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ORIGINAL ARTICLE

Attentional Bias in Children with Social Anxiety Disorder

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Abstract

Previous research stated a robust attentional bias to threat in adult anxiety. However, the number of studies analyzing attentional biases in clinically anxious children is limited and results are inconsistent. The present study aims to assess attentional biases in children with social anxiety disorder ($n=37$) and healthy control children ($n=42$) using a free-viewing eye-tracking paradigm. Children viewed different picture pairs consisting of social and non-social stimuli under two conditions (with/without a stressor to activate social threat perception). We found the direction of gaze regarding threatening stimuli to be context-dependent. Both groups showed a hypervigilance-avoidance pattern to angry faces when they were paired with houses. In face–face trials, angry faces were less often initially fixated than neutral or happy faces in both groups. However, schema activation differentially affected initial fixations in angry-neutral face pairs across groups. Children with social anxiety disorder more often initially directed their gaze to angry faces than did healthy control children, indicating a lack of inhibiting threat representations rather than a hypervigilance to threat.

Keywords Social anxiety disorder · Eye-tracking · Hypervigilance · Inhibition · Biased attention

Introduction

Social anxiety disorder (SAD) is prevalent, seriously impairing and strongly linked to an increased risk of comorbid diagnoses, especially mood disorders (Kessler et al. 1999). The highest incidence of SAD has been consistently found in childhood or early adolescence (Beesdo et al. 2009; Costello et al. 2005). Within the framework of their influential cognitive model of social anxiety, Clark and Wells (1995) discuss cognitive, in particular attentional biases to be an important variable specifically in the etiology and maintenance of social anxiety. While evidence for this assumption seems strong in adult social anxiety (e.g. Heinrichs and Hofmann 2001), there is minimal research focusing on biases in children with SAD. Thus, further research is needed to investigate the association between attentional biases and social anxiety in childhood.

Attentional Biases in Adult Anxiety Disorder

Cognitive processes (e.g., attention and memory biases) play an important role in general theoretical models of anxiety (e.g. Mogg and Bradley 1998; Williams et al. 1988) and are often studied to investigate mechanisms of etiology and maintenance in anxiety disorders (e.g., Heinrichs and Hofmann 2001). In the last decades, a growing body of research has investigated attentional biases and provides strong evidence for biased attention in adult anxiety ($d=0.47$ in Armstrong and Olatunji 2012; $d=0.41$ in Bar-Haim et al. 2007). However, static reaction time measures, which were mostly used (see Bar-Haim et al. 2007), provide only limited insight in the specific nature of attentional bias, given that it may be linked to *hypervigilance* or *maintenance* of attention to threat (for further discussion see Clarke et al. 2013). Cisler and Koster (2010) assumed that attentional bias towards threat in anxiety may be related to three different components. First, facilitated attention to threat-relevant information induces *initial hypervigilance* to threat. A lower detection threshold for these stimuli in anxious individuals is supposed to lead to a faster detection and an initial

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attention shift to threat (e.g., Mathews and Macintosh 1998; Mogg and Bradley 1998). Second, difficulty in disengaging attention from threat, which is linked to a threat elaboration mechanism (e.g., Beck and Clark 1997), may lead anxious individuals to *maintain attention* on threat stimuli. Third, as a strategic process, *attentional avoidance* is attended by allocating attention towards nonthreatening stimuli (Williams et al. 1988). Differentiating the components of attentional bias is beyond the scope of research on reaction time (Armstrong and Olatunji 2012; Clarke et al. 2013). The measurement of eye movements, in contrast, enables a dynamic assessment of the time course of attention. Results of eye-tracking experiments (see Armstrong and Olatunji 2012) in particular support *hypervigilance* to threat, whereas the specific role of *maintenance* of attention to threat remains unclear.

Attentional Biases in Child Anxiety Disorder

There are considerably fewer publications analyzing children's attentional bias to threat and a notable amount of studies whose findings are inconsistent (see also Shechner et al. 2012). Dudeney, Sharpe and Hunt (2015) recently performed a meta-analysis and examined 38 articles that investigated attention to threat in anxious children. In line with adult findings, they reported a significant attentional bias to threat in anxious children compared to non-anxious children ($d=0.21$). However, the difference is less robust and the effect size considerably smaller than in adults. Both anxious children as well as non-anxious children showed a significant bias to threatening stimuli over neutral stimuli ($d=0.54$ and $d=0.15$, respectively) using mostly static reaction time measures.

When considering previous eye-tracking studies in children, there is only moderate evidence for an anxiety-related *initial hypervigilance*. While Shechner et al. (2013) indeed reported more vigilance to threatening stimuli in anxious youth compared to youth with no mental disorder; Gamble and Rapee (2009) and In-Albon et al. (2010) both found no vigilance in anxious children. More recent studies found vigilance to threat in all children regardless of anxiety (Dodd et al. 2014; Seefeldt et al. 2014). The second component was only analyzed in one study so far. Dodd et al. (2014) investigated the length of initial fixations and found no evidence for *initial maintenance* of attention in anxious children. Results concerning the third component are also mixed. While Gamble and Rapee (2009) found *attentional avoidance* in all children and Dodd et al. (2014) found anxious children to avoid faces in general, Shechner et al. (2013) noted no evidence for avoidance in dwell time analysis, and Seefeldt et al. (2014) even mentioned a potential tendency in anxious children to reallocate attention to threat.

To summarize, further research is needed to provide evidence for attentional biases in pediatric anxiety. Given that studies which included children with SAD often investigated attentional biases in samples consisting of three or more different anxiety diagnoses (e.g. Dodd et al. 2014; Gamble and Rapee 2009; Shechner et al. 2013; Waters et al. 2013), clear evidence is missing, in particular, for SAD.

Investigation of Attentional Biases in Children with SAD

To date, only two studies have investigated attentional biases in a homogeneous sample of children with SAD (Seefeldt et al. 2014; Waters et al. 2011).

Waters et al. (2011) examined attentional biases with the visual probe task in which angry and happy faces were presented with neutral faces, respectively. Reaction times were compared between 27 children with SAD and 27 healthy control children between 5 and 12 years of age. An attentional bias towards angry faces emerged relative to neutral faces only in socially anxious children with high symptom severity. A low symptom severity in the anxiety group was associated with a significant bias away from angry faces. There was no attentional bias to angry faces in healthy control children. No group difference was found regarding an attentional bias to happy faces.

The only eye-tracking study on attentional biases investigating children with SAD was published by Seefeldt et al. (2014), who compared eye movements of 30 children with SAD between 8 and 12 years of age to those of 43 healthy control children. Picture-pairs of angry, happy and neutral faces and houses were presented in a free viewing task for 3000 ms. According to the dot-probe paradigm, either the letter "E" or "F" was presented directly after picture offset. Children were instructed to press a corresponding button as fast as possible. The letters disappeared after the participant's response or after a maximum of 10 s. There was a stress induction established in half of children to activate fear relevant schemata prior to gaze recording. Seefeldt et al. found a preference for faces (independent of emotional valence) in favor of houses and angry faces in favor of happy faces in all children. An attentional bias to threat relative to neutral faces was found only in children with SAD in the stressor condition. Regarding later stages of information processing (2500–3000 ms) anxious children tended to relocate their attention to threatening stimuli, whereas control children seemingly avoided threat. However, presentation time was not sufficiently long to investigate this visually detected pattern.

Aim of the Present Study

The present study investigates attention allocation in children with a primary diagnosis of SAD and in healthy control children using eye-tracking technology. We aim to analyze *initial hypervigilance* to threat and potential patterns of subsequent *attentional avoidance* or *relocation of attention* to threat in later stages of information processing. To extend previous findings, we employed an experimental paradigm similar to that of Seefeldt et al. (2014).

