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Higher attention bias for fear at 8 months of age is associated with better socioemotional competencies during toddlerhood

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ABSTRACT

Background: In previous studies, an attention bias for signals of fear and threat has been related to socioemotional problems, such as anxiety symptoms, and socioemotional competencies, such as altruistic behaviors in children, adolescents and adults. However, previous studies lack evidence about these relations among infants and toddlers.

Aims: Our aim was to study the association between the individual variance in attention bias for faces and, specifically, fearful faces during infancy and socioemotional problems and competencies during toddlerhood.

Study design and subjects: The study sample was comprised of 245 children (112 girls). We explored attentional face and fear biases at the age of 8 months using eye tracking and the face-distractor paradigm with neutral, happy and fearful faces and a scrambled-face control stimulus. Socioemotional problems and competencies were reported by parents with the Brief Infant and Toddler Social Emotional Assessment (BITSEA) when children were 24 months old.

Outcome measures and results: A higher attentional fear bias at 8 months of age was related to higher levels of socioemotional competence at 24 months of age ($\beta = .18$, $p = .008$), when infants' sex and temperamental affectivity, maternal age, education and depressive symptoms were controlled. We found no significant association between attentional face or fear bias and socioemotional problems.

Conclusions: We found that the heightened attention bias for fearful faces was related to positive outcomes in early socioemotional development. Longitudinal study designs are needed to explore the changes in the relation between the attention bias for fear or threat and socioemotional development during early childhood.

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1. Introduction

Faces and facial expressions are an important source of social and emotional information during early childhood. Newborn infants show an attentional preference for faces and especially for happy faces (Farroni et al., 2007; Johnson et al., 2015). This kind of attentional preference for an object based on its emotional salience can be defined as affect-biased attention (Todd et al., 2012). Attention biases for faces and facial expressions with negative valence seem to develop during early development: a pronounced attention bias for fearful faces has been detected by 7 months of age (Amso et al., 2014; Frank et al., 2009; Frank et al., 2012; Libertus et al., 2017; Peltola et al., 2009; Yrttiaho et al., 2014) and an attention bias for angry faces by 24 months of age (Leppänen et al., 2018; Reider et al., 2022; Vallorani et al., 2021). Attention networks comprise alerting, orienting and executive attention networks and two of them, alerting and orienting networks are particularly relevant during infancy (Posner et al., 2014). Early-life affect-biased attention is present in both attention alerting and orienting (Reider et al., 2022). Interestingly, studies using longitudinal study designs show that attention biases for faces and specifically for fearful faces decline during the second and third year postpartum (Kataja et al., 2022; Leppänen et al., 2018; Libertus et al., 2017).

According to the model by Morales et al. (2016), affect-biased attention may have reciprocal connections to socioemotional functioning during development, and it may be one of the factors placing some children on adaptive and others on maladaptive socioemotional trajectories. Several previous studies have shown this connection, and also bidirectional connections, focusing on the development of affect-biased attention and infant temperament (Bierstedt et al., 2022; de Haan et al., 2004; Fu et al., 2020; Johnson et al., 1991; Leppänen et al., 2011; Pérez-Edgar et al., 2017; Vallorani et al., 2021). Thus, attention bias generally for faces and specifically for fearful faces and individual differences in their strength may play a specific role in infant social-emotional development when they emerge during the second half of the first year postpartum.

Socio-emotional competence is a key aspect of child development. Socioemotional competencies refer to behaviors that indicate that a child has achieved the age-appropriate goals in socioemotional development (Briggs-Gowan & Carter, 1998; Feldman & Masalha, 2010). The prosocial behaviors include, for example, helping, sharing and cooperating others as well as social participation, setting limits and verbalizing own needs (Huber et al., 2019). Higher socioemotional competencies are related to, for instance, better academic achievement and better mental health and they play an important role in socio-emotional development and well-being independently of socio-emotional problems (Denham et al., 2009; Huber et al., 2019; Kaukiainen et al., 2002; Masten et al., 1995; Rubin et al., 2006).

Attention to faces and facial expressions of emotions has been stated to be foundation of social interaction and prosocial behaviors (Klin et al., 2015). Attention bias specifically for fearful faces has been related to neurobiological models of ability to behave ethically (Pfaff et al., 2008). More specifically, an ability to detect fear in others is foundation of altruistic behavior, that is, behavior of selfless manner for other individuals benefit. There are a few previous studies supporting these models during infancy and early childhood (Bedford et al., 2015; Peltola et al., 2018; Rajhans et al., 2016). For instance, a greater responsiveness to fearful faces has been related to increased altruistic behavior in 4–5-year-old children (Rajhans et al., 2016). However, a higher attention bias generally for faces, rather than an attention bias specifically for fearful faces measured with eye-tracking tasks during infancy has been related to more frequent helping responses measured with behavioral tasks at 2 years of age (Peltola et al., 2018) and callous-unemotional traits, as an extreme opposite of prosocial behaviors, at 2.5 years (Bedford et al., 2015) and at 4 years (Peltola et al., 2018). While information on how early affect-biased attention relates to later socioemotional competencies remains scarce, it is necessary to identify the infant's emotional attention bias profiles that are potentially related to typical and atypical socioemotional developmental trajectories.

