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Attention bias in the developmental unfolding of posttraumatic stress symptoms in young children at risk

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Abstract

Background—Threat-related attention bias relates to anxiety and posttraumatic stress symptoms in adults and adolescents, but few longitudinal studies examine such associations in young children. The current study examines prospective relations among attention bias, trauma exposure, and anxiety and trauma symptoms in a sample previously reported to manifest cross-sectional associations between attention bias and observed anxiety at preschool-age.

Methods—Young children [mean (MN)=5.0, $\pm$ 0.7 years, N=208] from a community-based sample completed the dot-probe task to assess their attention biases in response to angry faces. At baseline (T1) and at follow-up approximately nine months later (T2), anxiety and trauma exposure (i.e., violent and non-interpersonal events) and symptoms were assessed by maternal report.

Results—Neither attention bias nor baseline or recent trauma exposure predicted later anxiety. In contrast, attention bias towards threat and recent trauma exposure significantly predicted later trauma symptoms. There was evidence of symptom specificity such that attention bias towards threat significantly predicted hyperarousal and dissociation, but not avoidance or re-experiencing symptoms. Finally, moderation analyses indicated that the relationship between attention bias and trauma symptoms may differ according to children's experiences of probable abuse.

Conclusions—Attention profiles and trauma exposure may increase the risk that young children will develop trauma symptoms. Individual differences in these attentional patterns and children's exposure history may impact outcomes among high-risk children with potential implications for intervention.

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Keywords

Attention bias; stress; violence; anxiety; posttraumatic stress; trauma

Introduction

Attention bias to threat relates to anxiety and posttraumatic stress disorder (PTSD) symptoms in older children, adolescents, and adults (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van, 2007; Dudeney, Sharpe, & Hunt, 2015; Shechner et al., 2012). Recent cross-sectional research examines this association in preschoolers (Briggs-Gowan et al., 2015; Perez-Edgar et al., 2011; Swartz, Graham-Bermann, Mogg, Bradley, & Monk, 2011). However, the longitudinal effects of attention bias on children's anxiety has been examined in only a few studies, and none have examined its influence on developing trauma symptoms (Perez-Edgar et al., 2010; White et al., In press). Thus, there is a pressing need for longitudinal research on this topic in young children (Shechner et al., 2012), and the current study provides such data.

Typically, individuals show rapid, reflexive, early orienting towards extreme threats (LeDoux, 2000). However, some individuals devote disproportionate attention to milder threats, such as pictures of angry faces. The term 'attention bias' refers to this tendency and can be assessed with attention-capture paradigms, such as the dot-probe task (Bar-Haim et al., 2007; Shechner et al., 2012). Some influential cognitive models of anxiety emphasize two stages of information processing of threat. First, at temporally very early stages of processing, anxious individuals may excessively orient towards threats. Second, at later stages, anxious individuals may excessively engage cognitive control strategies that manifest different patterns of attention (Bar-Haim et al., 2007; Fox, Russo, & Dutton, 2002; Mogg, Bradley, de Bono, & Painter, 1997; Williams, 1988). Some individuals may continue to attend to threat, and this may enhance their perception of the environment as dangerous by ensuring that threats are detected. Others may initially detect threat but then divert their attention away from it. This may also enhance perception of the environment as dangerous by preventing them from further processing of environmental cues that could lead to reappraisal of the stimulus as non-threatening. In most research, the timing of the dot-probe task is such that it captures attention to threat at the second stage of processing. As such, biases in either direction on the dot-probe could predict anxiety. The predominant pattern in the literature links bias towards threat with anxiety symptoms (Bar-Haim et al., 2007). Recent research suggests that these associations arise very early in life (Briggs-Gowan et al., 2015; Perez-Edgar et al., 2011). Prior findings in young children include results from the first wave of data collected in our preschool cohort, followed longitudinally here. Cross-sectional data revealed that attention bias correlated significantly with observed fear/anxiety, but not with mother-reported anxiety or trauma symptoms (Briggs-Gowan et al., 2015).

Of note, findings in the literature are nuanced in PTSD, which has been linked to both bias towards threat and avoidance of threat (Bar-Haim et al., 2010; Bar-Haim et al., 2007; Sipos, Bar-Haim, Abend, Adler, & Bliese, 2014; Wald, Lubin, et al., 2011; Wald, Shechner, et al., 2011). These mixed findings could reflect individual differences in trauma pathways,

whereby biases in either direction predict maladaptive outcomes. Very little is known about how these pathways unfold in young children; however, one sample of 4-6-year-olds exposed to domestic violence revealed attention bias towards threat in children with PTSD but not in those without PTSD (Swartz et al., 2011). The current study provides a novel opportunity to examine the role of attention bias in the developmental unfolding of trauma symptoms and to investigate whether findings generalize across symptom types. Trauma symptoms manifest differently in early childhood than at older ages (Scheeringa, 2008). For example, avoidance/numbing symptoms are generally rare in young children, whereas hyperarousal is the predominant symptom presentation. Correlations among symptom clusters in young children tend to be more modest than in adults (Briggs-Gowan, Carter, & Ford, 2012; Carragher, Mills, Slade, Teesson, & Silove, 2010). Evidence of symptom specificity might have implications for early identification and treatment of young traumatized children.

