THE JOURNAL OF CHILD PSYCHOLOGY AND PSYCHIATRY

ACAMH THE ASSOCIATION FOR CHILD AND ADOLESCENT MENTAL HEALTH

Journal of Child Psychology and Psychiatry **:* (2016), pp **–** doi:10.1111/jcpp.12607

Attentional avoidance of fearful facial expressions following early life stress is associated with impaired social functioning

Kathryn L. Humphreys, Katharina Kircanski, Natalie L. Colich, and Ian H. Gotlib

Department of Psychology, Stanford University, Stanford, CA, USA

Background: Early life stress is associated with poorer social functioning. Attentional biases in response to threat-related cues, linked to both early experience and psychopathology, may explain this association. To date, however, no study has examined attentional biases to fearful facial expressions as a function of early life stress or examined these biases as a potential mediator of the relation between early life stress and social problems. **Methods:** In a sample of 154 children (ages 9–13 years) we examined the associations among interpersonal early life stressors (i.e., birth through age 6 years), attentional biases to emotional facial expressions using a dot-probe task, and social functioning on the Child Behavior Checklist. **Results:** High levels of early life stress were associated with both greater levels of social problems and an attentional bias away from fearful facial expressions, even after accounting for stressors occurring in later childhood. No biases were found for happy or sad facial expressions as a function of early life stress. Finally, attentional biases to fearful faces mediated the association between early life stress and social problems. **Conclusions:** Attentional avoidance of fearful facial expressions, evidenced by a bias away from these stimuli, may be a developmental response to early adversity and link the experience of early life stress to poorer social functioning. **Keywords:** Early life stress; attentional bias; fearful faces; social problems.

Introduction

The first years of life are characterized by enormous growth and plasticity in the human brain. Psychological insults during these critical years adversely affect functioning later in life (Humphreys & Zeanah, 2015; McLaughlin, Sheridan, & Lambert, 2014). Indeed, youth who experience early life stress (ELS) are at heightened risk for a broad range of negative outcomes, including greater problems in social functioning, lower peer acceptance, and increased peer rejection (Bolger & Patterson, 2001; Kim & Cicchetti, 2009).

To date, we do not understand how early adverse experiences lead to subsequent negative outcomes, including social problems. McCrory and Viding (2015) posited a theory of latent vulnerability in explaining the link between ELS and risk for psychopathology, suggesting that anomalous processing of threatening cues in the environment is a mechanism that underlies vulnerability to psychopathology. Biases in the allocation of attention toward or away from environmental stimuli affect the perception, evaluation, and memories of this information (Gotlib & Joormann, 2010). In this context, attentional biases in response to threat-relevant facial expressions (i.e., angry, fearful) have been associated with a range of psychopathology (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007).

Attentional biases are assessed most frequently with the dot-probe task, in which pairs of stimuli (words or images) are presented horizontally or vertically on a computer screen for a specified duration; typically one stimulus in each pair is valenced and the other is neutral. This display then disappears and a probe (i.e., dot) appears in the same location as one of the two stimuli; participants must indicate with a button press the location of the probe. Individuals respond more quickly to probes that replace stimuli to which they were attending. Using facial images in the dot-probe task is particularly useful in studying attentional biases in children, given that images do not require the semantic processes necessary to encode the content of verbal stimuli. An additional benefit is that human facial expressions are likely to be ecologically valid stimuli for children who have experienced interpersonal stressors (Fani, Bradley-Davino, Ressler, & McClure-Tone 2011).

There is growing evidence that attentional biases are influenced by environmental events in childhood and may contribute to heightened risk for psychopathology across adolescence and adulthood (Gibb, McGeary, & Beevers, 2016). In fact, stressful experiences in early life have been shown to predict subsequent cognitive biases (Fani et al., 2011). Importantly, the majority of studies examining attentional biases following experiences of ELS have focused on biases to angry-valence stimuli. For example, a history of physical abuse was associated with heightened attention to angry facial expressions and voices (see Pollak, 2008). In a seminal study on attentional biases following ELS, Pine et al. (2005) found that 7–13-year-old maltreated children exhibited attentional biases away from angry facial expressions. In contrast, however, Gibb et al.

Conflict of interest statement: No conflicts declared.

Published by John Wiley & Sons Ltd, 9600 Garsington Road, Oxford OX4 2DQ, UK and 350 Main St, Malden, MA 02148, USA

(2011) found biases toward angry facial expressions in children who had experienced ELS. In addition, in a study of adults, Fani et al. (2011) found no association between retrospectively reported child maltreatment and attentional biases to angry facial expressions. It is possible that these discrepant findings are due to the use of angry faces, which may be specific to the form of ELS experienced (e.g., if the child were the direct victim). Therefore, to assess attentional biases in individuals exposed to ELS that may be more heterogeneous with respect to the form of interpersonal ELS experienced, in the present study we examined responses on the dot-probe task to faces expressing fear.

Although fearful and angry facial expressions have been found to be comparable with respect to observers' ratings of negative emotion and arousal (Johnsen, Thayer, & Hugdahl, 1995), these two expressions convey different types of information. Although angry facial expressions are considered markers of certain and direct threat, fearful facial expressions are considered more ambiguous warning signals (Whalen, 1998). Certainly, experiences of ELS may consist of exposures to both angry and fearful facial expressions; however, fearful facial expressions may characterize a broader range of situations in which the child is not the direct victim, but is rather, a witness to interpersonal violence (e.g., violence between other family members). Indeed, using a morphed facial emotion identification task, Masten et al. (2008) found that children with histories of maltreatment were faster to identify fearful facial expressions than were children who were not maltreated.