Among infants, some studies have found an association between infant temperament and affect-biased attention for faces (de Haan et al., 2004; Fu et al., 2020; Pérez-Edgar et al., 2017) while other studies have observed a connection between temperament and more broad attentional patterns, such as the overall tendency to disengage attention (Johnson et al., 1991; Leppänen et al., 2011). However, some recent studies using longitudinal study designs and tasks for multiple components of attention have demonstrated bi-directional connections between the development of attention biases for emotional faces (i.e., angry and happy faces), and temperamental negative affect and social fear across the first two years postpartum (Bierstedt et al., 2022; Vallorani et al., 2021). Still, studies on a general attention bias for faces (i.e., face bias), and especially, fearful faces (i.e., fear bias) and socioemotional functioning remain scarce (Fu & Pérez-Edgar, 2019).

Children as young as 2 years can suffer from socioemotional and behavioral problems (Briggs-Gowan et al., 2016), which persist during childhood even until preadolescence (Briggs-Gowan et al., 2006; Mesman & Koot, 2001). Two main domains of socioemotional problems, internalizing and externalizing problems, can be detected during toddlerhood (Achenbach, 1966; Briggs-Gowan & Carter, 1998). Socioemotional problems and the delays in socioemotional competencies, while distinct developmental domains, are to some extent interrelated, especially during early years (Briggs-Gowan et al., 2001). Many recent models have proposed that there is a link between negative cognitive and attention biases and internalizing problems. More specifically, several models have proposed that heightened attention bias for threat or fear is related to anxiety symptoms (see review by Mogg & Bradley, 2018). Field and Lester (2010) have described three competing models on how attention biases, among other information processing biases, manifest during the development and relate to, for example, anxiety symptoms. According to the integral bias model, attention biases are innate and do not change during the development. Other individual factors, such as anxiety, are related to attention biases, but the relation stays stable over the course of development. Then, according to the moderation model, attention biases are present in the early childhood but diminish over time in typical development. In atypical development, for example, when a child has anxiety symptoms, the attention biases remain high over the course of the development. Finally, according to the acquisition model, the development of attention biases are linked with the cognitive, emotional and social development and the biases may emerge at any point of the development. Individual factors, such as anxiety, interact with the attention biases.

To our knowledge, there are no prior studies on socioemotional attention biases during infancy and psychiatric symptoms during late childhood. However, some findings suggest an association between fear or threat bias and the domain of behavioral regulatory problems, i.e., problems in eating, sleeping and calming down, which is the important third domain of socioemotional problems occurring during infancy and toddlerhood (Briggs-Gowan & Carter, 1998; Briggs-Gowan et al., 2016; Eskola et al., 2021; Gross, 2016). In addition, a higher attention bias for angry faces at 4 and 24 months of age has been related to temperamental negative emotionality, which is a well-known risk factor for elevated anxiety symptoms from childhood and onwards (Fox & Pine, 2012; Pérez-Edgar et al., 2017; Vallorani et al., 2021). Furthermore, previous studies in school-aged children, adolescents and adults have shown that threat-related attention biases are associated with higher levels of anxiety symptoms. However, these biases include not only attention bias toward threat, that is, an attentional preference for an object (Bar-Haim et al., 2007; Cisler & Koster, 2010; Dudeney et al., 2015; Fu & Pérez-Edgar, 2019; Georgiou et al., 2005; Shechner et al., 2012, 2013; Todd et al., 2012) but also an attention bias away from threat, that is, the attentional avoidance of negative faces (Brown et al., 2013; Grafton et al., 2016; Gunther et al., 2022; Morales et al., 2015; Shechner et al., 2012). While previous studies have shown that threat- and fear-related attention biases are a part of typical development and change rapidly during infancy and toddlerhood, the origins of the association between threat bias and anxiety symptoms have not yet been found (Fu & Pérez-Edgar, 2019).

The aim of this study was to investigate how attentional face and fear biases during infancy are associated with socioemotional problems and competencies during toddlerhood. We used a face-distractor paradigm to measure infants' probability to disengage attention from a neutral, happy and fearful face and a scrambled-face control picture. Attentional engagement and disengagement were examined by tracking infants' eye movements when they were exposed to different facial expressions and lateral distractors. Based on the eye-movement data, we calculated two attention bias variables adopted from previous studies using the face–distractor paradigm among infants between 7 and 8 months of age (Kataja et al., 2020; Yrttiaho et al., 2014). In previous studies, the probability of disengagement has been highest for the scrambled-face control picture, intermediate for happy and neutral faces and lowest for the fearful face, and, therefore, a composite score of the happy and neutral condition has been contrasted to the scrambled-face condition (as an index of "face bias") or the fear condition (as an index of "fear bias"; Kataja et al., 2020; Yrttiaho et al., 2014). Hence, in the present study, face bias was defined as the difference between disengagement probabilities in happy and neutral face conditions and the scrambled-face condition. Furthermore, fear bias was defined as the difference between disengagement probabilities in the fearful face condition and the happy and neutral face conditions. Socioemotional problems and competencies were assessed as two separately measured constructs using the Brief Infant and Toddler Socioemotional Assessment (BITSEA; Briggs-Gowan et al., 2004) filled out by one or both parents. As maternal depressive symptoms and infant temperament were possible confounding factors influencing both infant attention biases (Fu & Pérez-Edgar, 2019) and socioemotional problems and competencies (Bridgett et al., 2015), they were controlled for in the analyses.