Finally, trauma exposure increases risk for anxiety and trauma symptoms in young children (Briggs-Gowan et al., 2010; Levendosky, Bogat, & Martinez-Torteya, 2013). It also has been linked to attentional biases, and the effects of exposure may be stronger in children who manifest attentional biases than those with more normative patterns of attention (Bar-Haim et al., 2010; Briggs-Gowan et al., 2015; Gulley, Oppenheimer, & Hankin, 2014). Following the cognitive model above, children who have attentional biases at baseline and are trauma exposed may display greater symptom continuity or emergent symptoms over time than children with more normative patterns of attention or those without trauma exposure. Longitudinal studies to date have focused on anxiety and have not examined trauma symptoms in children (Perez-Edgar et al., 2010; White et al., in press), underscoring the unique opportunity offered by the current study.

This study tests two primary hypotheses in a high-risk sample of young children: Hypothesis 1: Attention bias to threat will predict later anxiety and trauma symptoms, controlling for baseline symptoms; Hypothesis 2: Attention bias and trauma exposure will independently predict change in symptoms over time. Trauma symptom models also will test for symptom specificity in the patterns observed. Exploratory Hypothesis 3: Attention bias will moderate (i.e., amplify) the effects of trauma exposure on later symptoms.

Methods

Participants

Participants were part of an intensive sub-study sample of 497 that was originally drawn by stratified random sampling from a survey sample of 1,857 3-5-year-olds recruited from pediatric practices (see also Briggs-Gowan et al., 2015). This sub-study included children without significant delays or neurodevelopmental conditions and their English-speaking, biological mothers. It was designed to investigate developmental risk for psychopathology and thus oversampled for past-year intimate partner violence and/or elevated disruptive behavior based on the original survey. We previously reported cross-sectional evidence that attention bias towards threat was associated with family violence and observed fear/anxiety in 218 4-6-year-olds. In that first paper, there were 269 eligible children and 218 of them had usable dot-probe data after cleaning.¹ Those 218 children were representative of full

sub-study sample (Briggs-Gowan et al., 2015). The current paper includes 208 of the initial 218 children (95.4%) who participated at Time 2 (T2). T2 occurred a mean of 9.4 months (± 3.4) after T1. Children were an average of 5.0 years (± 0.7) at T1 and 5.8 years (± 0.7) at T2. This sample was socio- demographically diverse and more than half of children were trauma-exposed at baseline (please see Table 1).

Procedures

Families attended two three-hour laboratory visits at T1. In the first visit, mothers completed measures of children's symptoms and functioning. In the second visit, an in-depth interview about family stress and violence was administered. At T2, mothers completed questionnaires via web-based questionnaires, paper surveys and phone interviews. Mothers were compensated for participation and transportation. Study protocols were approved by institutional review boards. Mandated reporting procedures were followed. Mothers provided informed consent. Staff monitored children for fatigue and distress, provided breaks, and discontinued assessments when appropriate.

Measures

Attention bias

Affective dot-probe. The computerized affective dot-probe task was administered at T1. Each trial began with the presentation of a 500-ms central fixation cross, followed by the 500-ms presentation of a side-by-side face pair (NimStim, Face Stimulus Set), followed by a target on the left or right. Photographs displaying pairs of emotional expressions (angry-neutral, happy-neutral, neutral-neutral) appeared on the right and left side of the fixation cross. Although happy faces were included, hypotheses center on angry bias given existing literature on threat-bias. Children completed the standard 180-trial or a 360-trial version (required for a sub-study). Bias scores were calculated from the first 180 trials (72 Angry, 72 Happy, 36 Neutral). Emotional stimulus location was counterbalanced. Immediately after the face-pair, a target (gold coin) appeared on the left or right side of the screen. Responses were recorded with a button box. The coin remained on the screen until a button was pressed. Every 90 trials, the child was given a break during which s/he 'earned' plastic gold coins to place in a transparent piggy back brought out by the research assistant. All children received prizes at the end of the task. Initial piloting in young children not included in this study revealed relatively low accuracy when the task was presented using instructions employed previously with older children. Higher accuracy was obtained when the task was framed as a game in which the child was instructed to catch the coins as quickly as possible to get a prize for doing a good job. Therefore, these developmentally-engaging instructions were used for all children in the current study. Research assistants attempted to administer the dot-probe to all children and used developmentally-appropriate methods to re-engage children who were off-task or non-compliant. Attention bias scores were calculated as the difference between reaction times (RTs) for incongruent (target same side as the neutral face) and congruent (target same side as the emotion face) trials, such that positive bias was toward the

¹Fifty-one children were excluded because they did not have usable dot-probe data due to failure to complete the task ($n=16$), low accuracy ($n=25$), acceptable accuracy but low trial count ($n=9$), or outlier reaction times ($n=1$).

emotion and negative bias was toward the neutral face. A categorical variable reflecting tertiles along the bias distribution also was calculated (Bias Away, Neutral, Bias Toward), as used in other studies (Briggs-Gowan et al., 2015; Perez-Edgar et al., 2011).