This study was designed to examine the relation between ELS and attentional bias to fearful faces. We administered a dot-probe task to children in which fearful, sad, and happy facial expressions were paired with neutral expressions. We hypothesized that ELS would be associated with attentional biases to fearful facial expressions; however, given the discrepant findings in the literature concerning the direction of attentional biases to threat in individuals who have experienced ELS, we did not generate hypotheses regarding whether ELS would be associated with greater attention toward or away from fearful facial expressions. In addition, we hypothesized that attentional biases in response to fearful facial expressions would mediate the predicted association between ELS and heightened social problems.

Methods

Participants

Participants were 154 children (65 boys, 89 girls) ages 9.11–13.98 years (mean age: 11.36 years, *SD*: 1.02) who were recruited to take part in a longitudinal study examining ELS and psychopathology across the pubertal transition. Children self-identified race: 41% reported 'White/Caucasian,' 11% 'Asian,' 9% 'Hispanic,' 9% 'African American,' 2% 'Native American,' '1% Pacific Islander,' and 27% 'Other' (e.g., more than one racial identity). Fifty-nine percent of the families reported annual incomes over $100,000. Participants were selected from the community using a combination of flyers and local media, and were recruited on the basis of having a significant history of ELS (high-ELS group) or not (low-ELS group). We recruited only participants who were eligible to complete a neuroimaging scan because of the inclusion of a functional magnetic resonance imaging (fMRI) session in the larger study protocol, not included here. The study was approved by the Stanford University Institutional Review Board; participants and their parents gave assent and informed consent, respectively. Participants were screened for initial inclusion/exclusion criteria through a telephone interview; potentially eligible individuals were then invited to the laboratory for in-person interviews and assessments. Inclusion criteria were that children be between 9–13 years old, be proficient in English, and have a Tanner score (Marshall & Tanner, 1968, 1970) of less than 4. We assessed the children's levels of pubertal development using child report. Children were presented with line drawings of pubic hair and breast/testes development at five different stages of development and were asked to pick the drawing that most resembles their own morphology; participants were rated on a 1–5 scale (1 signifying that no or little development has begun, and 5 indicating that the participant has achieved adult levels of pubertal development). A single score was calculated by averaging the pubic hair and breast/testes scores. We included only participants with a score below stage 4, which in this sample aligns with premenarche in girls, to ensure that our participants were in the early to mid stages of pubertal development. Exclusion criteria were factors that would preclude an fMRI scan (e.g., metal implants; for another component of this project), a history of major neurological or medical illness, severe learning disabilities that would make it difficult for participants to understand the study procedures and, for females, the onset of menses.

Procedure

Participants attended a laboratory session with a caregiver; both individuals in each dyad completed measures about the child and family. The child then completed the dot-probe task, as well as other tasks not relevant to this paper. Participants were compensated for their time.

Measures

Traumatic Events Screening Inventory – Parent Report Revised (TESI-PRR; Ghosh-Ippen et al., 2002). Exposure to trauma was assessed using the TESI, which has been recommended as a measure of exposure to traumatic events in young children (Stover & Berkowitz, 2005). The TESI-PRR is a revision of the original psychometrically sound TESI-PR that was developed to include events common in young children (Ford et al., 2000). This parent-report measure assesses potentially traumatic events for children, including accidents, abuse, and witnessing community and domestic violence. Given that stressors that occur earlier in life and interpersonal stressors both have been found to be associated with poorer outcomes (Horowitz, 2004; Lupien, McEwen, Gunnar, & Heim, 2009), for each child we summed scores for 15 interpersonal stressors (e.g., separation from caregiver, witnessing domestic violence, sexual abuse) that occurred between birth through age 6 years (an age cutoff selected to be consistent with other recent research [Furniss, Beyer, & Müller, 2009]). Using a score cutoff closest to the 90th percentile (a cutoff used previously to identify severe ELS; see Fuge et al., 2014), we defined two groups of participants with

high (four or more stressors; $n = 21$) and low (three or fewer stressors; $n = 133$) levels of ELS.

Social Problems Subscale of the Child Behavior Checklist 4–18 (CBCL; Achenbach, 1991). The CBCL is a parent-reported 113-item rating scale that yields a measure of social problems based on the child's behaviors during the preceding 6 months. Responses were scored on a 3-point scale, from 0 (*not true*) to 2 (*very true or often true*). The CBCL was normed on a large sample of children and has excellent reliability and validity (Achenbach, 1991). We used the T-score from the social problems narrow-band subscale as our measure of social problems.

Dot-probe task. We used a subset of the NimStim Face Stimulus Set (Tottenham et al., 2009) to assess attentional bias to happy, fearful, and sad facial expressions. We used facial expressions from six male and six female actors who represented a range of ethnicities. All facial expressions were presented in color on a gray background. Images were approximately 8 × 10 cm in size and image pairs were displayed approximately 14 cm apart (measured from the center).