To date, the condition of negative and positive stimuli being presented simultaneously was only employed in facial stimulus sets by Heinrichs and Reinhold (2010) and Seefeldt et al. (2014). In addition, few studies have added non-social stimuli and combined them with neutral facial expressions (Garner et al. 2006; Heinrichs and Reinhold 2010; Seefeldt et al. 2014). As in previous research (e.g., Gamble and Rapee 2009; Waters et al. 2013), we presented children with angry, neutral and happy faces. The additional expansion of face stimuli by using pictures of houses as non-social stimuli was retained to understand the impact of contextual factors on attention processes in anxious individuals (see Chen et al. 2002).

In the present study we focused on angry faces, relative to both neutral and happy faces, as well as houses. Clark and Wells (1995) assume that dysfunctional, negative beliefs about the self increase interpretations of threat in social situations in socially anxious individuals. Those self-schemeta are unstable and highly dependent on the situation. When alone or in situations which seem to be nonthreatening, socially anxious individuals have a more positive view of themselves than in situations which seem to be threatening. Analogous to the procedure in previous studies (Garner et al. 2006; Seefeldt et al. 2014), we implemented a stress induction condition in half of the participating children to investigate possible effects of schema activation on gaze behavior. By telling participants they would have to give a speech in front of a video camera after the task, which would be later evaluated, negative self-schemata should be activated and lead to increased biases to threat. Deviating from the paradigm used by Seefeldt et al. (2014), we removed the reaction task. When participants anticipate a reaction stimulus, this demands a fast response and builds expectations, which in turn may inadvertently affect children's eye movements on threatening or nonthreatening stimuli. Seefeldt et al. (2014) suspected a tendency of a subsequent relocation of attention to threat in anxious children after 2500 ms. However, the length of stimulus presentation may not have been sufficient to truly establish this pattern. To investigate the time course of attentional bias, including later stages of information processing and, in particular, subsequent pattern of relocation or avoidance, the duration of each trial was set to 5000 ms.

Hypotheses

Based on prior findings in eye-tracking studies in anxious youth, we hypothesized (1) to find *initial hypervigilance* to threat in healthy as well as socially anxious children (Dodd et al. 2014; Seefeldt et al. 2014). Children with SAD and healthy control children should orient their first fixation more frequently towards angry faces in all contexts. Specifically, in the stress induction condition, we expected (2) children with SAD to be more *initially hypervigilant* to angry faces if the competetive stimulus was a neutral face (see Seefeldt et al. 2014) or a house. The preferential initial processing of an emotional stimulus in favor of a neutral stimulus (Calvo et al. 2007) should be additionally enlarged by schema activation. We assumed (3) children with SAD to relocate their attention to threat in the stress induction conditions after 2500 ms, indicating *difficulties in disengaging* from threat (Seefeldt et al. 2014).

Method

Participants

Two groups of participants were recruited as part of a two-site (Bielefeld and Freiburg, Germany) research project to investigate cognitive and psychophysiological reactions in children with SAD according to emotional stimuli.[1] The flowchart of participants for the eye-tracking task is displayed in Fig. 1. Eligible subjects were children aged 9–13 years who (1) met DSM-5 or ICD-10 criteria for a current principal diagnosis of SAD or (2) did not meet DSM-5 criteria for any current or lifetime diagnosis (HC). Exclusion criteria were psychotic disorders or pervasive developmental disorders. Parents, who contacted us after study advertisements, completed a short screening procedure by phone. If their child was deemed eligible, trained interviewers with

[1] Apart from the eye-tracking task and the anxiety questionnaires described below, further tasks and questionnaire measures were performed and administered to reach goals of other project parts (Asbrand et al. 2016): Trier Social Stress Test for Children (TSST-C; Buske-Kirschbaum et al. 1997); Five Minute Speech Sample (FMSS; Magaña et al. 1986); Culture Fair Intelligence Test (CFT 20-R; Weiß 2006); Fear of Negative Child Evaluation (FNCE; Schreier and Heinrichs 2010); Child Behavior Checklist (CBCL; Achenbach 2000); Depression Inventory for Children (DIKJ; Stiensmeier-Pelster 2000); Mini Social Phobia Inventory (Mini-SPIN; Connor et al. 2001); Symptom Checklist K-9 (SCL-K-9, a short form of the SCL-90-R; Derogatis and Unger 2010). Within the frame of a randomized controlled treatment trial, a subset of those questionnaires was administered up to five times (pre, post, follow-ups). The diagnostic procedure and each of the experimental tasks were performed on separate days, with the eye-tracking experiment conducted prior to the intervention program.