Data cleaning was designed to exclude questionable trials and calculate bias only if a sufficient number of trials remained. Trials were excluded if they were inaccurate, <200 ms, >7000 ms, or >2.5 SD from an individual child's Mean reaction time. Bias scores were calculated only if there were at least 9 usable trials per emotion condition (congruent/incongruent) and accuracy was 65%.² Studies of young children typically require this lower level of accuracy relative to studies of older youth and adults (Perez-Edgar et al., 2011; White et al., In press), because inaccurate trials can reflect not only a lack of understanding of the task (a reason for exclusion), but also off-task or non-compliant behaviors that are common in young children. After cleaning, usable data were obtained for 81% of eligible children in the original sample (Briggs-Gowan et al., 2015). In this follow-up sample, average accuracy was 91% (+/-8.0) with 89% at or above 80% accuracy. The Mean number of trials used to calculate bias was 31.3 (+/-3.9) for congruent trials and 31.2 (+/-4.7) for incongruent trials (minimum=17).

Child Anxiety and trauma-related symptoms

Preschool-Age Psychiatric Assessment (PAPA) (Egger et al., 2006). T1 anxiety symptoms were assessed with mother-reports in the PAPA, a semi-structured diagnostic interview. Total anxiety was calculated by summing specific phobia, social phobia, generalized anxiety, and separation anxiety symptoms. Interviews were administered by trained research assistants. Reliability of administration and scoring was monitored for 20% of interviews by an expert clinical psychologist (Percent Agreement=81%-98%). PTSD symptom endorsement was low, as observed in other studies (Briggs-Gowan et al., 2010); therefore an alternate trauma symptom measure was used (described below).

Early Childhood Symptom Inventory (ECI) (Gadow & Sprafkin, 1997). DSM-IV anxiety symptoms were assessed with mother-reports on the ECI at T2. Mothers were asked to rate how often their child behaved in the way described compared to other children on a 4-point scale (0- Never, 1-Sometimes, 2-Often, 3-Very often). A 17-item anxiety score was calculated as the number of phobia, separation anxiety, and general anxiety symptoms endorsed as occurring often or very often ($\alpha=0.91$).

Trauma Symptom Checklist for Young Children (TSCYC) (Briere et al., 2001). Trauma symptoms were assessed with mother reports on the hyperarousal, avoidance, intrusion and dissociation scales of the TSCYC ($\alpha=0.83-0.94$). The average T1 correlation between subscales was .45, with correlations as low as .20. All children had TSCYC data at T2 but 70% (n=145) had it at T1, because it was added after T1 began due to concerns about the PAPA's sensitivity. Children with and without T1 data were similar on the TSCYC at T2 [$\text{mean}_{\text{without}}=9.9$ (+/-2.3); $\text{mean}_{\text{with}}=10.0$ (+/-2.4) $t=0.43$, $p=.67$].

²Children with accuracy of 65%-79% were similar to those with accuracy 80% in attention bias, but were slightly younger [$MN=56.5$, +/-9.0 versus $MN=60.9$, +/-14.53 months, $t(1,206)=-2.44$, $p=.02$] and had slower angry RTs [$MN=1205.2$, +/-383.8 versus $MN=1037.0$, +/-539.2, $t(1,206)=2.49$, $p=.01$]. Groups were similar in sex, anxiety, trauma symptoms, and exposure ($X^2=0.11-0.62$, ns).

Trauma exposures

Child-directed violence. At T1, mothers were interviewed with an adaptation of the Family Socialization Interview (FSI), a semi-structured interview that covered two eras, birth to one year before the visit and the past year (Dodge, Pettit, & Bates, 1994; O'Dor, Grasso, Forbes, Wakschlag, & Briggs-Gowan, 2015). The FSI addressed mothers' and their partners' disciplinary practices with the child. Probes were designed to capture severity of methods used (e.g., use of hand on skin, use of an object, duration of spanking). Administration fidelity was monitored throughout the study. Independent coders unaware of children's status rated the usual and most intense physical discipline used by the mother and her partner in each era as follows: 0=none, did not spank or physically punish; 1=mild, minor physical contact likely to cause minimal or no distress; 2=moderate, physical contact likely to cause discomfort but not leave a mark, e.g., spanking; 3=moderately severe, significant physical contact that causes discomfort and may leave a mark, e.g., prolonged spanking, use of object on clothing; 4=severe, physical discipline that leaves more permanent mark, e.g., object on bare skin. The FSI had very good inter-rater reliability [Kappas (K) from .69-.89, MN=.84] and strong criterion-related validity (O'Dor et al., 2015). Analyses used a dichotomous 'Probable abuse' variable that was positive if the mother or partner had employed physical discipline strategies potentially bordering on or crossing the threshold of physical abuse by use of methods likely to cause physical discomfort or leave a mark (codes>3).

Witnessing partner violence. The FSI also assessed violence between the mother and her partner when the child was in the home in each era. Coders rated severity of violence: 0=none; 1=mild, e.g., slamming doors; 2=moderate, e.g., pushing, destroying property, single hit; 3=severe, e.g., punching, hitting, using weapon; and 4=severe with harm. Inter-rater reliability was very good (K from .69-1.0, MN=.88, +/- .11). Witnessing violence was positive if moderate to severe physical violence was present (codes>2).