The dot-probe task was administered using E-Prime 2.0 (Psychology Software Tools, 2002) software on an IBM-compatible computer and Dell 17-inch color monitor. The task consisted of two blocks of 96 trials (192 trials in total) with one minute of rest between the blocks. Within each block, the trials were presented in a different, fully randomized order for each participant. Each block included 32 trials of each emotion type (happy, fearful, sad facial expressions paired with a neutral facial expression of the same model). Each block included two durations of stimulus presentation: 16 trials with 14-ms (subliminal) and 16 trials with 1,000-ms (supraliminal) stimulus presentation durations. Subliminal and supraliminal durations were presented randomly and were intermixed within blocks. At the start of each trial, participants were presented with a fixation cross in the center of the screen for 1,000 ms. Next, an image pair was presented either for 14 ms followed immediately by a mask for an additional 14 ms, or for 1,000 ms not followed by a mask. The stimulus mask was a black rectangle that was the same size and shape as the images. After these presentations, a black dot appeared in the center of the location where one of the images had been; participants were required to indicate the side of the screen on which the dot appeared by pressing the keyboard. For each combination of trial emotion and duration, the emotional face appeared with equal probability on each side of the screen, and the dot appeared with equal probability in the same location as the emotional face and the neutral face.

Participants were seated approximately 50 cm from the monitor. Participants' hands were positioned with the index finger of the left hand over the 'Z' key of the keyboard, labeled 'L,' and the index finger of the right hand over the 'M' key of the keyboard, labeled 'R.' Participants were instructed to detect the dot as quickly and as accurately as possible. Before beginning the task, participants were presented with written instructions with the experimenter present in the room to confirm understanding and answer any questions. Before completing the experimental trials alone, participants completed 10 practice trials with the experimenter present using facial expressions from actors not used in the experimental trials.

Data reduction and analysis

First, we examined differences between the low- and high-ELS groups in social problems using analysis of covariance (ANCOVA). Covariates included age, sex, and dummy-coded binary variables for race/ethnicity (White vs. non-White), income ($75,000 or less vs. more than $75,000), and parent's marital status (married/partnered vs. else). Each of these dummy-coded variables was examined in relation to social problems using independent-samples *t*-tests. To assess attentional biases, we conducted analyses consistent with those reported in prior work (Pine et al., 2005); thus, in the primary analyses we conducted independent samples *t*-tests and ANCOVAs to examine ELS-group differences in attentional biases for threat-relevant (i.e., fearful) facial expressions at the supraliminal level. Although we included both 14 ms and 1,000 ms durations in the task, we analyzed only the 1,000 ms trials given our interest in processes that occur at the conscious, or supraliminal, level; bias scores, mean reaction times, and accuracy rates for both durations of stimulus presentation are presented in supplemental Table S1. In secondary analyses, we examined attentional biases for supraliminal happy and sad facial expressions. In addition, we conducted chi-square analyses to examine tertiles of the direction of attentional bias as a function of ELS group. All analyses were two-tailed and, when equal variances between two groups could not be assumed, we present the degrees of freedom, *t*-value, and *p*-value provided from the correction for unequal variances.

Reaction time (RT) data were included for all task trials for which participants gave a correct response (error trials constituted 4% of the data). There were no differences in error rates between the high- and low-ELS groups, $t(152) = 0.83$, $p = .41$. For each participant, outlier RTs (>2 *SD* from the mean RT across all trials) were excluded; outlier RTs represented 0.49% of the data, and the two ELS groups did not differ in the proportion of outlier RTs, $t(152) = -0.36$, $p = .72$.

For each participant, mean RT was calculated as a function of stimulus emotion. As is standard procedure, we computed attentional bias scores separately for each emotion (sad, fearful, happy) using the following formula:

$$\text{Attentional bias score} = \text{RT for incongruent trials} - \text{RT during congruent trials.}$$

Thus, positive attentional bias scores indicate allocation of attention toward the emotional face relative to the neutral face, and negative attentional bias scores indicate allocation of attention away from the emotional face relative to the neutral face.

To test attentional bias scores as a putative mediator of the association between ELS group and social problems, per expert recommendations (e.g., Hayes 2009; MacKinnon, Fairchild, & Fritz, 2007) we implemented a single-step nonparametric resampling procedure (using 1,000 samples with replacement) for testing indirect effects using a powerful and valid test of mediation (Hayes, 2013). Mediation is supported when the indirect effect is statistically significant. To assess the indirect effect, we calculated 95% bias-corrected and accelerated (BCa) confidence intervals (CI) for coefficients; if the CI does not include zero, the indirect effect is considered to be statistically significant.

Results

Table 1 presents the demographic variables by ELS group. Consistent with previous findings indicating that interpersonal stressors are clustered with other stressors (see Zeanah & Humphreys, 2015), the low- and high-ELS groups differed in family structure and income. Compared to their low-ELS peers, participants in the high-ELS group were more likely to be in households without married/partnered caregivers and to have lower average family incomes, and were slightly but significantly younger; there were no differences in the gender composition of the two

Table 1 Descriptive statistics

	Low-ELS	High-ELS	t or χ^2
Age	11.41 (1.06)	11.03 (0.66)	2.24*
Sex (Percent Male)	41%	48%	0.29
Race/Ethnicity			
White/Caucasian	41%	33%	25.50***
African American	8%	10%	
Hispanic	9%	10%	
Asian	12%	0%	
Native American	1%	10%	
Pacific Islander	1%	5%	
Other	27%	19%	
No response given	1%	14%	
Primary Caregiver's Marital Status			
Single	6%	24%	12.79*
Married/Partnered	74%	43%	
Divorced	17%	33%	
Widowed	1%	0%	
No response given	3%	0%	
Family Income			
Less than $25,000	4%	24%	17.26**
$25,001–$75,000	17%	33%	
$75,001–$150,000	29%	14%	
More than $150,000	35%	19%	
No response given	17%	10%	
Mean Number of Interpersonal Stressors	0.88 (0.99)	5.33 (1.56)	−12.69***

M (*SD*) or %. ELS = early life stress. *$p < .05$; **$p < .01$; ***$p < .001$.