Our first study question was whether infant's face and fear biases at the age of 8 months would be associated with socioemotional problems at the age of 2 years. Problem behaviors included internalizing and externalizing behaviors and other problem behaviors. Our second study question was whether an infant's face and fear biases at the age of 8 months were associated with socioemotional competencies at the age of 2 years. Competencies included social communication skills and ability to express one's feelings. Socioemotional problems and competencies assessed using BITSEA have been negatively correlated (Briggs-Gowan et al., 2004). However, based on previous theoretical models and research findings we anticipated that higher attention bias for fearful faces would be related to both higher socioemotional problems (Dudeney et al., 2015; Mogg & Bradley, 2018) and higher socioemotional competencies (Grossmann et al., 2018; Klin et al., 2015; Peltola et al., 2018).

2. Materials and methods

2.1. Participants and study design

Participants ($n = 242$), all northern European, belonged to the Study that has been established to investigate the effects of early life stress and child development. The Cohort study sample ($n = 3808$ families, www.utu.fi/finnbrain) represents the source population in Finland adequately (Karlsson et al., 2018). Recruitment took place in maternity clinics at gestational week 12 during ultrasound visits in South-Western Hospital District and Åland Islands via personal contacts of study nurses between December 2011 and April 2015. Inclusion criteria were verified pregnancy and sufficient knowledge of Finnish or Swedish, which are the official languages of Finland. The participants of the present study belonged to the Focus Cohort drawn from the main cohort to study the effects of elevated maternal psychological distress during pregnancy on child development. The Focus Cohort included mothers with elevated depressive-, anxiety- and/or pregnancy-related anxiety symptoms during pregnancy and their controls with few such symptoms. A detailed description of the Focus Cohort criteria is found in the Cohort Profile report by Karlsson et al. (2018). The study protocols of the FinnBrain Birth Cohort Study were granted approval by the Ethics Committee of the Hospital District of Southwestern Finland.

The eye-tracking measurement was conducted as a part of the study visits of Child Development and Parental Functioning Lab at the infant age of 8 months. The study visits included also measurements of infant temperament and executive functions and the mother–infant interaction. The visits took place in the FinnBrain laboratories between March 2013 and July 2016. Socioemotional problems and competencies were measured using the Finnish version of BITSEA (Haapsamo et al., 2009) at the children's age of 2 years. The questionnaire was sent to all participating mothers and fathers via mail or e-mail according to their choices. The formation of the final sample size is described in Fig. 1.

2.2. Materials

2.2.1. Background factors

Parental characteristics were collected using questionnaires at gestational week 14 and 3- and 24 months postpartum. Information included parents' age at the delivery and education at gestational week 14. In addition, parental depressive symptoms were measured using the Edinburgh Postnatal Depression Scale (EPDS; Cox et al., 1987) at gestational week 14 and at 24 months postpartum. Missing item-level values (gestational week 14: 0.28%; 24 months postpartum: 0.21%) were imputed with the mean of each scale. Internal consistency (Cronbach's α) of the maternal scores of EPDS was good (at gestational week 14: $\alpha = .85$; at 2 years: $\alpha = .88$). Information about infants' sex and gestational weeks at birth was drawn from the Finnish Medical Birth Register administered by the National Institute for Health and Welfare (www.thl.fi). Descriptive information of the sample is displayed in Table 1.

2.2.2. Eye-tracking of emotional faces

The eye-tracking measurement was described in more detail in Kataja et al. (2020). In short, the infants were seated on their