Recent traumatic events. Exposure to 'any' potentially traumatic event between T1 and T2 was assessed with the Child Life Events Screener (CLES) {Briggs-Gowan, 2012 #2234}. Events included animal attack, serious car crash, accident, injury or witnessed family violence. This was supplemented with mother-reports of child-directed violence on the Parent-Child Conflict Tactic Scales (CTSPC) (Straus, Hamby, Finkelhor, Moore, & Runyan, 1998), which was positive if 1+ severe form of physical aggression was reported (i.e., Hit with a fist/kicked hard; Hit on another part of the body besides bottom with a belt/other object; Slapped on face/head/ears; Hit on bottom with a belt/other object).

Developmental level

Differential Ability Scales-Second Edition (DAS-II) (Elliott, 1983). The Picture Similarities subscale of the DAS provided a direct measure of developmental level at T1.

Analytic approach

Prior to hypothesis testing, simple analyses were conducted to evaluate the distributions of key variables. Dependent variables were log-transformed to reduce skew. Child age, sex, and number of usable dot-probe angry trials were covariates in all models. Ethnicity, poverty and developmental level were not significantly correlated with both IV and DVs and therefore

are not included as covariates ($p > .10$). Analyses were designed to test two primary hypotheses: Hypothesis 1, attention bias would predict change in symptoms over time; Hypothesis 2, attention bias and trauma exposure would independently predict change in symptoms over time; and exploratory Hypothesis 3 that attention bias would moderate (amplify) the relation between trauma exposure and later symptoms. These hypotheses were tested with separate regression models for anxiety and trauma symptoms with PROC SURVEYREG in SAS 9.0. Variables were entered in the following steps: 1, baseline symptoms, covariates; 2, continuous attention bias scores; 3, trauma history exposure reported at T1; and 4, recent trauma exposure. We conducted a profile analysis (Tabachnick & Fidell, 2001) to evaluate whether patterns varied by trauma symptom type. To minimize the risk of Type I error due to multiple comparisons, we planned a priori to conduct this analysis only if the main attention bias effect was significant. The profile analysis was tested within a repeated measures analysis of covariance with SAS 9.0 PROC GLM with TSCYC subscales as repeated DVs. A significant within-subject effect would indicate symptom specificity, meaning that attention bias predicted some symptoms more strongly than others. A significant between-subject effect would indicate a general effect across symptoms. To further minimize risk of Type I error, effects on individual subscales were examined only if the within-subject effect was significant. Finally, to test hypothesis 3 (moderation), the tertile-based attention bias variable was used, allowing examination of effects at both ends of the continuum. Such patterns are relevant because both bias away and towards threat may influence symptomatology. This approach has been used previously in studies of attention bias in young children (Perez-Edgar et al., 2011). Exposure-by-bias interactions were tested individually in models that controlled for other exposures, baseline symptoms, and covariates.

The SAS Procedures employed allowed model estimation procedures to account for the complex stratified sampling design. Analyses employed sampling weights that accounted for both unequal probabilities of selection and differential non-response rates. β are interpreted as effect sizes as follows: $\geq .5$ large; .30-.49 medium; .15-.29 small to moderate; and $\beta \sim .1$ small (Pearson r is approximately equal to β) (Nieminen, Lehtiniemi, Vähäkangas, Huusko, & Rautio, 2013).

Results

Descriptive analyses

Attention bias scores were not significantly associated with child age, developmental level, sex, angry-trial accuracy, angry-trial RT, or number of trials used to calculate bias ($r = -.08$ -.08, ns). Attention bias was not significantly correlated with mother-reported anxiety or trauma symptoms at T1 (please see Table 2), consistent with previously reported cross-sectional evidence that attention bias correlated with observed anxiety but not mothers' reports (Briggs-Gowan et al., 2015). However, the addition of longitudinal data revealed a new pattern such that attention bias at T1 predicted mother-reported trauma symptoms at T2. Child-directed violence and witnessed violence correlated with T1 anxiety and witnessed violence and recent exposure predicted T2 anxiety. Non-interpersonal trauma was not

significantly associated with symptoms at either T1 or T2; for statistical parsimony this variable was not included in regression models.

Anxiety symptoms model

Consistent with the above correlations, the regression model for anxiety symptoms indicated that baseline anxiety predicted later anxiety, $B = .34$, $SE = .78$, $p < .0001$. Trauma exposure and attention bias did not predict later anxiety symptoms (all $ps > .05$). For details, please see on-line supplemental Table S1. Bias-by-exposure interactions for witnessed violence, probable abuse, and recent events were non-significant (F s from 1.60 to 2.77, all $ps > .05$, details available upon request).

Trauma symptoms model

Supporting Hypothesis 1, attention bias towards threat significantly predicted later trauma symptoms in the total trauma symptoms model (Table 3). The direction of this effect indicated greater risk for symptoms in children who devoted disproportionate attention towards threats at baseline. Attention bias remained significant after exposure variables were added to the model (Step 3), supporting Hypothesis 2. In addition, recent exposures predicted increasing trauma symptoms. Baseline probable abuse and witnessed violence were not significant.