ELS groups ($p = .56$). While specific racial/ethnic identities differed significantly by ELS group, the two groups did not differ in the proportion of individuals who identified as White/Caucasian versus other groups, $\chi^2(1) = 0.05$, $p = .82$.

Group differences in social functioning

To examine whether demographic variables were associated with social functioning, we tested each variable on which participants in the low- and high-ELS groups differed significantly with respect to its relation with social problems. The CBCL was completed by 141 of the 154 total participants (92%). Only caregivers' marital status was significantly associated with social problems, $t(45.58) = 2.32$, $p = .025$: children whose caregiver was not married/partnered ($M = 55.03$, $SE = 1.19$) reported higher levels of social problems than did children whose caregiver was partnered or married ($M = 52.10$, $SE = 0.43$). When caregivers' marital status (i.e., married/partnered vs. other) was included as a covariate in an ANCOVA with ELS group, only ELS was a significant predictor of social problems ($F(136) = 5.16$, $p = .025$) with an effect size ($d = -.60$, 95% CI [−1.11, −0.09]) in the medium range (Cohen, 1988). As predicted, children in the high-ELS group ($M = 56.59$, $SE = 1.28$) had greater levels of social problems than did children in the low-ELS group ($M = 53.43$, $SE = 0.69$).

Group differences in attentional biases to fearful facial expressions

Consistent with our predictions, the low- and high-ELS groups differed in attentional bias to fearful facial expressions, $t(152) = 2.28$, $p = .024$, with an effect size ($d = .54$, 95% CI [0.07, 1.00]) in the medium range. As shown in Figure 1, participants in the high-ELS group exhibited a significant attentional bias away from fearful facial expressions, $t(20) = -2.48$, $p = .022$; there was no attentional bias either toward or away from fearful facial expressions in the low-ELS group, $t(132) = -0.51$, $p = .61$. All potential demographic covariates were found to be unrelated to biases to fearful facial expressions (ps > .05); furthermore the association between ELS group and attentional bias to fearful facial expressions remained significant after covariates (i.e., age, caregiver marital status, race/ethnicity, and income) were included individually.

Next, we examined whether more recent life stressors were responsible for the association between ELS and attentional biases to fearful facial expressions. Thus, we created a sum of interpersonal stressors that occurred from age 7 years onward to obtain a measure of life stress in later childhood. Not surprisingly, the low- and high-ELS groups differed in the number of later childhood stressors experienced ($M = 1.50$ [$SD = 1.62$] vs. 3.14 [2.08], respectively, $t(152) = -4.16$, $p < .001$). Importantly, however, even after including the sum of interpersonal stressors that occurred in later childhood in an ANCOVA, ELS group continued to significantly predict an attentional bias away from fearful faces ($F(1, 151) = 6.35$, $p = .013$); later childhood stressors were not related to attentional biases to fearful faces in this model ($p = .27$).

Finally, the low- and high-ELS groups did not differ significantly in attentional bias scores for either

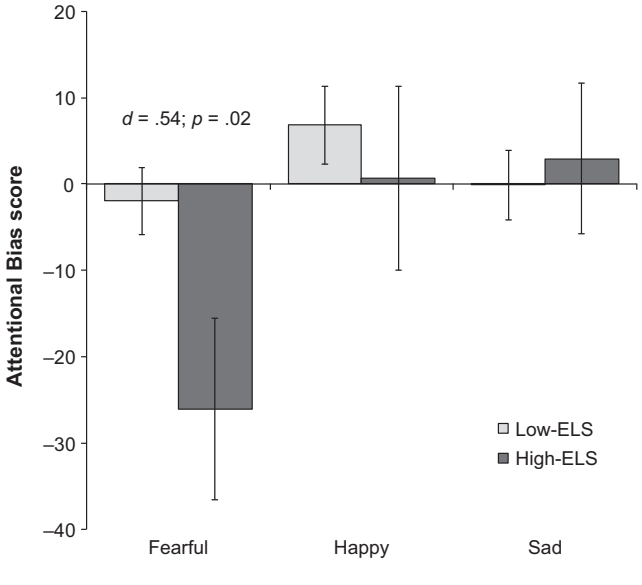

Figure 1 Attentional biases to emotion facial expressions from the 1,000 ms duration presentation in the low-ELS and high-ELS groups. *Note.* ELS = early life stress. Error bars = ±1 standard error

happy ($t(152) = 0.51$, $p = .61$, $d = .12$, 95% CI [−0.34, 0.58]) or sad facial expressions ($t(152) = -0.28$, $p = .78$, $d = -.07$, 95% CI [−0.53, 0.39]). To examine whether attentional bias scores differed significantly from zero, we conducted one-sample *t*-tests within the low- and high-ELS groups separately for the three emotions. The only condition for which attentional bias scores differed significantly from zero was biases away from fearful facial expressions in the high-ELS group.

To ensure that these group differences were not being driven by one or more participants with particularly strong biases, we conducted a further examination of the relation between levels of ELS and children's attentional biases to fearful facial expressions by dividing participants into three equal-size groups (tendency to attend toward fearful facial expressions [$n = 51$; bias scores = <−24.00], no consistent bias [$n = 52$; bias scores > −24.00 and <14.30], or tendency to attend away from fearful facial expressions [$n = 51$]; bias scores = >14.30). We then used these cut-points derived from the fearful facial expressions to examine attentional biases for happy and sad facial expressions (see Table 2). As expected based on our previous analyses, there was a significant association between ELS group and attentional bias tertile to fearful facial expressions, $\chi^2(1) = 9.10$, $p = .011$. Relative to the low-ELS group, children in the high-ELS group were 4.06 times more likely (95% CI [1.56, 10.59]) to direct their attention away from fearful facial expressions than they were to demonstrate no bias or a bias toward fearful facial expressions. There was no significant association between ELS group and bias tertile for happy or sad facial expressions ($\chi^2(1) = 4.25$, $p = .12$ and $\chi^2(1) = 0.24$, $p = .89$, respectively).