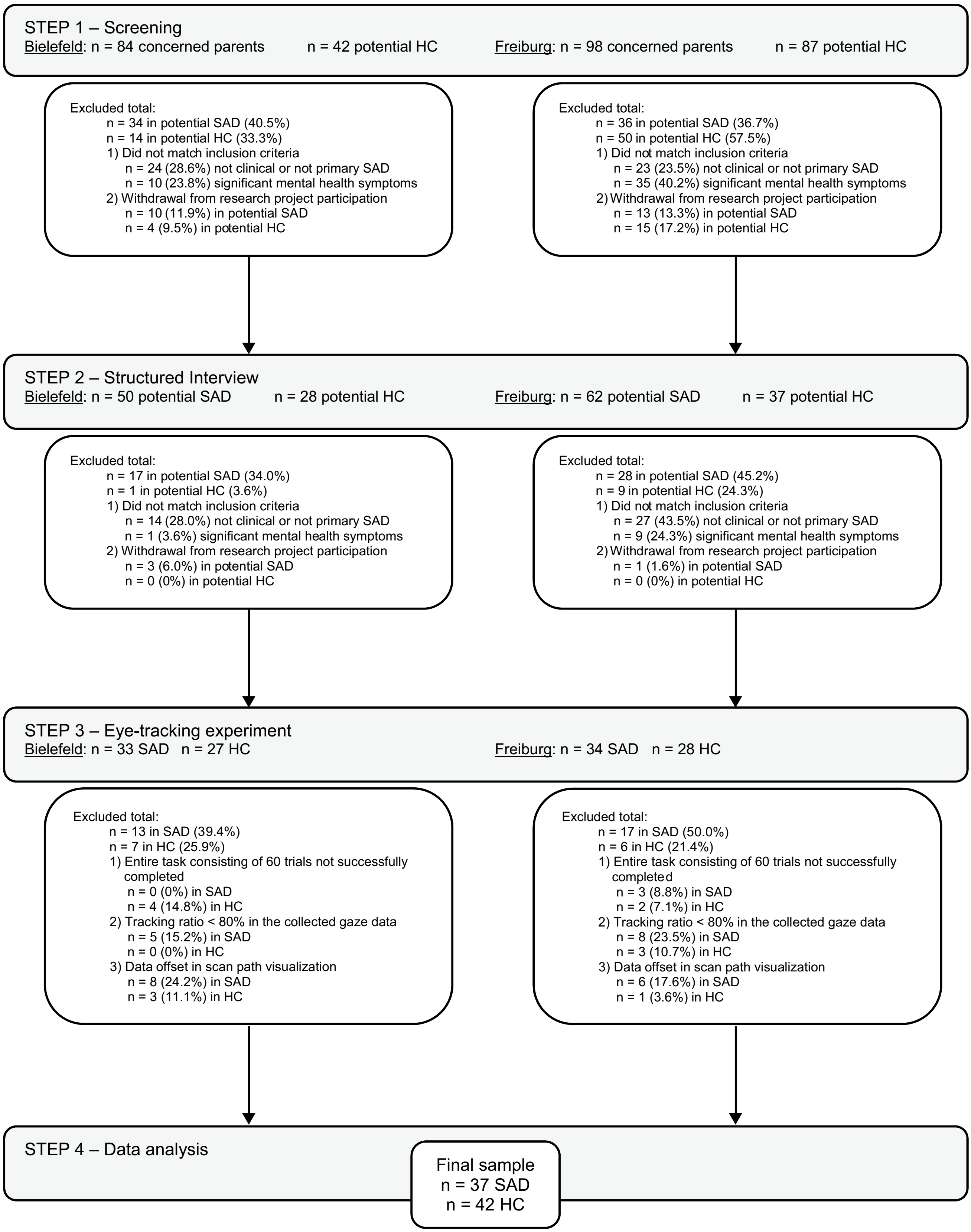

Fig. 1 Flow chart of study participants

clinical experience administered the Kinder-DIPS (DSM-IV-TR German Version; Schneider et al. 2009), a structured interview based on the Anxiety Disorders Interview Schedule for children (ADIS-C; Silverman and Nelles 1988), to assess clinical status. Diagnoses were made based on both parent and child report. The interview sessions were videotaped and afterwards supervised by a senior clinical psychologist. Though the assessment of social anxiety refers to DSM-IV criteria of social phobia, the similarity of the diagnostic criteria for SAD according to the DSM-5 enables the transfer of social phobia to SAD. Children from both sites included in the eye-tracking task ($N = 122$) did not differ in age, sex, group or self-reported symptom severity (all $p > .33$). To ensure good data quality, we applied a strict algorithm, which included a successful completion of the task, a tracking ratio of at least 80% and the absence of an observable data offset in the scan paths (Holmqvist et al. 2011).[2] $N = 43$ participants ($n = 30$ SAD; $n = 13$ HC) were excluded from eye movement analysis (see Fig. 1 for reasons of exclusion). Those children neither differed significantly in age, sex, stress induction condition or study site nor in self-reported symptom severity or number of comorbid diagnoses in SAD (all $p > .13$). However, the proportion of children with SAD was significantly higher in excluded, compared to included, children, indicating anxious children may be more difficult to track than control children ($p = .02$). A final sample of $n = 79$ remained for eye movement data analysis.

Measures

To describe differences in social anxiety between both groups, the Social Phobia and Anxiety Inventory for Children (SPAI-C; Beidel et al. 1995; Melfsen et al. 2001) and the Social Anxiety Scale for Children Revised (SASC-R; La Greca and Stone 1993; Melfsen and Florin 1997) were electronically administered to the children. Furthermore, a parent version of the latter questionnaire was given to at least one parent of each child (SASC-R; Schreier and Heinrichs 2008). Social anxiety symptoms were measured using a Likert scale from 0 (never or hardly ever) to 2 (almost always or always; SPAI-C) and 1 (not at all) to 5 (all the time; SASC-R). In the present sample, Cronbach's Alpha were all $a > 0.95$.

Materials and Apparatus

Stimuli consisted of 30 pairs of pictures, including an angry facial expression in each pair combined with neutral and happy expressions of the same person, as well as pictures of houses ($n = 10$, respectively). The pictures, which were already used in a previous study (Seefeldt et al. 2014), were drawn from a larger pool of facial expressions. Half of the actors, each of them presenting an angry, neutral and happy facial expression, were adults (3 female, 2 male), and half of them were children (2 female, 3 male) to balance effects of age and gender. All stimuli measured approximately 9 cm × 6.5 cm and were matched in complexity. They were presented catty-cornered with a distance of 11 cm between the center coordinates of each picture, equivalent to a visual angle of 10.5°. The location of each stimulus was counterbalanced regarding its valence (negative, neutral, positive and non-social) as well as regarding the age and gender of the person pictured. The central fixation cross covered about 5 cm × 5 cm and was visible only between trials. The background color for the pictures and the fixation cross was gray. Children were seated approximately 60 cm away from a 17″-monitor with a pixel resolution of 1024 × 768. The stimulus set was presented via Presentation Version 12.1 (Neurobehavioral Systems, Albany, California) software and comprised of 2 blocks of 30 trials. The order of trials was randomized within each block. Eye movements were recorded with a 1250 Hz iView High-Speed Eye Tracker in Bielefeld and a 240 Hz iView Eye Tracker in Freiburg (both SensoMotoric Instruments GmbH, Germany). Overall bias scores from both sites were compared to control for the different sampling frequency. There was no significant difference in either the overall first fixation bias score ($t_{77} = -1.283$, $p = .203$) or the overall dwell time bias score ($t_{77} = 0.008$, $p = .994$).

Procedure

All participating children and their parents gave written informed consents to the present study and its procedures. The project was approved by an ethical review board. Children received a voucher (amount: 25 Euro), and parents received an additional 35 Euro in cash for project participation.

At the beginning of the task, children were told that their eye movements would be recorded, while being presented

[2] Exclusion of invalid data in eye-tracking experiments is rarely reported in clinical studies. The investigation of attentional biases is often based on area of interest (AOI) analysis. According to Holmqvist et al. (2011, pp. 224–225), data offsets are major concerns for AOI analyses. The application of the algorithm described in our paper (level 3 in particular) refers to the suggestions made by Holmqvist et al., concerning how to deal with inaccurate data. As can be seen in Fig. 1, there were three levels of data exclusion. (1) We checked if data were recorded for the full 60 trials. (2) We checked the tracking ratio in the collected gaze data. Participants with a tracking ratio < 80% were excluded. (3) Scan path visualization of four stimulus pairs (balanced regarding position of stimuli, age and gender) was checked for data offset. Participants were excluded if two or more of these four stimulus pairs were rated as invalid (e.g. due to a miscalibration in one corner, drift in the eye-tracker). In this case, AOIs were not hit, although children might have looked at the stimulus.

with a fixation cross and pictures of faces and houses. However, they were not instructed to fixate on the presented stimuli. They were instructed to look at the central fixation cross when it was visible on the screen. Therefore, only passive viewing was demanded for this task. Prior to the implementation of the stress induction condition, we assessed children's present anxiety on a 0–10 Likert scale. Children who were randomly assigned to the stress induction condition ($n = 15$ SAD and $n = 20$ HC in the to-be analyzed sample) were told that they would give a short presentation in front of a video camera after the visual attention task. To prepare for the presentation, the participants would receive a short text and be given 5 min to prepare. Their performance of the presentation would then later be evaluated through their video recording. To check the success and extent of this anxiety induction, children in the stress induction condition repeatedly rated their anxiety. The experiment then started with the presentation of four probe trials, followed by a standard 5-point calibration procedure. Prior to each trial, a fixation cross was presented for a variable duration between 750 and 1250 ms. The inter-trial interval varied randomly to prevent predictability of trial onset and reduce the monotony of the task. Each picture pair was presented for 5000 ms, yielding a total task duration of approximately 6 min.

