year follow-up. *Depression and Anxiety, 28*(5), 406–411. doi:10.1002/da.20808.

Waters, A. M., Mogg, K., Bradley, B. P., & Pine, D. S. (2008). Attentional bias for emotional faces in children with generalized anxiety disorder. *Journal of the American Academy of Child and Adolescent Psychiatry, 47*(4), 435–442. doi:10.1097/CHI.0b013e3181642992.

Waters, A. M., Henry, J., Mogg, K., Bradley, B. P., & Pine, D. S. (2010). Attentional bias towards angry faces in childhood anxiety disorders. *Journal of Behavior Therapy and Experimental Psychiatry, 41*(2), 158–164. doi:10.1016/j.jbtep.2009.12.001.

Waters, A. M., Bradley, B. P., & Mogg, K. (2014). Biased attention to threat in paediatric anxiety disorders (generalized anxiety disorder, social phobia, specific phobia, separation anxiety disorder) as a function of "distress" versus "fear" diagnostic categorization. *Psychological Medicine, 44*(3), 607–616. doi:10.1017/S0033291713000779.

White, L. K., McDermott, J. M., Degnan, K. A., Henderson, H. A., & Fox, N. A. (2011). Behavioral inhibition and anxiety: the moderating roles of inhibitory control and attention shifting. *Journal of Abnormal Child Psychology, 39*(5), 735–747. doi:10.1007/s10802-011-9490-x.

White. L. K., Henderson, H. A., Pérez-Edgar, K. E., Walker, O. L., Degnan, K. A., Shechner, T., Fox, N. A. (2014). Prospective relations between behavioral inhibition, threat-related attention bias, and anxiety. Manuscript submitted for publication

Williams, L. R., Degnan, K. A., Perez-Edgar, K. E., Henderson, H. A., Rubin, K. H., Pine, D. S., & Fox, N. A. (2009). Impact of behavioral inhibition and parenting style on internalizing and externalizing problems from early childhood through adolescence. *Journal of Abnormal Child Psychology, 37*(8), 1063–1075. doi:10.1007/s10802-009-9331-3.