Models testing for bias-by-exposure interactions (exploratory Hypothesis 3) indicated a significant bias-by-probable abuse interaction, $F(2,130)=3.30$, $p = .04$. This effect appeared to reflect opposite patterns, such that bias away from threat predicted trauma symptoms in the probable abuse group but bias towards threat predicted symptoms in the non-abuse group (please see Figure 1). The linear contrast was significant in the non-abuse group, $F_{non-abuse}(1,102)=4.56$, $p = .04$, but not in the probable abuse group, $F_{probable\ abuse}(1,30)=3.24$, $p = .09$, and thus should be interpreted cautiously. Pairwise comparisons did not survive Bonferroni correction. All other interactions were non-significant (F s from 0.06 to 1.49, all $ps > .20$).³

In terms of symptom specificity, the significant main effect of attention bias on the Total TSCYC score (reported above) allowed us to test the profile analysis. Consistent with the total trauma symptoms model, the between-subject effects of attention bias and recent traumatic events were significant, indicating that these factors were generally associated with trauma symptoms overall (Table 4). Significant within-subject effects suggested symptom specificity for attention bias and statistically permitted examination of univariate models. Results revealed that attention bias towards threat predicted increases in hyperarousal and dissociation, but not avoidance or intrusion/re-experiencing.³

Discussion

Three main findings emerged from this longitudinal follow-up of preschool-age children, many of whom were trauma exposed. First, the longitudinal element in the current study brought to light new evidence that attention bias towards threat may contribute to the

³The same pattern of attention bias effects was observed when children with accuracy <80% were excluded from all models.

emergence of trauma symptoms, not evident concurrent with the initial exposure. These effects were particularly salient for hyperarousal and dissociation. Second, recent trauma exposure also contributed to increasing trauma symptoms at follow-up. Finally, the present findings suggest that the direction of attention bias as a risk process for traumatic symptoms may vary depending on environmental context. The novelty of this work lies in the longitudinal investigation of attention bias in developmental pathways of trauma symptoms, an understudied topic in children of all ages, and the consideration of individual differences in environmental context in these pathways.

Attention bias towards threat did not predict later anxiety symptoms. This is consistent with other studies that have failed to identify a main effect of attention bias on anxiety symptoms in young children (Perez-Edgar et al., 2011; White et al., in press). However, it contrasts with our earlier finding that bias towards threat correlated with observed fear/anxiety in this sample at the baseline and is inconsistent with robust evidence of attention bias-anxiety associations at older ages (Dudeney et al., 2015). Ongoing research might clarify whether this inconsistency reflects methodological limitations in the assessment of early anxiety, such as mothers' difficulty recognizing anxiety or perhaps greater sensitivity of observational paradigms for capturing anxiety in young children, or the impact of development, creating unique associations in young children.

In contrast, attention bias towards threat predicted later trauma symptoms, meaning that children who devoted disproportionate attention towards threats were at greater risk for trauma symptoms. Attention bias and trauma symptoms were not related in previously-reported cross-sectional analyses in this sample (Briggs-Gowan et al., 2015), suggesting that effects may emerge over time. This association also fits with a cross-sectional study that identified attention bias towards threat in young children with PTSD compared to those without PTSD (Swartz et al., 2011). Thus, associations may unfold over development, perhaps in the context of ongoing exposure to adverse environments. Furthermore, attention bias predicted increasing symptoms of hyperarousal and dissociation but not intrusion or avoidance. This symptom specificity may relate to the clinical presentation of trauma symptoms in young children, as avoidance and intrusion symptoms tend to be rarer and/or less easily identified than in older children (Scheeringa, 2008). It also might reflect a developmental progression such that in young children attention bias initially influences the emergence and persistence of hyperarousal and dissociation symptoms but influences the development of other symptoms over the course of ongoing exposures and/or maturation. Further research is essential to replicate these patterns in other young child samples and determine whether this theorized developmental sequence manifests across time.

The above findings indicate that attention bias towards threat may be a mechanism influencing developmental pathways of trauma symptoms in young children. However, patterns may vary for children with more extreme traumas. Other studies have identified bias away from threat in individuals (mostly adults) who have experienced extreme trauma, such as child abuse and combat (Bar-Haim et al., 2010; Pine et al., 2005; Wald, Lubin, et al., 2011; Wald, Shechner, et al., 2011). In adults, this bias away from threat has been shown to predict poorer trauma outcomes one year later (Wald, Lubin, et al., 2011; Wald, Shechner, et al., 2011). In line with this, moderation analyses revealed a significant attention bias-by-

probable abuse interaction, with effects in opposite directions according to abuse history. Attention bias towards threat predicted trauma symptoms in children without 'probable abuse' (consistent with the above main effect) whereas bias away from threat showed trend-level prediction of trauma symptoms in the probable abuse group. While it is important to interpret this finding cautiously, its consistency with adult findings suggests that individual differences in attention bias and severity of trauma exposure may together shape developmental pathways of trauma symptoms in children. Further research is essential to establish how these processes unfold across development within context.

Finally, evidence that attention bias and trauma exposure during the 9-month follow-up period each predicted later symptoms underscores the dynamic nature of children's functioning and their ongoing vulnerability to adverse environments. Thus, pinpointing how threat-related biases and ongoing exposures influence emergent psychopathology within a developmental environmental context may shed critical light on how brain-based and contextual processes culminate in often severe, impairing forms of psychopathology, including anxiety, PTSD, and complex PTSD. The patterns observed in this high risk sample, if replicated, could inform tailored interventions that are informed by children's unique exposure histories and attentional patterns.