ELS and social problems: mediation by attentional bias to fearful facial expressions

We used a single-step mediation to examine whether individual differences in attentional biases to fearful facial expressions mediated the association between ELS group and social problems. Because zero was not within the 95% CI, the indirect effect differed significantly from zero (point estimate = −0.59 [0.43], 95% CI [−1.74, −0.04]). As depicted in Figure 2, this finding indicates that greater avoidance of fearful facial expressions significantly mediated the relation between ELS and poorer social functioning. The association between ELS and social functioning remained significant even when we included attentional biases to fearful facial expressions. We repeated the analysis with age, parent's marital status (i.e., married/partnered vs. not), and number of interpersonal stressors in later childhood included as covariates, and the indirect effect remained significant (95% CI [−1.99, −0.001]).

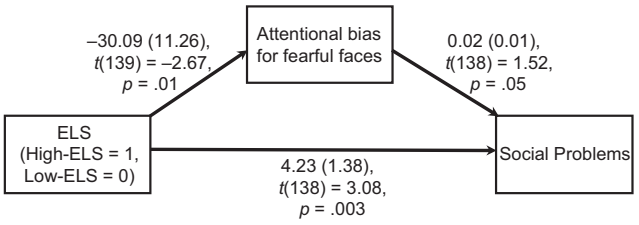

Figure 2 Mediation model of the association between ELS group and social problems as mediated by attentional biases for fearful facial expressions (1,000 ms). The indirect effect of attentional biases for fearful facial expressions was significant (95% Confidence Interval [−1.74, −0.04]). Unstandardized coefficient (standard error). ELS = early life stress

Table 2 Percent in the three attentional bias groups by condition based on equal distribution of attentional bias scores to fearful facial expressions (all 1,000 ms presentation times)

	Low-ELS	High-ELS	χ^2
Fear			
Away	29%	62%	9.10*
No Bias	36%	19%	
Toward	35%	19%	
Happy			
Away	24%	38%	4.25
No Bias	36%	14%	
Toward	40%	48%	
Sad			
Away	26%	29%	0.24
No Bias	34%	29%	
Toward	41%	43%	

ELS = early life stress. *$p < .05$.

Discussion

In a sample of 154 children, we found that low and high exposure to interpersonal ELS was associated with different patterns of attentional bias to fearful facial expressions. Specifically, we found that children high in ELS demonstrated an attentional bias away from fearful facial expressions, a finding that was obtained using both dimensional and tertile approaches to examining the direction of attentional bias. Furthermore, attentional avoidance of fearful facial expressions mediated the association between ELS and poorer social functioning. This study adds to the growing body of work highlighting the importance and possible development of cognitive biases following the experience of early adversity, and is consistent with the critical role of attentional processes in guiding learning and behavior (Shechner et al., 2012). Threat-related attentional biases following ELS have been postulated to contribute to dysfunctional real-life social interactions (Pine et al., 2005), relevant to the increased social problems found in children who experienced high levels of ELS (Bolger & Patterson, 2001; Kim & Cicchetti, 2009).

The construct of attentional biases as assessed by the dot-probe and similar tasks is assumed to reflect naturalistic behavior outside of the laboratory. Avoidance of fearful facial expressions may result in social distancing from others, which in turn could

reduce opportunities for further experience in social interactions. Both withdrawal and aggression have been proposed to mediate the association between early stress in the form of maltreatment and later difficulties with peers (see Bolger & Patterson, 2001). The present study provides evidence that attentional avoidance is associated with social withdrawal, findings that are consistent with the formulation that a bias away from fearful faces results in decreased social engagement. Furthermore, attentional biases to threat have been linked to social withdrawal in children and adolescents (Pérez-Edgar et al., 2010). It will be important in future research to include measures that parse different types of social functioning in order to gain a more comprehensive understanding of whether and how avoidance of fearful facial expressions might lead to greater social problems.

Previous studies have documented the presence of attentional biases to threat-related stimuli following the experience of ELS; this study, however, is the first to examine attentional biases to fearful facial expressions following ELS. Fearful facial expressions may signal danger in the environment and, consequently, represent an important stimulus class for humans, particularly for those who have experienced interpersonal stressors. Neuroimaging studies also underscore the importance of fearful facial cues. For example, relative to healthy controls, adolescents with a history of maltreatment have been found to exhibit elevated amygdala activation to fearful faces (Maheu et al., 2010). Garrett et al. (2012) found increased medial prefrontal activation during the viewing of fearful facial expressions in adolescents following exposure to interpersonal stressors. They argued that this brain region was recruited in an attempt to avoid processing threat-related material, resulting in less accurate memory for this emotional expression.

Although studies examining information processing in anxiety disorders tend to report attentional biases toward threat-relevant cues (Bar-Haim et al., 2007), the study with the sample most similar to that assessed in the present study examined biases in children with and without histories of maltreatment (Pine et al., 2005); as we did, these authors found an attentional bias away from threat-relevant material. Combined with Pine et al.'s findings, the present results suggest that early experiences of stress lead children to attend away from threat-related cues. Clearly, both psychopathology and early adversity in children are characterized by attentional biases either toward or away from threat-relevant stimuli. It will be important in future research to delineate parameters of these disorders and experiences that influence the direction of these biases.