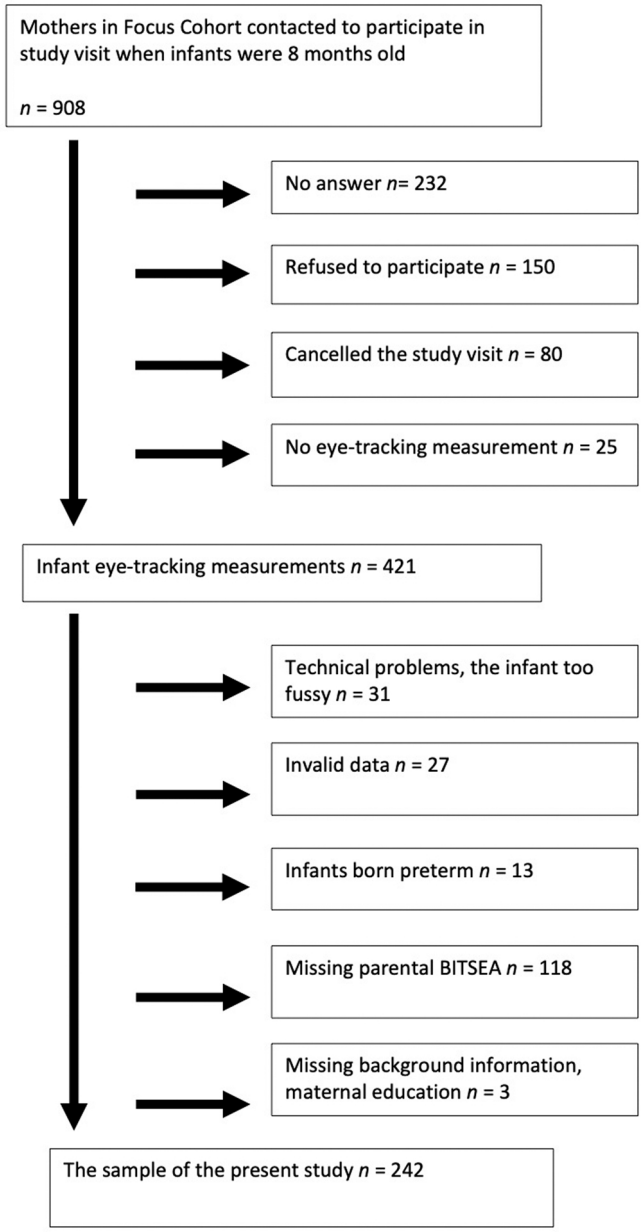

Fig. 1. Flowchart of the recruitment process.

Table 1
Descriptive statistics for the participating infants ($n = 250$), mothers ($n = 250$) and fathers ($n = 190$).

			n (%) or median (min–max)
Infant Characteristics (n=250)			
	Infant sex, n, girls		113 (45%)
	Duration of gestation at birth, weeks		40 (38–42)
Maternal Characteristics ($n = 250$)			
	Age at the delivery (years)		32 (21–44)
	Education (missing $n = 4$)		
		High school, vocational school or lower	59 (24%)
		Tertiary vocational	80 (33%)
		University degree or higher	107 (43%)
	EPDS, prenatal (missing $n = 6$)		4 (0–22)
	EPDS, postnatal (missing $n = 34$)		3 (0 – 21)
Paternal Characteristics ($n = 190$)			
	Age at the delivery (years)		32 (21–48)
	Education (missing $n = 16$)		
		High school, vocational school or lower	63 (36%)
		Tertiary vocational	65 (37%)
		University degree or higher	46 (26%)
	EPDS, prenatal (missing $n = 19$)		2 (0–16)
	EPDS, postnatal (missing $n = 29$)		3 (0–20)

parent's lap at a distance of 50–70 cm from the tracker (Desktop Mount, EyeLink1000 +, SR Research Ltd, Toronto, Ontario, Canada), and the computer screen was placed 15 cm behind the tracker. The researcher conducted a 5-point calibration and validation routine before the experiment. The tracker estimated and recorded the x- and y-coordinates of the gaze location on the screen at the frequency of 500 Hz.

Infants' attention disengagement from emotional faces was investigated with an overlap face-distractor paradigm (Aslin & Salapatek, 1975; Peltola et al., 2008) with neutral, happy and fearful facial expressions. The stimuli were adopted from the study of Peltola et al. (2008). A scrambled-face picture was used as a control stimulus. The distractor stimuli were black and white checkerboards or vertically arranged circles (15.4° x 4.3°). In every trial, an emotional or a scrambled face was presented at the center of the screen for 4000 ms in a semi-random order. The overlapping peripheral distractor stimulus emerged semi-randomly on the right or left side of the central stimulus 1000 ms after the face onset and remained for the rest 3000 ms of the trial. The experiment consisted of 48 trials (12 trials per stimulus condition).

2.3. Gaze acquisition and raw data processing

The eye-tracker recorded the x- and y-coordinates of the estimated gaze location on the screen and information about the trial with the type of facial expression of the presented central stimulus and the location (left or right) of the distractor stimulus. The data were analyzed offline by using the library of Matlab (Mathworks, Natick, MA) scripts (Leppänen et al., 2015) designed to cope with the challenges of analyzing data collected from poorly cooperating participants, such as infants. Attention disengagements from the central stimulus to the lateral distractor were analyzed during the time period from 150 ms to 1000 ms after the appearance of the distractor stimulus. Three inclusion criteria were used to select the valid trials: 1) the infant fixated at least 70% of the time on the central stimulus before the attention disengagement or before the end of analyzing period, 2) there were no gaps longer than 200 ms in the recorded gaze data, and 3) there were no gaps in the recorded data just before or just after the attention disengagement. Participants with at least three valid trials per condition were included in the final analyses.

2.4. Eye-tracking variables

Disengagement probability (DP) was calculated as the proportion of gaze shifts from the central stimulus to the lateral distractor during the analysis period. The number of gaze shifts was divided by the number of all valid trials, and it ranged from 0 to 1. DP was calculated separately for each face condition (i.e., neutral, happy, fearful and scrambled face).