Future directions and limitations

First, in this initial investigation of the prospective effects of attention bias in high-risk young children, our hypotheses were conservatively focused on threat-related attention bias and did not examine happy bias for two reasons: there is a substantial theoretical and empirical literature supporting threat biases in anxiety and trauma symptoms (Bar-Haim et al., 2007; Dudeney et al., 2015), and there is limited theoretical development about why happy bias would affect developmental pathways and testing such models would have increased the risk of Type I error. Future research examining the specificity of effects to angry faces will be important. Second, while framing the dot-probe as a game of catching coins enabled successful completion of the task with young children, it raises the possibility of motivational effects that cannot be addressed by our design. Third, we did not systematically assess when traumatic events occurred, due to concern that inquiring extensively about the timing of violent events might compromise rapport with mothers and lead to under-reporting of exposures. Thus, we were not able to examine timing more specifically than to show that 'recent' events during the follow-up period predicted trauma symptoms. Relatedly, as attention bias was not assessed at follow-up, how recent events may have affected attention bias and their joint influences on symptoms could not be examined. Finally, method variance introduced via the different measures available at different time point is a limitation. The optimal extension of this work would be utilizing nuanced, multi-method assessments equivalent across time points.

Summary

Disrupted attention in response to threats may influence the development of trauma symptoms in young children living in high-risk environments. Recent successes with attention bias modification training with older youth (Shechner et al., 2014) suggest that

similar approaches may be effective in deflecting maladaptive developmental trajectories at their origin. However, the application of attention bias findings to treatment is still in its early stages. A foundation of empirical data about the normative developmental course of attention biases, the impact of exposures on biases, and their independent and joint influences on developmental pathways over time may be essential to the success of such interventions with high-risk populations.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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References

- Bar-Haim Y, Holoshitz Y, Eldar S, Frenkel TI, Muller D, Charney DS, et al. Wald I. Life-threatening danger and suppression of attention bias to threat. *American Journal of Psychiatry*. 2010; 167(6): 694–698. [PubMed: 20395400]
- Bar-Haim Y, Lamy D, Pergamin L, Bakermans-Kranenburg MJ, van IMH. Threat-related attentional bias in anxious and nonanxious individuals: a meta-analytic study. *Psychological Bulletin*. 2007; 133(1):1–24. [PubMed: 17201568]
- Briere J, Johnson K, Bissada A, Damon L, Crouch J, Gil E, et al. Ernst V. The Trauma Symptom Checklist for Young Children (TSCYC): reliability and association with abuse exposure in a multi-site study. *Child Abuse Negl*. 2001; 25(8):1001–1014. [PubMed: 11601594]
- Briggs-Gowan MJ, Carter AS, Clark R, Augustyn M, McCarthy KJ, Ford JD. Exposure to potentially traumatic events in early childhood: differential links to emergent psychopathology. *Journal of Child Psychology and Psychiatry*. 2010; 51(10):1132–1140. [PubMed: 20840502]
- Briggs-Gowan MJ, Carter AS, Ford JD. Parsing the effects violence exposure in early childhood: modeling developmental pathways. *J Pediatr Psychol*. 2012; 37(1):11–22. [PubMed: 21903730]
- Briggs-Gowan MJ, Pollak SD, Grasso D, Voss J, Zobel E, McCarthy KM, et al. Pine DS. Attention bias and anxiety in young children exposed to family violence. *Journal of Child Psychology and Psychiatry*. 2015; 56(11):1194–1201. [PubMed: 26716142]
- Carragher N, Mills K, Slade T, Teesson M, Silove D. Factor structure of posttraumatic stress disorder symptoms in the Australian general population. *J Anxiety Disord*. 2010; 24(5):520–527. [PubMed: 20399604]
- Dodge K, Pettit G, Bates J. Socialization mediators of the relation between socioeconomic status and child conduct problems. *Child Dev*. 1994; 65:649–665. [PubMed: 8013245]
- Dudeney J, Sharpe L, Hunt C. Attentional bias towards threatening stimuli in children with anxiety: A meta-analysis. *Clin Psychol Rev*. 2015; 40:66–75. [PubMed: 26071667]
- Egger HL, Erkanli A, Keeler G, Potts E, Walter BK, Angold A. Test-Retest Reliability of the Preschool Age Psychiatric Assessment (PAPA). *Journal of the American Academy of Child and Adolescent Psychiatry*. 2006; 45(5):538–549. [PubMed: 16601400]
- Elliott, C. *Differential Abilities Scales: Introductory and technical handbook*. New York: Psychological Corporation; 1983.
- Fox E, Russo R, Dutton K. Attentional Bias for Threat: Evidence for Delayed Disengagement from Emotional Faces. *Cogn Emot*. 2002; 16(3):355–379. [PubMed: 18273395]
- Gadow, KD.; Sprafkin, J. *Early Childhood Inventory 4: Norms Manual*. Checkmate Plus; Stonybrook, NY: 1997.