Preparation and Analysis of Data

For data analysis, we used BeGaze3 Software (Sensomotoric Instruments GmbH, Germany). To investigate *initial hypervigilance*, we counted how frequently the threatening stimulus captured first fixation. Fixations were counted if they fell on the defined areas of interest and lasted for 100 ms or longer (e.g., Dodd et al. 2014; Seefeldt et al. 2014; Shechner et al. 2013; Gamble and Rapee 2010; Heinrichs and Reinhold 2010). Accordingly, areas of interest included the entirety of both the faces and the houses. Following previous studies (e.g., Dodd et al. 2014; Gamble and Rapee 2009; Garner et al. 2006), bias scores for each stimulus pair were calculated, dividing the number of trials in which the first fixation made to stimuli fell on the angry face by the number of trials in which at least one stimulus was fixated. A first fixation bias score > 0.50 consequently indicated an initial orientation towards threat, while a score < 0.50 indicated an initial orientation towards the alternative stimulus. Definitions of what constitutes a bias differed between studies (Bar-Haim et al. 2007). In some studies, the definition of attentional bias referred to relative differences in attention allocation between anxious and non-anxious individuals (e.g., Gamble and Rapee 2009; In-Albon et al. 2010; Seefeldt et al. 2014). Other studies additionally reported bias scores that referred to absolute differences in attention allocation to threatening stimuli relative to competetively presented non-threatening stimuli in anxious children (e.g., Dodd et al. 2014; Shechner et al. 2013). Thus, different conclusions may be drawn from same-sized ratios, or similar conclusions may be drawn from different-sized ratios. In the present study, bias scores were tested *between* and *within* groups to assess *relative* (i.e. comparing children with SAD to those without an anxiety disorder) and *absolute* (i.e. comparing attention distribution for children with SAD/without an anxiety disorder to allocation of attention to stimuli by chance) attentional biases. To investigate relocation to threat after 2500 ms, an epoch-related analysis was used (see Heinrichs and Reinhold 2010; In-Albon et al. 2010). The full 5 s of viewing time were therefore subdivided into ten 500 ms intervals, and dwelltime bias scores were computed separately for each interval and stimulus pair. These bias scores were calculated as a function of the dwelltime spent on the angry face divided by the total dwelltime spent on the angry face and the competing, simultaneously presented stimulus. All statistical analyses were conducted using SPSS 22 (SPSS Inc., USA) with an alpha level of 0.05. Significance levels and degrees of freedom were adjusted according to Bonferroni and Greenhouse-Geisser, respectively.

Reliability Estimates of Reported Eye Movement Indices[3]

Reliability was calculated for attentional bias scores using Cronbach's alpha. Eye movement data were included from both children with SAD and HC children in the final sample. Internal consistencies were calculated for each stimulus pair one by one and separately for the first and second presentation of each stimulus set. As displayed in Table 1, Cronbach's alpha was moderate for first fixation bias score in angry–house pairs and negative for first fixation bias scores in angry–neutral and angry–happy face pairs. Analogous to the procedure in a recent study, which previously reported negative reliability values for first fixation bias scores (Waechter et al. 2014), we further examined reliability by splitting the number of trials within each stimulus pair according to the position of the angry face. Therefore, Cronbach's alpha was calculated for trials, in which the angry face was presented on lower or upper left position and for trials, in which the angry face was presented in lower or upper right position, separately. The resulting 12 reliability estimates in all three stimulus pairs ranged from low to moderate ($0.28 \leq a \leq 0.68$). Negative reliability estimates may be driven by participants' overall tendency to first fixate on the left stimulus on the screen. The calculation of bias scores

[3] Following a request from an anonymous reviewer to include reliability of eye movement data in the discussion, reliability estimates for bias scores to threat were calculated post-hoc and added to the manuscript.

Table 1 Reliability estimates for attentional bias indices by picture pair

	Cronbach's alpha					
	In angry–neutral pairs		In angry–happy pairs		In angry–house pairs	
	Alpha[a]	Alpha[b]	Alpha[a]	Alpha[b]	Alpha[a]	Alpha[b]
First fixation bias score	−0.63	−0.01	−0.37	−0.14	0.56	0.56
Dwell time bias score by interval						
0–500 ms	0.06	0.42	0.22	−0.03	0.74	0.67
500–1000 ms	−0.08	0.19	0.18	0.33	0.66	0.62
1000–1500 ms	0.43	0.57	0.33	0.33	0.72	0.63
1500–2000 ms	0.22	0.29	0.34	0.30	0.49	0.28
2000–2500 ms	0.22	0.16	0.35	0.28	0.41	0.40
2500–3000 ms	0.01	0.21	0.21	0.41	0.37	0.38
3000–3500 ms	0.40	0.28	0.05	0.57	0.39	0.56
3500–4000 ms	0.38	0.22	0.32	0.42	0.36	0.49
4000–4500 ms	0.35	−0.04	0.41	0.35	0.32	0.58
4500–5000 ms	−0.01	0.20	0.52	0.13	0.60	0.55

$N = 79$

[a]First presentation of stimulus set

[b]Second presentation of stimulus set

Table 2 Demographics, questionnaire measures and initial check of eye-tracking data as a function of diagnostic group

	Children with SAD ($n = 37$)	HC children ($n = 42$)	Test value	p
Demographics				
Age (years)	11.4 (1.2)	11.5 (1.4)	$t_{77} = -0.361$	.719
Sex (% male)	37.8	40.5	$\chi^2 = 0.057$	.811
Questionnaires				
Child: SPAI-C (26 items)	23.3 (10.2)	3.0 (3.7)	$t_{45} = -11.5$	<.001
Child: SASC-R (18 items)	50.6 (13.9)	26.4 (7.0)	$t_{52} = -9.548$	<.001
Parent: SASC-R (18 items)	60.0 (12.0)	27.3 (6.5)	$t_{52} = -14.588$	<.001
Initial check of eye-tracking data				
Number of trials with fixation to a stimulus	58.7 (3.0)	59.2 (1.4)	$Z = -0.866$	.390
Average dwell time on both stimuli (ms)	3601.0 (889.7)	3865.6 (538.7)	$Z = -1.002$	.316

Standard deviations in parentheses

SPAI-C Social phobia and anxiety inventory for children (0–52)

SASC-R Social Anxiety Scale for Children Revised (18–90)

by collapsing across stimulus location resulted in two negatively correlated sets of items (see Waechter et al. 2014). Reliability for dwell time bias scores was calculated for each time interval and stimulus pair, one by one. Cronbach's alpha ranged from −0.08 to 0.74 (see Table 1).

Results

Descriptive Statistics

Demographics and mean scores on questionnaire measures for children with SAD and healthy control children are displayed in Table 2. The average clinical severity rating (CSR) for the principal diagnosis of SAD was CSR = 5.1 ($SD = 0.7$). Forty-three percent of children with SAD ($n = 16$) met the criteria for at least one comorbid diagnosis, including further anxiety disorder ($n = 7$), attention-deficit and disruptive

Table 3 First fixation bias scores by group, condition and picture pair

	Social anxiety disorder ($n=37$)			Healthy control ($n=42$)		
	M (SD)	Test value	p^a	M (SD)	Test value	p^a
Bias scores without SI						
Angry–neutral	0.45 (0.10)	$t_{21}=-2.45$	.023	0.45 (0.11)	$t_{21}=-2.29$	.032
Angry–happy	0.45 (0.09)	$t_{21}=-2.56$	.018	0.38 (0.09)	$t_{21}=-6.67$	<.001*
Angry–house	0.76 (0.13)	$t_{21}=9.77$	<.001*	0.72 (0.16)	$t_{21}=6.44$	<.001*
Bias scores with SI						
Angry–neutral	0.51 (0.07)	$t_{14}=0.74$	.470	0.47 (0.10)	$t_{19}=-1.27$	.218
Angry–happy	0.45 (0.07)	$t_{14}=-2.58$	.022	0.44 (0.11)	$t_{19}=-2.35$	.030
Angry–house	0.66 (0.21)	$t_{14}=32.83$	.014	0.75 (0.17)	$t_{19}=6.42$	<.001*

[a]Each bias score was tested against 0.50, indicating equal allocation of first fixation to both stimuli presented simultaneously (within-subjects)

SI stress induction

*$p<.008$ (adjusted according to Bonferroni); The upper part of this Table relates to the first hypothesis and the lower part of this Table relates to the second hypothesis

behavior disorder ($n=3$), sleep disorder ($n=2$), selective mutism ($n=2$) and elimination disorder ($n=2$). Group comparisons showed—as expected—a significant effect of group membership on children's and parent's social anxiety scores but no significant differences in age or gender. An initial check of eye-tracking data did not reveal significant differences between anxious and control children in the final sample, indicating consistent data quality across groups (see Table 2).