Face bias was defined as the difference between the DPs for the scrambled face and the DPs for non-fearful faces, that is, neutral and happy faces (Yrttiaho et al., 2014).

Fear bias was defined as the difference between the DPs for non-fearful faces (i.e., neutral, happy) and the DPs for fearful faces (Yrttiaho et al., 2014).

2.5. Measurement of socioemotional problems and competencies

The Brief Infant Toddler Social Emotional Assessment (BITSEA) was completed by both parents at the children's age of 24 months. The BITSEA is a brief 42-item version of the Infant Toddler Social Emotional Assessment created for screening socioemotional problems and competencies among 12–36-month-olds in pediatric settings (Alakortes et al., 2015; Briggs-Gowan et al., 2004). Parents gave responses to statements using a 3-point Likert scale (0 = not true/rarely, 1 = somewhat true/sometimes, 2 = very true/often).

The questionnaire comprised of 31 items measuring socioemotional problems and 11 items measuring competencies. Missing values (problems: 0.16%; competencies: 0.13%) were imputed with the mean (problems, max. 4 missing values were allowed; competencies, max. 1 missing value were allowed). The descriptive statistics of the BITSEA scores are presented in Table 2. The reliability of the BITSEA was explored in the whole sample collected in the larger cohort study ($n = 1448$). The internal consistency was good for social-emotional competence scale (*CFI* = 0.98, *RMSEA* = 0.02, *McDonald's* $\omega = 0.60$) and acceptable for social-emotional problems scale (*CFI* = 0.71, *RMSEA* = 0.06, $\omega = 0.76$). Since the subscales of the problems scale showed marginal internal consistency, (internalizing problems: *CFI* = 0.77, *RMSEA* = 0.08, $\omega = 0.69$; externalizing problems: *CFI* = 0.92, *RMSEA* = 0.09, $\omega = 0.63$) they were excluded from the analyses. These finding about the consistency are in line with the previous studies in Finnish general population using the BITSEA (Alakortes et al., 2015; Kovaniemi et al., 2018). In this sample, mothers reported more problems for boys than fathers reported, and girls obtained higher competence scores than boys in both parent's reports (Mann-Whitney U-test, maternal report, $p = .009$; paternal report, $p = .024$). Both of these findings were reported also in a previous study (Alakortes et al., 2015). The BITSEA examiner's manual provides cut-off scores for possible problems at the highest 25th percentile and a possible deficit or delay in competencies at the lowest 15th. In the present sample, using the cut-off scores presented in examiner's manual, the scores of 12 boys (8.8%) and 11 girls (9.7%) indicated possible socioemotional problems, and the scores of 7 boys (5.1%) and 11 girls (9.7%) indicate a possible deficit or delay in socioemotional competencies. Correspondent percentiles are typically lower in the present sample as the 25th percentile of socioemotional problems was 10 (vs. 14 in the examiner's manual) for boys and 9 (vs. 12) for girls and as the 15th percentile of socioemotional competencies was 15 (vs. 14) for boys and 16 (vs. 16) for girls.

2.5.1. Covariates: an infant's positive and negative emotional reactivity

Infant negative and positive emotional reactivity dimensions of temperament were assessed using the widely used, valid and reliable Infant Behavior Questionnaire Revised Short Form (IBQ-R SF) (Gartstein & Rothbart, 2003; Putnam et al., 2014) at 6 months and was included as a covariate in the analyses. In the analyses, we used the two scales adopted from the short form of the IBQ-R: Negative Affectivity and Surgency/Extraversion. Missing subscales of surgency/extraversion and negative affectivity (SUR: 0.88%; NEG: 0.42%) were imputed with the mean (SUR: max. 2 missing subscales, max. 2 missing items in a subscale; NEG: max. 1 missing subscale, max. 2 missing items in a subscale). The report of either of the parents or the mean of both of the parent reports was used when available. The parents reported their infants' behavior on a scale from one to seven based on the past two weeks. The scores were used as continuous variables with higher scores reflecting higher levels of the temperament feature in question. Internal consistency (Cronbach's α) of the maternal and paternal scores of IBQ-R SF was adequate (SUR/mothers α = .90; NEG/mothers α = .85; SUR/-fathers α = .90; NEG/fathers α = .84).

2.6. Statistical analyses

IBM SPSS Statistics 26 was used in the data analyses. First, we computed Mann-Whitney U-tests to examine if the face and fear biases were observed in the present sample, as observed in the complete eye-tracking sample of our study ($n = 363$; Kataja et al., 2020). We conducted two main analyses. First, a regression analysis was performed to predict BITSEA Problems by face bias and fear bias and tested against a Bonferroni-adjusted alpha level of.025 (.05/2). Possible confounding factors, such as an infant's sex, maternal age, education and depressive symptoms at the 1st trimester of pregnancy and 24 months postpartum and an infant's temperamental negative affectivity and surgency/extraversion were entered in the models as covariates. We used multiple imputation for the missing values of the covariates. In addition, we did some post-hoc analyses including a regression analysis to predict Internalizing Problems and Externalizing Problems by face and fear bias, as they constitute the BITSEA Problems scale. Second, a regression analysis was