- Gulley LD, Oppenheimer CW, Hankin BL. Associations among negative parenting, attention bias to anger, and social anxiety among youth. *Dev Psychol*. 2014; 50(2):577–585. [PubMed: 23815705]
- LeDoux JE. Emotion circuits in the brain. *Annual Review of Neuroscience*. 2000; 23:155–184.
- Levendosky AA, Bogat GA, Martinez-Torteya C. PTSD symptoms in young children exposed to intimate partner violence. *Violence Against Women*. 2013; 19(2):187–201. [PubMed: 23420836]
- Mogg K, Bradley BP, de Bono J, Painter M. Time course of attentional bias for threat information in non-clinical anxiety. *Behav Res Ther*. 1997; 35(4):297–303. [PubMed: 9134784]
- Nieminen P, Lehtiniemi H, Vähäkangas K, Huusko A, Rautio A. Standardised regression coefficient as an effect size index in summarising findings in epidemiological studies. *Epidemiology Biostatistics and Public Health*. 2013; 10(4)
- O'Dor, S.; Grasso, D.; Forbes, D.; Wakschlag, LS.; Briggs-Gowan, MJ. The Family Socialization Interview (FSI): A Comprehensive Assessment of Parental Disciplinary Behaviors, Manuscript Under Revision. *Prevention Science*; 2015.
- Perez-Edgar K, Bar-Haim Y, McDermott JM, Chronis-Tuscano A, Pine DS, Fox NA. Attention biases to threat and behavioral inhibition in early childhood shape adolescent social withdrawal. *Emotion*. 2010; 10(3):349–357. [PubMed: 20515224]
- Perez-Edgar K, Reeb-Sutherland BC, McDermott JM, White LK, Henderson HA, Degnan KA, et al. Fox NA. Attention biases to threat link behavioral inhibition to social withdrawal over time in very young children. *J Abnorm Child Psychol*. 2011; 39(6):885–895. [PubMed: 21318555]
- Pine DS, Mogg K, Bradley BP, Montgomery L, Monk CS, McClure E, et al. Kaufman J. Attention bias to threat in maltreated children: implications for vulnerability to stress-related psychopathology. *American Journal of Psychiatry*. 2005; 162(2):291–296. [PubMed: 15677593]
- Scheeringa MS. Developmental considerations for diagnosing PTSD and acute stress disorder in preschool and school-age children. *Am J Psychiatry*. 2008; 165(10):1237–1239. [PubMed: 18829877]
- Shechner T, Britton JC, Perez-Edgar K, Bar-Haim Y, Ernst M, Fox NA, et al. Pine DS. Attention biases, anxiety, and development: toward or away from threats or rewards? *Depress Anxiety*. 2012; 29(4):282–294. [PubMed: 22170764]
- Shechner T, Rimón-Chakir A, Britton JC, Lotan D, Apter A, Bliese PD, et al. Bar-Haim Y. Attention bias modification treatment augmenting effects on cognitive behavioral therapy in children with anxiety: randomized controlled trial. *J Am Acad Child Adolesc Psychiatry*. 2014; 53(1):61–71. [PubMed: 24342386]
- Sipos ML, Bar-Haim Y, Abend R, Adler AB, Bliese PD. Postdeployment threat-related attention bias interacts with combat exposure to account for PTSD and anxiety symptoms in soldiers. *Depress Anxiety*. 2014; 31(2):124–129. [PubMed: 23959788]
- Straus MA, Hamby SL, Finkelhor D, Moore DW, Runyan D. Identification of child maltreatment with the Parent-Child Conflict Tactics Scales: development and psychometric data for a national sample of American parents. *Child Abuse and Neglect*. 1998; 22(4):249–270. [PubMed: 9589178]
- Swartz JR, Graham-Bermann SA, Mogg K, Bradley BP, Monk CS. Attention bias to emotional faces in young children exposed to intimate partner violence. *Journal of Child and Adolescent Trauma*. 2011; 4:109–122.
- Tabachnick, BG.; Fidell, LS. *Using Multivariate Statistics*. Fourth. Boston, MA: Allyn and Bacon; 2001. Profile Analysis: The Multivariate Approach to Repeated Measures; p. 391–455.
- Wald I, Lubin G, Holoshitz Y, Muller D, Fruchter E, Pine DS, et al. Bar-Haim Y. Battlefield-like stress following simulated combat and suppression of attention bias to threat. *Psychol Med*. 2011; 41(4): 699–707. [PubMed: 21108868]
- Wald I, Shechner T, Bitton S, Holoshitz Y, Charney DS, Muller D, et al. Bar-Haim Y. Attention bias away from threat during life threatening danger predicts PTSD symptoms at one-year follow-up. *Depress Anxiety*. 2011; 28(5):406–411. [PubMed: 21381159]
- White LK, Degnan KA, Henderson HA, Perez-Edgar K, Walker OL, Schechner T, et al. Fox NA. Developmental relations between behavioral inhibition, anxiety, and attention biases to threat and positive information. *Child Dev*. In press.
- Williams LJ. Tunnel vision or general interference? Cognitive load and attentional bias are both important. *Am J Psychol*. 1988; 101(2):171–191. [PubMed: 3389419]

Key points

- This study provides novel evidence implicating attentional biases in the development of trauma symptoms in young children. Children with more disrupted patterns of attention in response to threatening faces were at increased risk for trauma symptoms over time.
- Findings further highlighted the impact trauma exposure and recent exposures on anxiety and trauma symptoms in young children.
- Further investigation of the interplay between attention biases and early, chronic or repeated trauma exposure is needed to articulate the early developmental pathways to PTSD beginning early in life.
- Attention bias modification treatments may be beneficial for young children, but understanding of how these processes unfold developmentally, especially in children raised in high-risk environments will be important to successful intervention.