Preliminary Analysis: Effect of Stress Induction on Self-Reported Child Anxiety

Anxiety ratings of children who were assigned to the stress induction condition were entered into a 2×(2) repeated measure ANOVA with group (SAD and HC) as the between-subject factor and time (prior to and directly after stress induction) as the within-subject factor. The interaction was not significant, F (1, 33) = 2.34, $p=.136$, $\eta_p^2=0.066$. However, there were significant main effects of time, F (1, 33) = 6.49, $p=.016$, $\eta_p^2=0.164$, with higher anxiety ratings after stress induction ($M_{pre}=0.98$, $SD_{pre}=0.21$, $M_{post}=1.48$, $SD_{post}=0.31$) and group, F (1, 33) = 6.87, $p=.013$, $\eta_p^2=0.172$, with higher anxiety ratings in SAD than in HC ($M_{SAD}=1.87$, $SD_{SAD}=1.94$, $M_{HC}=0.60$, $SD_{HC}=0.84$).

Hypothesis 1

Do all children show an *initial hypervigilance* to threatening stimuli?

First fixations of children who were not assigned to the stress induction condition were analyzed in order to investigate *initial hypervigilance* to threat. We conducted a 2×3 ANOVA to assess relative biases (i.e. bias scores differ between groups) and one-sample *t*-tests to assess absolute biases (i.e. bias scores differ from chance).

Relative Attentional Biases?

First fixation bias scores were entered into a 2×3 ANOVA with group (SAD and HC) as between-subjects factor and stimulus (angry–neutral, angry–happy and angry–house) as within-subjects factor. The interaction effect was not significant [F (2, 84) = 0.963, $p=.386$, $\eta_p^2=0.022$]. However, there was a significant, small effect for group (F (1, 42) = 4.982, $p=.031$, $\eta_p^2=0.106$) with higher bias scores in children with SAD ($M=0.56$, $SD=0.06$) than in HC children ($M=0.52$, $SD=0.06$). Thus, children with SAD showed a relative attentional bias to threat in comparison to HC children. Furthermore, a significant, large effect for stimulus emerged [F (2, 84) = 98.417, $p<.001$, $\eta_p^2=0.701$]. Post-hoc comparisons indicated that bias scores in angry–house pairs were higher than in angry-neutral and angry–happy face pairs (both $p<.001$). No significant difference emerged between bias scores in angry–neutral and angry–happy pairs ($p=.418$). Regarding the context of presentation, all children were more likely to fixate first on the angry face if the alternative stimulus was a house.

Absolute Attentional Biases?

Bias scores of children with SAD and HC children were separately compared to an equal distribution of attention to both competing stimuli with one-sample *t*-tests. The upper part of Table 3 displays first fixation bias scores by group and picture pair, extended by statistical values. The Bonferroni adjusted significance level was $p=.008$. Unexpectedly, both groups showed a similar tendency to initially avoid angry faces in favor of neutral faces (both $p<.033$). The

Table 4 Detailed statistical values of non-significant main effects and interaction effects in the ANOVA (with group: SAD, HC; stress induction: yes/no; stimulus pair: angry–neutral, angry–happy, angry–house; lower table also includes time intervall: 10 times 500 ms)

	df	*F*	*p*	η_p^2
2 × 2 × (3) ANOVA				
Group	1, 75	0.658	.420	0.009
Stress induction condition	1, 75	0.620	.433	0.008
Group × stress induction condition	1, 75	3.104	.082	0.040
Stimulus × group	2, 123[a]	1.463	.236	0.019
Stimulus × stress induction condition	2, 123[a]	2.523	.095	0.033
Stimulus × group × stress induction condition	2, 123[a]	2.340	.111	0.030
2 × 2 (3 × 10) ANOVA				
Group	1, 74	1.779	.186	0.023
Stress induction condition	1, 74	1.555	.216	0.021
Group × stress induction condition	1, 74	0.434	.512	0.006
Stimulus × stress induction condition	2, 112[a]	0.723	.452	0.010
Stimulus × group × stress induction condition	2, 112[a]	0.654	.482	0.009
Time intervall × group	7, 508[a]	1.549	.150	0.021
Time intervall × stress induction condition	7, 508[a]	1.272	.263	0.017
Time intervall × group × stress induction condition	7, 508[a]	1.096	.364	0.015
Stimulus × time intervall × group	11, 845[a]	0.908	.534	0.012
Stimulus × time intervall × stress induction condition	11, 845[a]	0.678	.766	0.009
Stimulus × time intervall × group × stress induction condition	11, 845[a]	1.135	.329	0.015

[a]Degrees of freedom were adjusted according to Greenhouse-Geisser. These analyses were performed to investigate the impact of the stress induction procedure on first fixation bias scores and to analyze the attention allocation across 5000 ms

angry–happy stimulus comparison revealed a significant first fixation bias to happy faces in HC children ($p < .001$). The same tendency emerged in children with SAD but was not statistically significant, considering the necessary alpha adjustment ($p = .018$). As expected, a significant first fixation bias was found in angry face–house pairs. In accordance with our prediction, both groups fixated more often on angry faces first than on houses (both $p < .001$).

An absolute attentional bias to angry faces occurred in all children only when houses were presented simultaneously. HC children furthermore showed a significant bias to happy faces.

Hypothesis 2

Does a stress induction procedure increase first fixation biases in anxious children?

The following ANOVA, which was employed to analyze differential effects between groups, included all children. One-sample *t*-tests were performed within groups, only including children in the stress induction condition.

Relative Attentional Biases?

A three-way mixed ANOVA with group (SAD and HC) and stress induction condition (SI and noSI) as between-subjects factors and stimulus (angry–neutral, angry–happy and angry-house) as within-subjects factor was conducted to assess potential differences between anxious children and healthy controls regarding the impact of stress induction on first fixation bias scores. A significant, large main effect for stimulus occurred, F (2, 123) = 120.08, $p < .001$, $\eta_p^2 = 0.616$. Post-hoc analyses indicated that the mean bias scores of all three picture pairs differed significantly from each other (all $p < .030$). The bias score was highest in angry–house pairs and lowest in angry–happy face pairs. There were no significant main effects for group or stress induction condition (all $p > .419$, all $\eta_p^2 < 0.010$) nor significant interaction effects (all $p > .081$, all $\eta_p^2 < 0.041$). Statistical details of non-significant main effects and interaction effects are displayed in the upper part of Table 4.

Thus, there was no evidence for an enhanced relative bias after schema activation. Again, the probability to first fixate on the angry face was highest in the context of a house.

Absolute Attentional Biases?