Shifting attention away from such information is posited to maintain heightened anxiety (Mogg & Bradley, 1998). This attentional avoidance has been conceptualized as 'strategic' and consciously controlled (Cisler & Koster, 2010), although it is important to recognize that it may also reflect automatic processes. Regardless of whether attentional avoidance of threat-related material is strategic or automatic, however, it may function to reduce distress (In-Albon, Kossowsky, & Schneider, 2010). While this avoidance has short-term benefits, including reducing fear or anxiety responses to threatening stimuli, in the longer term it can result in a failure to habituate to threat (Rachman, 1998).

Investigators have also documented biases away from threatening information in individuals undergoing painful and unpleasant experiences (e.g., Nixon, Brewer, McKinnon, Cameron, & Bray, 2014). Similarly, avoidance of threat has been found in both children and adults with other forms of psychopathology (In-Albon et al., 2010; Waters, Mogg, Bradley, & Pine, 2011). Among individuals exposed to life-threatening stress, the degree of attentional bias away from threatening material was associated with greater levels of symptom distress (a composite of post-traumatic stress disorder [PTSD], depression, and anxiety) (Bar-Haim et al., 2010). The link between avoidance of threatening information and psychopathology has also been reported in prospective studies. For example, in a large sample of infantry soldiers, biases away from threatening material before military deployment predicted subsequent PTSD symptoms following combat (Wald et al., 2013).

Integrating the present findings with research in behavioral genetics (Lau et al., 2012), it appears that early environmental experiences play a crucial role in the development of attentional biases in response to threat-related cues. Avoidance of material that reminds individuals of traumas is a key feature of PTSD, and is a required symptom criterion that interferes with extinction of feared stimuli (Rothbaum & Davis, 2003). Consequently, a central feature of the most effective interventions for PTSD with both children and adults is exposure to feared stimuli. Our findings that ELS, rather than later childhood stressors, predict attentional biases provide further support that early experiences guide the development of this level of processing. In fact, there was no association of later childhood stressors and attentional biases, suggesting that there is a sensitive period for the development of attentional biases following interpersonal stressors. Additional research is needed, however, to explore developmentally sensitive boundaries for biases away from threat-related cues as a function of stress. This work might also help us elucidate the etiology of attentional biases, that have been posited to play a role in the onset and maintenance of mood and anxiety disorders (Gotlib & Joormann, 2010; Mathews & Mackintosh, 1998). It will be important that future research examine the temporal relations among ELS, attentional biases, and psychopathology.

While there is growing evidence supporting the efficacy of attentional bias modification for the treatment of psychopathology (Hakamata et al., 2010), these studies typically train individuals to orient away from threatening stimuli. For individuals who experienced a high number of stressors in early life, the functional implications of treatment intended to focus attention toward threatening material are not clear, particularly if continued stressors are present. As Masten et al. (2008) noted, fearful facial expressions in one's caregivers or siblings may be particularly salient threat cues in homes with interpersonal stressors. Avoidance is often posited to interfere with appropriate habituation of threatening stimuli (Cisler & Koster, 2010) and may interfere with appropriate social functioning. Yet, the adaptive significance of avoidance in youth who have experienced ELS is not well understood.

We should note four limitations of this study. First, although including fearful facial expressions as experimental stimuli significantly advances our understanding of attentional biases in response to threat-related cues following ELS, we did not include a direct comparison with angry facial expressions. Second, we focused in this paper on the supraliminal presentation of facial expressions; this stimulus duration, however, was intermixed with subliminal presentations during the task, which may have affected our results. As a related point, we used 1,000 ms as the duration of the supraliminal presentation; other stimulus durations (e.g., 500 ms) have been used in the literature and may be profitably examined in future studies of ELS. Third, although we constrained the age at which children in the high-ELS group experienced their stressful event from birth through age 6 years and limited our study to interpersonal stressors, the high-ELS group likely still represents a heterogeneous sample. Matching a low- and high-stress group on other demographic factors is an important extension of this work. In addition, we measured ELS by retrospective parental reports. Although such reports may be subject to errors of commission or omission, there is strong evidence supporting the validity of retrospective reports of serious adverse situations experienced in childhood (Brewin, Andrews, & Gotlib, 1993; Brown, Craig, Harris, Handley, & Harvey, 2007). Finally, it is possible that simply attending the laboratory session constituted an additional stressor for some children; this possibility should be assessed in future studies.

Conclusion

This study indicates that ELS is associated with an attentional avoidance of stimuli signaling environmental threat, as evidenced by an attentional bias away from fearful emotional facial expressions. Furthermore, the increased levels of social problems reported following ELS was mediated by these attentional biases, indicating a potential mechanism that underlies impairments in social functioning, and likely a broader risk for psychopathology, following the experience of ELS.

Supporting information

Additional Supporting Information may be found in the online version of this article:

Table S1. Bias score, mean reaction time, and accuracy rates by condition and early life stress group.

Acknowledgements

The authors thank Morgan Popolizio and Alexandria Price for their assistance in scheduling and running the participants. This research was supported by National Institute of Mental Health Grants F32-MH107129 (K.L.H.), F32-MH096385 (K.K.), and R01-MH101495 (I.H.G.), the Brain & Behavior Research Foundation (formerly NARSAD) Young Investigator Awards 23819 to K.L.H. and 20814 to K.K. who is now at the Emotion and Development Branch, National Institute of Mental Health, National Institutes of Health, Bethesda, MD. The authors have declared that they have no competing or potential conflicts of interest.