Figure 1. Attention bias-by-probable abuse interaction predicts trauma symptoms

Table 1
Participant characteristics and exposures (N=208)

	<u>N (%)</u>
<u>Sociodemographic characteristics</u>	
Boys	98 (47.1)
Girls	110 (52.9)
African American	98 (47.1)
Hispanic	67 (32.2)
Caucasian	39 (18.8)
Other	4 (1.9)
Non-poor	108 (51.9)
Poor	100 (48.1)
<u>Baseline exposures</u> [/]	
Probable abuse	45 (22.7)
Witnessed partner violence	59 (29.7)
Non-interpersonal	64 (32.2)
Any exposure	114 (58.2)
<u>Recent exposures</u>	
Any trauma	49 (23.7)

[/]Twelve children with incomplete exposure interview data are excluded from these estimates.

Table 2

Correlations among key variables over time

		T1 ^I				T2 ^I			
	n	Anxiety	Trauma total	Anxiety	Total PTSD	Hyperarousal	Intrusion	Avoidance	Dissociation
<u>Child Characteristics</u>									
Age	208	.07	.00	-.10	.06	.04	-.04	-.07	.14
Sex	208	.11	.13	.11	.05	.02	.04	-.10	.12
Developmental level	208	.08	.07	.00	.14	.12	.09	.08	.14
Attention bias (T1)	208	.04	.01	-.01	.16	.20*	.02	.03	.18*
<u>Symptoms (T1)</u>									
Anxiety symptoms	208	-	.44****	.33****	.33****	.32****	.19*	.19*	.29****
Trauma symptoms ^I	145	.44****	-	.48****	.45****	.43****	.24****	.29****	.39****
<u>Exposures (T1)</u>									
Child-directed violence	196	.18*	.04	-.01	.06	.10	.01	.14	-.01
Witnessed partner violence	196	.15*	.15	.21**	-.06	-.08	.00	-.01	-.07
Non-interpersonal event	196	.07	.08	-.00	.10	.12	.06	-.04	.08
Any recent exposure (T 2)	208	.06	.13	.02	.25**	.24**	.19*	.21**	.16

*
p<.05,

**

p<.01,

p<.001,

p<.0001;^I Trauma correlations restricted to those with T1 TSCYC data, *n* = 145.

Table 3
Prediction of total trauma symptoms (N=145)

	Step 1	Step 2	Step 3	Step 4
<u>Baseline variables</u>	β (SE) <i>p</i>	β (SE) <i>p</i>	β (SE) <i>p</i>	β (SE) <i>p</i>
Intercept	0.00 (0.13) ****	0.00 (0.13) ****	0.00 (0.13) ****	0.00 (0.12) ****
Age	0.10 (0.00)	0.12 (0.00)	0.12 (0.00)	0.09 (0.00)
Trial count	-0.14 (0.00)	-0.16 (0.00)	-0.16 (0.00)	-0.15 (0.00)
Sex (female)	-0.01 (0.02)	-0.02 (0.02)	0.01 (0.02)	0.02 (0.02)
Total TSCYC	0.47 (0.01) ****	0.46 (0.01) ****	0.49 (0.01) ****	0.46 (0.01) ****
Attention bias		0.18 (0.00) **	0.17 (0.00) **	0.18 (0.00) **
Probable abuse			0.03 (0.02)	-0.03 (0.02)
Witnessed violence			-0.14 (0.02)	-0.13 (0.02)
Recent events				0.22 (0.02) *

*
 $p < .05$,

**
 $p < .01$,

 $p < .001$,

 $p < .0001$

Table 4
Exploratory profile analysis indicating symptom specificity

	F Between subjects	F Within Subjects	Hyperarousal β (SE)	Intrusion β (SE)	Avoidance β (SE)	Dissociation β (SE)
Intercept	-	-	0.00 (0.17) ****	0.00 (0.11) ****	0.00 (0.09) ****	0.00 (0.15) ****
Trial count	2.98	6.59 **	-0.24 (0.00) **	0.00 (0.00)	0.07 (0.00)	-0.14 (0.00)
Age	0.92	6.45 **	0.13 (0.00)	-0.07 (0.00)	-0.16 (0.00)	0.19 (0.00) *
Sex (1-female)	0.04	1.42	-0.02 (0.03)	0.05 (0.02)	-0.10 (0.02)	0.09 (0.03)
Total Trauma Symptoms	35.93 ****	9.78 ****	0.44 (0.01) ****	0.26 (0.01) **	0.32 (0.00) ****	0.39 (0.01) ****
Attention bias	5.93 *	5.05 **	0.22 (0.00) **	0.05 (0.00)	0.03 (0.00)	0.21 (0.00) *
Probable abuse	0.13	0.99	0.01 (0.04)	-0.07 (0.02)	0.07 (0.02)	-0.09 (0.03)
Witnessed violence	2.99	2.31	-0.15 (0.03) *	-0.02 (0.02)	-0.05 (0.02)	-0.14 (0.03)
Recent events	7.52 **	1.05	0.19 (0.04) *	0.21 (0.02) *	0.17 (0.02)	0.13 (0.03)

* $p < .05$,

** $p < .01$,

*** $p < .001$,

**** $p < .0001$

Note. Greenhouse-Geisser adjusted p -values presented for within-subject effects ($Epsilon = 0.6671$)