First fixation bias scores of children who were assigned to the stress induction condition were additionally analyzed with one-sample *t*-test to assess absolute bias scores within children in both groups (see lower part of Table 3). In HC children, the mean bias score in angry–house pairs differed significantly from chance. As displayed in Table 3, no other significant effects emerged. Unexpectedly, the mean bias

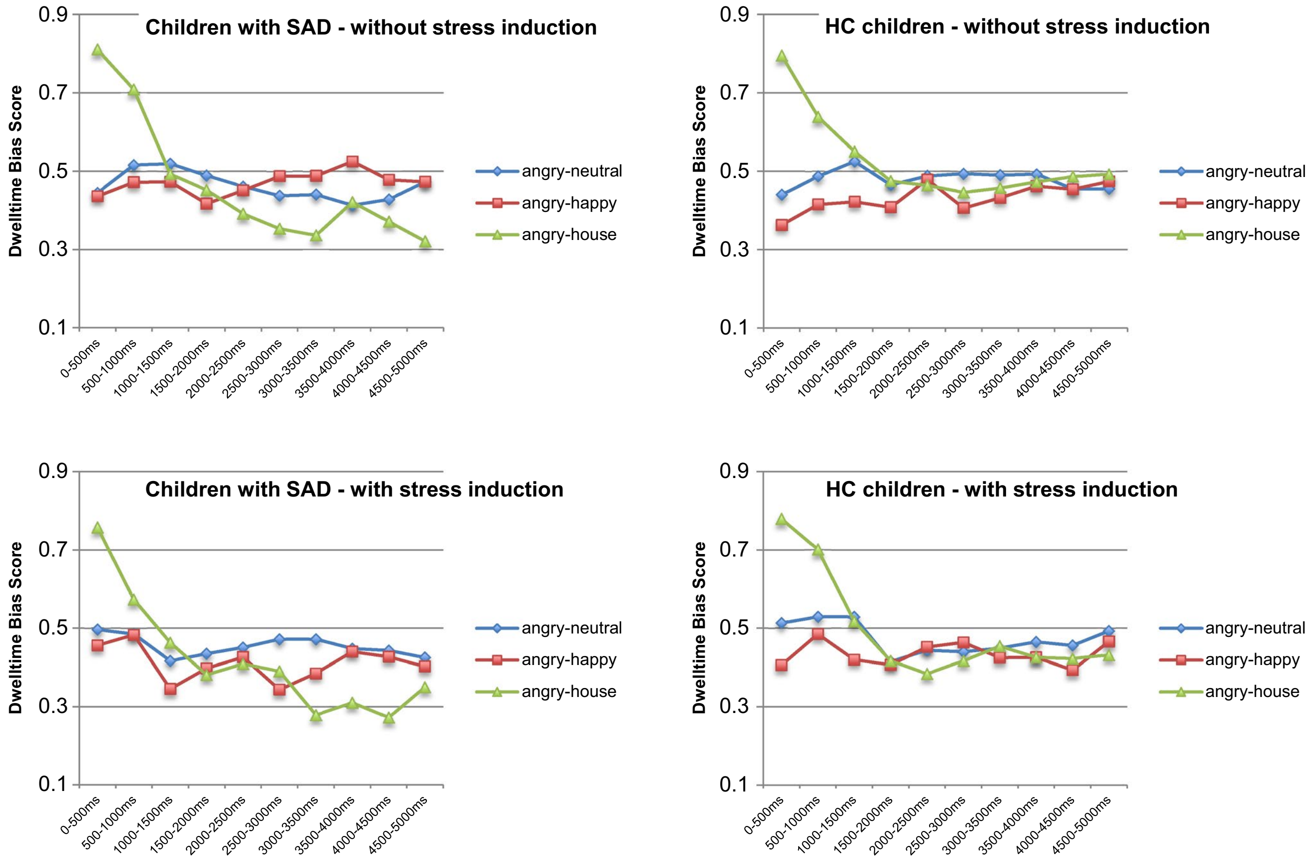

Fig. 2 Dwell time bias scores indicate the percentages of time spent looking at the angry face as a function of total dwell time for both stimuli presented at each time bin

score in angry-house pairs did not differ significantly from 0.50 in children with SAD. To further explore this result, a post-hoc examination of the individual bias scores in a scatter-plot, a small sub-sample of $n = 3$ children, who first fixated on house stimuli in more than 65% of trials, were identified in the SAD group in the angry–house stimulus condition.

After schema activation, a significant absolute bias to threat occurred only in children in the HC group and when the alternative stimulus was a house. There was no significant absolute bias away from threat.

Hypothesis 3

Do anxious children relocate attention to threat after stress induction?

Total dwell time was analyzed in all children to test whether children with SAD in the stress induction condition relocate their attention to or away from threat in a later period of threat exposure. A $2 \times 2 \times (3 \times 10)$ repeated measures ANOVA with group (SAD and HC) and stress induction condition (SI and noSI) as between-subjects factors and stimulus (angry–neutral, angry–happy and angry–house) and time interval (10 time bins à 500 ms) as within-subjects factors was performed. The attentional distributions for different stimulus pairs are displayed separately for group and stress induction condition in Fig. 2. The analysis yielded significant main effects for stimulus [F (2, 112) = 4.48, $p = .022$, $\eta_p^2 = 0.057$] and time intervall [F (7, 508) = 24.92, $p < .001$, $\eta_p^2 = 0.252$], which were qualified by a significant interaction effect for stimulus x time intervall (F (11, 845) = 19.18, $p < .001$, $\eta_p^2 = 0.206$). Dwell time on angry faces varied only slightly in angry–neutral and angry–happy face pairs over the total presentation time of 5000 ms, whereas remarkable changes were observable in angry–house pairs. Furthermore, there was a significant interaction between stimulus and group [F (2, 112) = 3.91, $p = .033$, $\eta_p^2 = 0.050$]. The difference between the mean dwell time bias scores, averaged across the total presentation time of 5000 ms, in angry–happy and angry–house pairs was significantly higher in HC children than in children with SAD. As presented in the Figure, irrespective of group and stress induction condition, the dwell time on angry faces in favor of houses decreased considerably after the first second and fell below the balance of 0.50 upon the second. Finally, dwell time bias scores resulted in a preference of the non-social stimulus in the last 3 s of the presentation, especially in children with SAD. There was no relocation of attention to threat in children with SAD in the stress induction condition. Statistical details of non-significant main effects and interaction effects can be found in the lower part of Table 4.

Association Between First Fixation Bias Scores and Total Dwell Time with Self-Reported Symptom Severity[4]

Post-hoc, we investigated the association between the level of child anxiety as measured with the SPAI-C and the SASC-R and both first fixation bias scores and total dwell time to angry faces. Spearman coefficients were computed including all children.

There was no significant correlation between the self-reported anxiety level and the attentional bias score in angry–neutral face pairs (SPAI-C: $r = .179$, $p = .120$; SASC-R: $r = .150$, $p = .194$), nor between the self-reported anxiety level and the attentional bias score in angry–house pairs (SPAI-C: $r = .057$, $p = .623$; SASC-R: $r = .077$, $p = .504$). However, children's attentional bias score in angry–happy face pairs was significantly associated with the self-reported anxiety level in the SPAI-C ($r = .260$, $p = .023$) but not in the SASC-R ($r = .201$, $p = .080$). Children who reported more anxiety first fixated more often on the angry face when presented with angry-happy face pairs.

Furthermore, we investigated if the anxiety level was associated with total dwell time on angry faces. Children's self-reported anxiety level was not associated with total dwell time on angry faces in angry-neutral pairs (SPAI-C: $r = -.165$, $p = .151$; SASC-R: $r = -.148$, $p = .199$), nor with total dwell time in angry–happy pairs (SPAI-C: $r = -.147$, $p = .201$; SASC-R: $r = -.108$, $p = .349$). There was a significant correlation between children's total dwell time on angry faces in angry–house pairs and both self-report measures of anxiety (SPAI-C: $r = -.329$, $p = .003$; SASC-R: $r = -.265$, $p = .020$). A higher level of anxiety was associated with a lower dwell time on angry faces in favor of houses.

Discussion

The current study examined the eye movements of children with SAD between the ages of 9 and 13 years. First fixations and the dwell time over 5000 ms were analyzed. Considering the influence of different contexts as well as activated schemata of anxiety, we implemented various competing stimuli and a stress induction condition in half of the children prior to the task.

Hypothesis 1

Do all children show an *initial hypervigilance* to threatening stimuli?