Table 2
Maternal and paternal mean scores, standard deviations, ranges and percentiles of the BITSEA scales (Problems and Competencies) for girls and boys. The lowest 15th percentile for Competencies and the highest 25th percentile for Problems were calculated within the present sample. Comparisons were made with the non-parametric Wilcoxon test.

	mean (sd)			range		lowest 15th percentile		highest 25th percentile	
n (maternal/paternal)	Maternal report	Paternal report		Maternal report	Paternal report	Maternal report	Paternal report	Maternal report	Paternal report
Problems									
all (227/113)	7.31 (4.26)	6.67 (3.86)	$p = .025$	0–22	0–17			10	9.65
girls (105/56)	6.75 (3.86)	6.98 (3.90)	$p = .83$	0–22	0–15			9	9.23
boys (122/57)	7.79 (4.53)	6.37 (3.84)	$p = .004$	0–18	0–17			11	10
Competencies									
all (230/114)	18.23 (2.40)	17.11 (2.96)	$p = .059$	6.6–22	8–22	16	14		
girls (106/56)	18.70 (2.12)	17.84 (2.63)	$p = .10$	6.6–22	11–22	17	15		
boys (124/58)	17.82 (2.49)	16.40 (3.10)	$p = .26$	12–22	8–21	15	12.87		

performed to predict BITSEA Competencies by face and fear bias and tested against a Bonferroni-adjusted alpha level of .025 (.05/2). In addition to these main analyses, we report Spearman correlations between the main variables and all continuous covariates: maternal depressive symptoms at the 1st trimester of pregnancy and 24 months postpartum and an infant's temperamental negative affectivity and surgency/extraversion. Mann-Whitney U-test was used to compare BITSEA Problems and BITSEA Competencies between boys and girls. A Kruskal-Wallis-test was used to compare BITSEA Problems and BITSEA Competencies between the three groups of maternal education level.

3. Results

3.1. Attention to emotional faces

The means and standard deviations for the calculated face- and fear biases are presented in Table 3. The disengagement probability (DP) was highest for the control picture (M =.80, SD =.20), intermediate for the neutral (M =.62, SD =.27) and happy faces (M =.61, SD =.26) and lowest for the fearful faces (M =.47, SD =.29). DPs for the control picture were significantly higher than DPs for the neutral ($Z = -9.27$, $p < 0.001$), happy ($Z = -9.78$, $p < .001$) and fearful ($Z = -12.03$, $p < .001$) faces. In addition, DPs for the fearful faces were significantly lower than DPs for the happy ($Z = -8.49$, $p < .001$) and the neutral ($Z = -9.49$, $p < .001$) faces. Finally, DPs for the happy and neutral faces did not differ significantly from each other ($Z = -.36$, $p = .72$). This kind of attention patterns were found also among the infants excluded from the analyses because of the missing BITSEA data ($n = 100$; control picture M =.78, SD =.24; neutral faces M =.61, SD =.25, happy faces M =.60, SD =.26; fearful faces M =.47, SD =.26). These findings demonstrate an age-typical, general attention bias for faces and more specific attention bias for fearful faces reported previously for the complete sample of our study ($n = 363$; Kataja et al., 2020) and in other previous studies (Leppänen et al., 2018; Peltola et al., 2008; Yrttiaho et al., 2014).

3.2. Descriptive statistics and correlations between main variables and background factors

Descriptive statistics for the main variables and a correlation table for all the variables are presented in Table 3. The subscales of socioemotional problems and competencies correlated with several background factors. Higher levels of socioemotional problems were related to elevated levels of maternal concurrent depressive symptoms (r=.25, $p < .001$) and greater levels of infant negative affectivity (r=.32, $p < .001$). Better socioemotional competencies were related to lower levels of maternal concurrent depressive symptoms ($r = -.22$, $p = .001$), reduced levels of negative emotionality (r=−.19, $p = .006$) and higher levels of positive emotionality at 6 months (r=.18, $p = .005$). In addition, girls were rated higher than boys in social competencies ($Z = -2.62$, $p = .009$) but not in social problems ($Z = -.98$, $p = .33$). We found no evidence of the association between maternal education and socioemotional problems ($p = .73$) or competencies (p=.81).

3.3. Correlations between attention biases and socioemotional problems and competencies

Spearman correlations between face- and fear biases and the subscales of problems and competencies in the BITSEA are presented in Table 3. We observed a positive correlation between fear bias and socioemotional competencies ($r = .17$, $p = .009$).

3.4. Regression of attention biases on socioemotional problems

A regression analysis predicting infants' socioemotional problems at 24 months by their face and fear biases at 8 months is presented in Table 4 ($n = 245$, adj. R^2 =.18, $p < .001$). Face and fear biases were not associated with social-emotional problems. In sum, our data did not lend support for attention biases as an explanation for variance in socioemotional problems.

Table 3
Means and standard deviations for the variables and Spearman correlations between the variables.