Correspondence

Kathryn Humphreys, Department of Psychology, Stanford University, Stanford, CA 94305, USA; Email: k.humphreys@stanford.edu

Key points

- Early life stress is associated with difficulties in social functioning, including withdrawal and aggression.
- Attentional bias to emotional faces, including attentional allocation either toward or away from threat-related cues, may underlie this association.
- We found an attentional bias away from fearful facial expressions in children with a history of early life stress.
- This attentional avoidance of fearful faces mediated the association between early life stress and social problems in early adolescence.

References

Achenbach, T.M. (1991). *Integrative guide for the 1991 CBCL/4-18, YSR, and TRF profiles*. Burlington, VT: University of Vermont.

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. *American Journal of Psychiatry*, *167*, 694–698.

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*, 1–24.

Bolger, K., & Patterson, C. (2001). Developmental pathways from child maltreatment to peer rejection. *Child Development*, *72*, 549–568.

Brewin, C.R., Andrews, B., & Gotlib, I.H. (1993). Psychopathology and early experience: A reappraisal of retrospective reports. *Psychological Bulletin*, *113*, 82–98.

Brown, G.W., Craig, T.K.J., Harris, T.O., Handley, R.V., & Harvey, A.L. (2007). Validity of retrospective measures of early maltreatment and depressive episodes using the Childhood Experience of Care and Abuse (CECA) instrument – A life-course study of adult chronic depression – 2. *Journal of Affective Disorders*, *103*, 217–224.

Cisler, J.M., & Koster, E.H.W. (2010). Mechanisms of attentional biases towards threat in anxiety disorders: An integrative review. *Clinical Psychology Review*, *30*, 203–216.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Hillsdale, NJ: Erlbaum.

Fani, N., Bradley-Davino, B.Ressler, K.J., & McClure-Tone, E.B. (2011). Attention bias in adult survivors of childhood maltreatment with and without posttraumatic stress disorder. *Cognitive Therapy and Research*, *35*, 57–67.

Ford, J.D., Racusin, R., Ellis, C.G., Daviss, W.B., Reiser, J., Fleischer, A., & Thomas, J. (2000). Child maltreatment, other trauma exposure, and posttraumatic symptomatology among children with oppositional defiant and attention deficit hyperactivity disorders. *Child Maltreatment*, *5*, 205–217.

Fuge, P., Aust, S., Fan, Y., Weigand, A., Gärtner, M., Feeser, M., & Grimm, S. (2014). Interaction of early life stress and corticotropin-releasing hormone receptor gene: Effects on working memory. *Biological Psychiatry*, *76*, 888–894.

Furniss, T., Beyer, T., & Müller, J.M. (2009). Impact of life events on child mental health before school entry at age six. *European Child and Adolescent Psychiatry*, *18*, 717–724.

Garrett, A.S., Carrion, V., Kletter, H., Karchemskiy, A., Weems, C.F., & Reiss, A. (2012). Brain activation to facial expressions in youth with PTSD symptoms. *Depression and Anxiety*, *29*, 449–459.

Ghosh-Ippen, C., Ford, J., Racusin, R., Acker, M., Bosquet, K., Rogers, C., & Edwards, J. (2002). *Trauma events screening inventory-parent report revised*. San Francisco: The Child Trauma Research Project of the Early Trauma Network and The National Center for PTSD Dartmouth Child Trauma Research Group.

Gibb, B.E., Johnson, A.L., Benas, J.S., Uhrlass, D.J., Knopik, V.S., & McGeary, J.E. (2011). Children's 5-HTTLPR genotype moderates the link between maternal criticism and attentional biases specifically for facial displays of anger. *Cognition & Emotion*, *25*, 1104–1120.

Gibb, B.E., McGeary, J.E., & Beevers, C.G. (2016). Attentional biases to emotional stimuli: Key components of the RDoC constructs of sustained threat and loss. *American Journal of Medical Genetics Part B: Neuropsychiatric Genetics*, *171*, 65–80.

Gotlib, I.H., & Joormann, J. (2010). Cognition and depression: Current status and future directions. *Annual Review of Clinical Psychology*, *6*, 285–312.

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

Hayes, A. (2013). *Introduction to mediation, moderation, and conditional process analysis*. New York: Guilford Press.

Hayes, A.F. (2009). Beyond Baron and Kenny: Statistical mediation analysis in the new millennium. *Communication Monographs*, *76*, 408–420.

Horowitz, L.M. (2004). *Interpersonal foundations of psychopathology*. Washington, DC: American Psychological Association.

Humphreys, K.L., & Zeanah, C.H. (2015). Deviations from the expectable environment in early childhood and emerging psychopathology. *Neuropsychopharmacology*, *40*, 154–170.

In-Albon, T., Kossowsky, J., & Schneider, S. (2010). Vigilance and avoidance of threat in the eye movements of children with separation anxiety disorder. *Journal of Abnormal Child Psychology*, *38*, 225–235.

Johnsen, B.H., Thayer, J.F., & Hugdahl, K. (1995). Affective judgment of the Ekman faces: A dimensional approach. *Journal of Psychophysiology*, *9*, 193–202.

Kim, J., & Cicchetti, D. (2009). Longitudinal pathways linking child maltreatment, emotion regulation, peer relations, and psychopathology. *Journal of Child Psychology and Psychiatry*, *51*, 706–716.