The analysis of first fixations to angry faces across stimulus conditions revealed a significant attentional bias towards angry faces in children with SAD compared to HC children. This falls in line with prior findings, indicating an attentional bias to threat in child anxiety (e.g. Dudeney et al. 2015; Shechner et al. 2013). However, our finding only supports a relative bias between groups, averaged across the different competing stimuli (i.e. neutral and happy faces as well as houses). As outlined above, it is also important to consider biases with regard to their difference from chance (i.e. 0.50). Below, absolute biases in each stimulus condition are discussed separately.

Angry Versus Neutral Faces

In contrast to our prediction, no absolute bias to threat (score > 0.50) occurred, when attention allocation was analyzed in angry–neutral face pairs. Likewise, children in both groups tended to avoid angry faces. This result indicates a similar tendency shown in previous findings reported by Stirling et al. (2006), who found overall avoidance of negative faces in children. Recent studies also failed to find differences in initial attention allocation between anxious children and healthy control children (e.g., Dodd et al. 2014; Seefeldt et al. 2014). However, these studies stated an increased orientation to threat (score > 0.50) in all children. Age range, stimulus material or other inconsistencies across studies may not explain this discrepancy because the present study and Seefeldt and colleagues used very similar stimuli, experimental procedure and samples. However, we used a strict algorithm for checking data quality which was not described in any of the previous studies. This may imply that even slight changes in experimental procedures or different levels of data quality may result in different bias scores, which in turn are associated with different interpretations.

Angry Versus Happy Faces

First fixation bias scores in angry–happy face trials indicated a significant preference for happy faces in healthy control children. The same tendency emerged in children with SAD, however it was not statistical significant. Previous studies found happy faces to be evocative stimuli, being preferred in favor of neutral faces in anxious participants as well as in healthy controls (e.g. Garner et al. 2006; Shechner et al. 2013). Our finding with a combination of angry and

[4] The association between the self-reported anxiety level and the attentional bias scores and dwell time was analyzed following another request from an anonymous reviewer post-hoc.

happy faces is further consistent with Gamble and Rapee (2010), who found a preference for happy faces in favor of angry faces throughout 5000 ms exposure in adults, as well as with Heinrichs and Reinhold (2010), who found the same tendency in children. In addition, In-Albon et al. (2010) reported that in 76% of trials, children with separation anxiety disorder and healthy control children first fixate on pictures of reuniting. Hence, beyond both anxiety disorders, anxious children in general show a preference for positive rather than negative stimuli. Following the model of Mathews and Mackintosh (1998), participating children indeed succeeded in sufficiently inhibiting the threat representation of angry faces. Interestingly, there was a significant association between the self-reported level of anxiety and the attentional bias score. Children with a higher level of anxiety more often fixated on the angry face, suggesting that avoidance of threatening stimuli is less effective in high socially anxious children.

Angry Faces Versus Houses

Consistent with the existing literature (e.g., Gamble and Rapee 2010; Garner et al. 2006; Heinrichs and Reinhold 2010; Seefeldt et al. 2014), children in both groups equally showed a significant first fixation bias to angry faces. In contrast to both face–face contexts, the angry face was not avoided in face-object trials. Although these bias scores seem to support the assumption of *initial hypervigilance* to threat (e.g., Mogg and Bradley 1998), they do not have to be incompatible with avoidance of threat. A general preference for faces over non-social stimuli (e.g., Gamble and Rapee 2010) appears to be independent of the emotional valence, given that even neutral faces capture greater attention in the context of houses (e.g., Garner et al. 2006; Heinrichs and Reinhold 2010). Our findings indicate that the salience of angry faces relative to houses more strongly affected attention allocation than avoidance of these stimuli.

Hypothesis 2

Does a stress induction procedure increase first fixation biases in anxious children?

Participants' ratings of anxiety prior to and after stress induction indicated an increase in self-reported anxiety in children with SAD and in healthy controls. Overall, children reported low levels of distress.

The between-group analysis of first fixations across stimulus conditions revealed no evidence for an increased first fixation bias in children with SAD compared to HC children after schema activation. However, attention allocation in each stimulus condition was differentially affected by the stress induction procedure, which may explain the absence of the expected interaction effect. Absolute bias scores in each stimulus condition are discussed below.

Angry Versus Neutral Faces

In line with theoretical considerations (Clark and Wells 1995), we found social-evaluative stress to influence orientation to angry faces. Stress induction affected initial attention processes by increasing the number of first fixations to angry faces presented in combination with neutral faces. Although this effect was seemingly stronger in children with SAD than in healthy controls, there was no significant interaction in our sample in contrast to other studies (see Garner et al. 2006; Seefeldt et al. 2014). Thus, present bias scores in angry–neutral face pairs suggest initial avoidance of threatening stimuli in all children. In line with the theoretical considerations of Mathews and Mackintosh (1998), children with SAD failed to continue avoiding threat after stress induction. Schema activation may differentially reduce avoidance, indicating the potential inhibitory effect on information processing.

Angry Versus Happy Faces

The absolute attentional bias to happy faces in HC children disappeared under the stress induction condition when social-evaluative stress increased initial attention allocation to threat in healthy controls. Apart from angry–neutral face pairs, anxious children's first fixation bias scores did not differ as a function of stress induction condition. Abnormal evaluation processes of happy faces in anxious children need to be taken into account to explain differential effects of stress induction on attention allocation to threat. Alden et al. (2008) reported social anxiety to be associated with negative interpretations of positive social events. If socially anxious individuals evaluated happy expressions in a negative fashion, e.g., as a sign of mocking (Bradley et al. 1999), avoidance of threat would be equivalent to avoidance of both facial stimuli. In that case, total dwelltime on the blank area should be elevated in angry–happy face trials (see Dodd et al. 2014) because children need to fixate somewhere on the screen.

Angry Faces Versus Houses

First fixation bias scores in angry–house pairs were differentially affected by the stress induction. Whereas first fixations of HC children were similarly allocated with or without prior stress induction, first fixation bias scores in children with SAD differed significantly from chance, only without prior stress induction. In contrast to our hypothesis, bias scores in the stress induction condition were seemingly smaller, indicating a weaker preference for angry faces in favor of houses in children with SAD. This finding is consistent with Garner et al. (2006), who found a reduced bias to faces relative to objects in high anxious compared to low anxious adults. Post-hoc, we identified a small sub-sample of $n=3$ children, who first fixated on house stimuli in more than 65% of trials. In line with recent findings (Dodd et al. 2014) that reported anxious children to be avoidant of face stimuli relative to non-anxious children, a small sub-sample of children with SAD in our study succeeded in avoiding the angry faces when presented with houses. However, the majority of children more often allocated initial attention to the angry face.

Hypothesis 3

Do anxious children relocate attention to threat after stress induction?

Angry Versus Neutral Faces

The dwell time analysis over 5000 ms revealed no evidence for attentional relocation or *avoidance* in later stages of information processes after stress induction. Thus, the hypothesis of Seefeldt et al. (2014) was not supported in the present study.

Angry Versus Happy Faces

The dwell time examination revealed a slightly maintained preference for happy faces in favor of angry faces throughout the full 5000 ms in the stress induction condition in both groups.

Angry Faces Versus Houses

The dwell time analysis in the stress induction condition showed *initial hypervigilance* to faces in both groups followed by *attentional avoidance* of faces in anxious participants. This finding does not match our hypothesis of a relocation of attention to angry faces (see Seefeldt et al. 2014). However, a similar pattern of vigilance and avoidance of faces in favor of houses was found in highly anxious children (not meeting the threshold for diagnosis) over a trial duration of 4000 ms (Heinrichs and Reinhold 2010). Our data in face-house trials are furthermore consistent with In-Albon et al. (2010), who investigated separation anxiety disorder in children, and fit the hypervigilance-avoidance hypothesis in anxiety (e.g., Mogg and Bradley 1998). In the present study, the total dwell time on angry faces in favor of houses was negatively associated with the anxiety level as measured using self-report questionnaires. Taking the full 5000 ms of stimulus presentation into consideration, the children who were more anxious avoided the angry face more often than children who were less anxious.