	Variables	n	mean (SD)	1	2	3	4	5	6	7	8
1	Maternal age	246	31.22 (4.22)								
2	Maternal EPDS (1st trimester)	240	4.74 (4.21)	-.031							
3	Maternal EPDS (24 months postpartum)	216	4.59 (4.65)	-.028	.56 * *						
4	SUR	239	4.84 (.66)	-.045	.028	.019					
5	NEG	226	3.14 (.65)	-.047	.12	.16[a]	.083				
6	Face Bias	246	.19 (.24)	-.042	-.072	.004	.024	-.008			
7	Fear Bias	246	.15 (.20)	.008	.12	.055	.079	.012	.084		
8	BITSEA/Problems	245	7.12 (3.92)	-0.63	-.030	.25 * *	-.072	.32 * *	-.034	.069	
9	BITSEA/Competencies	246	17.99 (2.28)	-.080	-.22 * *	-.19 * *	.18 * *	-.010	.073	.17 * *	-.25 * *

[a] $p < .05$; * * $p < .01$; EPDS = Edinburgh Postnatal Depression Scale; SUR = Surgency/Extraversion, IBQ-R; NEG = negative affectivity, IBQ-R

Table 4
Results of Regression Analysis of Socioemotional Problems by Attentional Face Bias and Fear Bias ($n = 242$).

	Socioemotional Problems	
	Unstandardized Coefficients, Beta (Standard Error)	Standardized Coefficients, Beta
Infant Sex	-0.38 (0.46)	-.049
Maternal Age	-0.019 (0.056)	-.020
Maternal education	-0.067 (0.30)	-.014
EPDS 1st trimester	0.12 (0.063)	.13
EPDS 24 mo postpartum	**0.16 (0.060)**	**.17**
SUR 6 mo	**-0.90 (0.35)**	**-.15**
NEG 6 mo	**1.97 (0.37)**	**.32**
Face Bias 8 mo	-0.011 (0.97)	-.001
Fear Bias 8 mo	1.04 (1.18)	.054

The statistically significant associations are bolded.
EPDS = Edinburgh Postnatal Depression Scale, SUR = Surgency/ Extraversion, Infant Behavior Questionnaire, NEG = Negative affectivity, Infant Behavior Questionnaire

3.5. Regression of infant attention biases on socioemotional competencies

A regression analysis predicting infants' socioemotional competencies at 24 months by their face and fear biases at 8 months is presented in Table 4 ($n = 242$, adj. $R^2 = .12$, $p < .001$). Infant fear bias ($\beta = 1.70$, $p = .014$, $sr_i^2 = .025$) was positively associated with child socioemotional competencies after controlling for the effects of the confounding factors, but the face bias was not ($\beta = .61$, $p = .28$, $sr_i^2 = .0050$).(Table 5).

4. Discussion

Our aim was to study how individual differences in an attention bias for faces and specifically for fearful faces at 8 months are associated with socioemotional problems and socioemotional competencies at 24 months. Consistent with our expectations, a higher attention bias for fearful faces during infancy was associated with better socioemotional competencies during toddlerhood. However, in contrast to our hypotheses, we found no evidence for an association between an attention bias for faces or fearful faces and socioemotional problems.

Our finding showing an association between an attention bias for fearful faces and socioemotional competencies is in line with the study by Grossman et al. (2018) showing that infants' increased responsiveness to fearful faces at 7 months is related to a greater helping of others, which is one important marker of social competence at 14 months. As the previous and present findings focus on attention for fearful faces during the period when sensitivity to fear of others first emerge in typical development, these findings may be taken as signs of very early precursors of prosocial behavior. Our results are in line with findings showing that increased attention to fearful faces during infancy is related to not only specific characteristics in social functioning, e.g., helping-type responses and altruistic behavior (Grossmann et al., 2018), but also to socioemotional competencies during toddlerhood more broadly.

However, this result is in contrast to a previous study by Peltola et al. (2018) using a similar eye-tracking protocol, i.e., the face-distractor paradigm with neutral, happy and fearful faces and scrambled face, in which an attention bias specifically for fearful faces during infancy was not related to the later laboratory observed helping-type traits in toddlerhood after controlling for the general attention bias for faces. The explanation for the inconsistency in the results might be that the competencies scale of the BITSEA contains more broadly the aspects of socioemotional functioning, including prosocial behavior and other aspects of social communication reported by the parent, compared to observed real-life helping responses in laboratory settings.

Our hypothesis on the association between attention bias for fearful faces and socioemotional problems was not supported.

Table 5
Results of the Regression Analysis of Socioemotional Competencies by Attentional Face Bias and Fear Bias ($n = 242$).