Lau, J.Y.F., Hilbert, K., Goodman, R., Gregory, A.M., Pine, D.S., Viding, E.M., & Eley, T.C. (2012). Investigating the genetic and environmental bases of biases in threat recognition and avoidance in children with anxiety problems. *Biology of Mood & Anxiety Disorders*, *2*, 12.

Lupien, S.J., McEwen, B.S., Gunnar, M.R., & Heim, C. (2009). Effects of stress throughout the lifespan on the brain, behaviour and cognition. *Nature Reviews Neuroscience*, *10*, 434–445.

MacKinnon, D.P., Fairchild, A.J., & Fritz, M.S. (2007). Mediation analysis. *Annual Review of Psychology*, *58*, 593–614.

Maheu, F.S., Dozier, M., Guyer, A.E., Mandell, D., Peloso, E., Poeth, K., … & Ernst, M., (2010). A preliminary study of medial temporal lobe function in youths with a history of caregiver deprivation and emotional neglect. *Cognitive, Affective & Behavioral Neuroscience*, *10*, 34–49.

Marshall, W.A., & Tanner, J.M. (1968). Growth and physiological development during adolescence. *Annual Review of Medicine*, *19*, 283–300.

Marshall, W.A., & Tanner, J.M. (1970). Variations in the pattern of pubertal changes in boys. *Archives of Disease in Childhood*, *45*, 13–23.

Masten, C.L., Guyer, A.E., Hodgdon, H.B., McClure, E.B., Charney, D.S., Ernst, M., & Monk, C.S. (2008). Recognition of facial emotions among maltreated children with high rates of post-traumatic stress disorder. *Child Abuse & Neglect*, *32*, 139–153.

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

McCrory, E.J., & Viding, E. (2015). The theory of latent vulnerability: Reconceptualizing the link between childhood maltreatment and psychiatric disorder. *Development and Psychopathology*, *27*, 493–505.

McLaughlin, K.A., Sheridan, M.A., & Lambert, H.K. (2014). Childhood adversity and neural development: Deprivation and threat as distinct dimensions of early experience. *Neuroscience and Biobehavioral Reviews*, *47*, 578–591.

Mogg, K., & Bradley, B.P. (1998). A cognitive-motivational analysis of anxiety. *Behaviour Research and Therapy*, *36*, 809–848.

Nixon, R.D.V., Brewer, N., McKinnon, A.C., Cameron, K., & Bray, J. (2014). Attention bias for threatening information in children following a distressing medical procedure. *Australian Psychologist*, *49*, 223–231.

Pérez-Edgar, K., Bar-Haim, Y., McDermott, J.M., Chronis-Tuscano, A., Pine, D.S., & Fox, N.A. (2010). Attention biases

to threat and behavioral inhibition in early childhood shape adolescent social withdrawal. *Emotion*, *10*, 349–357.
Pine, D.S., Mogg, K., Bradley, B.P., Montgomery, L., Monk, C.S., McClure, E., & Kaufman, J. (2005). Attention bias to threat in maltreated children: Implications for vulnerability to stress-related psychopathology. *American Journal of Psychiatry*, *162*, 291–296.
Pollak, S.D. (2008). Mechanisms linking early experience and the emergence of emotions: Illustrations from the study of maltreated children. *Current Directions in Psychological Science*, *17*, 370–375.
Psychology Software Tools (2002). *E-Prime 1.1.*, Pittsburgh, PA: University of Pittsburgh.
Rachman, S. (1998). A cognitive theory of obsessions: Elaborations. *Behaviour Research and Therapy*, *36*, 385–401.
Rothbaum, B.O., & Davis, M. (2003). Applying learning principles to the treatment of post-trauma reactions. *Annals of the New York Academy of Sciences*, *1008*, 112–121.
Shechner, T., Britton, J.C., Pérez-Edgar, K., Bar-Haim, Y., Ernst, M., Fox, N.A., ... & Pine, D.S., et al. (2012). Attention biases, anxiety, and development: Toward or away from threats or rewards? *Depression and Anxiety*, *29*, 282–294.
Stover, C.S., & Berkowitz, S. (2005). Assessing violence exposure and trauma symptoms in young children: A critical review of measures. *Journal of Traumatic Stress*, *18*, 707–717.
Tottenham, N., Tanaka, J.W., Leon, A.C., McCarry, T., Nurse, M., Hare, T.A., ... & Nelson, C. (2009). The NimStim set of facial expressions: Judgments from untrained research participants. *Psychiatry Research*, *168*, 242–249.
Wald, I., Degnan, K.A., Gorodetsky, E., Charney, D.S., Fox, N.A., Fruchter, E., & Bar-Haim, Y. (2013). Attention to threats and combat-related posttraumatic stress symptoms. *JAMA Psychiatry*, *70*, 401.
Waters, A., Mogg, K., Bradley, B., & Pine, D. (2011). Attention bias for angry faces in children with social phobia. *Journal of Experimental Psychopathology*, *2*, 475–489.
Whalen, P.J. (1998). Fear, vigilance, and ambiguity: Initial neuroimaging studies of the human amygdala. *Current Directions in Psychological Science*, *7*, 177–188.
Zeanah, C.H., & Humphreys, K.L. (2015). Current directions in the study of risk and adversity in infancy. In S.D. Caulkins (Ed.), *Handbook of infant biopsychosocial development* (pp. 315–335). New York: Guilford Press.

Accepted for publication: 6 May 2016