	Socioemotional Competencies	
	Unstand. Beta (*SE*)	Stand. Beta
Infant Sex	**0.79 (0.27)**	**.18**
Maternal Age	-0.045 (0.032)	-.089
Maternal education	0.25 (0.17)	.090
EPDS 1st trimester	**-0.10 (0.037)**	**-.19**
EPDS 24 mo postpartum	-0.024 (0.048)	-.048
SUR 6 mo	**0.69 (0.21)**	**.21**
NEG 6 mo	0.072 (0.22)	.021
Face Bias 8 mo	0.61 (0.56)	.067
Fear Bias 8 mo	**1.70 (0.69)**	**.16**

However, this should be interpreted with caution, as the possible association may not be detected due to the limitations of the present study. In previous studies among school-aged children, adolescents and adults, a heightened attention toward threat or fear (Bar-Haim et al., 2007; Cisler & Koster, 2010; Georgiou et al., 2005) or away from threat (Brown et al., 2013; Grafton et al., 2016; Gunther et al., 2022) has been related to elevated anxiety symptoms. The BITSEA's socioemotional problems subscale consists of internalizing, externalizing and regulatory symptoms, and anxiety symptoms conceptually belong to the category of internalizing problems. It is possible that even if socioemotional problems can be divided into internalizing, externalizing and regulatory problems during toddlerhood, the problems remain undifferentiated at this age such that specific associations between attention biases and socioemotional problems could be observed. In addition, the present sample represents the general population, and the overall level of socioemotional problems during toddlerhood is low. It is possible that the association between attention biases and socioemotional functioning might be observed in clinical populations comprising of children with higher levels of socioemotional problems. Individual differences in socioemotional attention biases may also be related to socioemotional problems, but the socioemotional problems during toddlerhood are not easily detected by the BITSEA problem scale.

According to the models of affect-biased attention, emotional attention biases may have causal effects on child development, as they shape the information the individual receives from the environment (Morales et al., 2016). This means that, for instance, interventions increasing attention bias for fearful faces might influence improved socioemotional competencies. In school-aged children and adults, the relation between a higher attentional threat bias and anxiety symptoms is causal, and interventions decreasing attention bias for threat are developed (Van Bockstaele et al., 2014). Results have been promising (Lowther & Newman, 2014; Van Bockstaele et al., 2014), but it has also been stated that the current evidence is not sufficiently strong enough to motivate clinical recommendations (Kruijt et al., 2019). However, attention bias modification used with older children cannot be applied to infants without studies showing the association between negative attention biases and psychopathology among infants. The relation between attention biases and socioemotional problems in infants might to be different in nature than that of the older children and adults. In our previous study, we found an association between early behavioral regulatory problems and a lower attention bias for fear (Eskola et al., 2021), but, in the present study, we failed to observe a connection between infant attentional fear bias and socioemotional problems. Moreover, a heightened attention bias for fear seems to be related to positive developmental outcomes, that is, socioemotional competencies. Therefore, the early attention biases need to be studied also in relation to other developmental aspects than socioemotional problems.

Limitations in this study include the use of the brief version of the Infant and Toddler Socioemotional Assessment in that only the two main dimensions of the socioemotional functioning, i.e., competencies and problems, were used in the analyses. The long version of the questionnaire, ITSEA, includes an additional main dimension, dysregulation and 17 subscales for the main dimensions. Thus, the long version could have yielded results that remained uncovered in the present study. Another limitation is that, in our sample, the level of socioemotional problems was low, and findings concerning socioemotional problems may not be applicable to clinical populations. On the other hand, one of the strengths of this study is a relatively large sample size of infants. In addition, to reduce the effects of the subjectivity in parental reporting of infant behavior, both parents' reports were used when available and the parental depressive symptoms were controlled in the analyses.

4.1. Conclusions

Our main findings suggest that individual variance in attentional bias for fearful faces at 8 months of age is associated with better socioemotional functioning at 24 months. More specifically, our results showed that a higher attention bias for fearful faces is related to better socioemotional competencies. Whether there is a causal relation behind this association remains an important topic for future research. Finally, we found no evidence for the association between attention bias for faces or, specifically, for fearful faces and socioemotional problems. Thus, our results do not support the hypothesis that the association between a higher attention bias and adverse outcomes in socioemotional development, which has been well established among school-aged children, adolescents and adults, exists already during infancy. Rather, an age-typical, higher attention bias for fear during infancy seems to be related to positive developmental outcomes in socioemotional competencies during toddlerhood.

Author note

Portions of these findings were presented as a poster presentation at the virtual International Congress of Infant Studies, July 6–9, 2020. The data used in this study partly overlaps with the data used in the following papers on different study questions: Aatsinki et al., (2020), Eskola et al. (2021), Kataja et al. (2019,2020,2020,2021, 2022)and Tuulari et al. (2020).

CRediT authorship contribution statement

Eeva Eskola: Writing – original draft, Formal analyses **Eeva-Leena Kataja:** Methodology, Investigation, Data curation, Funding acquisition, Writing – original draft, **Jukka Hyönä:** Supervision, Writing – review & editing **Saara Nolvi**: Investigation, Funding acquisition, Writing – review & editing, **Tuomo Häikiö,** Methodology, Software, Data curation, Writing – review & editing **Alice S. Carter:** Methodology, Writing – review & editing **Hasse Karlsson:** Conceptualization, Methodology, Funding acquisition, Writing – review & editing, **Linnea Karlsson:** Conceptualization, Methodology, Funding acquisition, Writing – review & editing **Riikka Korja:** Supervision, Funding acquisition, Writing – original draft.

Declaration of Competing Interest

None

Data availability

The data that has been used is confidential.

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