However, this finding seems to be context-specific, as there was a lack of corresponding attention allocation in both face–face pair conditions. Both groups were probably initially vigilant to faces due to the low salience of objects. In face–face trials, the evaluation of stimuli as threatening becomes important and impacts children's direction of gaze. On the other hand, only objects as competing stimuli offer an occasion to avoid social cues, which are, in general, potentially ambiguous or threatening for anxious individuals. An interpretive bias in social anxiety was previously found for both neutral facial expressions (e.g. Mohlman et al. 2007; Yoon and Zinbarg 2008) and happy facial expressions (e.g. Alden et al. 2008). Chen et al. (2002) previously combined faces with objects and reported similar results in a dot-probe task. Participants with SAD avoided social stimuli when there was an opportunity to do so. Our findings concerning the dwell time in angry face-house pairs are furthermore in line with Garner et al. (2006), who suggested a strategic reduction of attention to threat in anxious individuals, particularly after stress induction. This would become apparent in a subsequent disengagement of gaze from threatening stimuli, which aims to alleviate discomfort and discourage further social interaction.

Concluding Comments

In sum, the present findings rather support avoidance of than hypervigilance to threat in children. Without prior stress induction, the probability to first fixate on the angry face was significantly higher in children with SAD than in HC children. However, absolute bias scores were below 0.50 in both groups, indicating a lack of inhibiting threat representations in children with SAD. Furthermore, an important finding is that direction of gaze regarding threatening stimuli is not independent of its context. In fact, we were only able to replicate parts of our previous results despite using the same stimuli, a very similar paradigm and the same eye-tracking technology: Children in both groups preferred social over non-social stimuli; they did not differ significantly regarding the distribution of initial fixation in angry–neutral face pairs; in the stress induction condition, children with SAD showed an increased initial attention allocation to angry faces in favor of neutral faces. In the present paper, bias scores of subsequent processing in the context of houses fell below 0.30 only in children with SAD, supporting theoretical assumptions of subsequent *attentional avoidance* of threat (e.g., Mogg and Bradley 1998). In contrast to neutral or happy faces, houses represented unambiguous, nonthreatening stimuli and were therefore preferred by anxious children. Different effects of stress induction on initial attention allocation in angry–neutral face pairs proposed a lack of inhibition in children with SAD. Mathews and Mackintosh (1998) suggested that threatening cues attract attention when an individual fails to adequately inhibit the threat representation. Although in line with these theoretical assumptions, this effect is quite small and also does not reach statistical significance with the present sample size.

The measurement of eye movements provides plenty of data that can be analyzed to investigate biased attention (see Armstrong and Olatunji 2012). *Initial hypervigilance* to threat is most commonly assessed by counting how often the threatening stimulus captures initial fixation (e.g., Dodd et al. 2014; Gamble and Rapee 2009). Others analyzed the latency of first fixations made for presented stimuli (e.g. Garner et al. 2006). *Attentional avoidance* or *sustained attention* in later stages of information processing has been assessed heterogeneously. While Gamble and Rapee (2009) counted the number of fixations, recent studies (e.g. Dodd et al. 2014; In-Albon et al. 2010; Seefeldt et al. 2014) compared the dwelltime on each stimulus. Yet there is no consensus to which indices are suitable to investigate biased attention, complicating comparability between studies. Furthermore, only little is known about reliability of these variables, given that very few studies assessing attentional bias to threat reported psychometric properties of eye movement measurement (e.g. Lazarov et al. 2016; Waechter et al. 2014). In the present paper, reliability of first fixation bias scores were similar to those reported previously by Waechter et al. (2014). Cronbach's alpha was negative in both face–face pairs, but increased considerably (all $\alpha \geq 0.28$) when considering stimulus position within each stimulus pair. While reliability of dwell time bias scores was high ($\alpha > 0.90$) for the duration of the full trial (6000 ms in Lazarov et al. 2016; 5000 ms in Waechter et al. 2014), α ranged from negative to 0.67 when the time course was divided in 10 time bins à 500 ms (Waechter et al. 2014). We found very comparable reliability estimates for dwell time bias scores for each time interval in our sample. Reliability estimates in our study are therefore in line with previous findings, suggesting only low to moderate reliability of attentional bias indices. Future research should include the analysis of reliability of attentional bias measurement to allow modification and improvement of assessment, experimental tasks and, if applicable, the underlying theory (for further discussion see Rodebaugh et al. 2016).

Strengths and Limitations

In the present study, participants were carefully assessed confirming eligibility by using a structured interview for children and their parents. Furthermore, to assure the validity of diagnoses, we used questionnaire measures to evaluate symptom severity reported by the children themselves and by at least one parent for each child. Participants were recruited from a small age range to enable consideration of developmental variations in attentional processes. In addition to first fixation bias scores, dwell time was investigated using a presentation duration of 5000 ms to consider even later stages of information processing. With the implementation of a stress induction condition, the impact of schema activation on attentional bias scores was analyzed, which was rarely done in previous studies in anxious children. Furthermore, the use of various competetive stimuli enabled us to analyze the context specificity of bias scores.

However, some limitations also apply: First, in light of methodical considerations, a validation step after calibration and a recalibration procedure during eye movement measurement would have improved the data quality of eye-tracking. We addressed these aspects post-hoc and needed to exclude 35.2% of the children from the study. The analysis of complex interactions was thus underpowered due to the considerable reduction of sample size. For ecological validity reasons, in contrast to Seefeldt et al. (2014), children with comorbid diagnoses were not excluded, in order to provide for the high comorbidity between anxiety disorders and anxiety and other mental disorders in general (Costello et al. 2005). The comparison of results between both studies might, therefore, be limited. Additionally, bias scores of children with SAD were only compared to bias scores of healthy control children, and correspondingly, our findings may not be specific to SAD, but associated with anxiety in youth in general.

Clinical Implications

In sum, the present results illustrate little convergence of findings regarding the direction and extent of an attentional bias in anxious children. Other than in adults, steps of cognitive and emotional development may be important mechanisms that individually influence attention allocation. Furthermore, bias scores in our study were mostly between 40 and 60%, indicating at most a relative preference in some conditions. Previous eye-tracking studies reported bias scores of similar size (e.g., Dodd et al. 2014; Garner et al. 2006; Seefeldt et al. 2014), raising the question of when it is suitable to assume a "bias" in attention allocation. The clinical significance of such a bias may be debatable, especially when interpreting a gaze behavior that applies to all children as "abnormal" (e.g., avoidance in the present paper or initial vigilance to threat found by Dodd et al. 2014; Dudeney et al. 2015 and Seefeldt et al. 2014). However, clinical significance should be of particular importance, considering therapeutic implications drawn from attentional biases found in experimental paradigms. In the last decade, there was a remarkable growth of research employing cognitive bias modification (CBM) techniques attempting to gain therapeutic benefits in the treatment of clinical anxiety (MacLeod and Mathews 2012). CBM aims to reduce cognitive processing biases, including both attentional biases

(CBM-A) and interpretive biases (CBM-I). In a recent meta-analysis, Cristea et al. (2015) evaluated CBM outcomes in children and adolescents. Within a total sample of $k=23$ studies, $k=9$ studies investigated CBM-A interventions, they found a significant, moderate effect ($g=0.53$) of CBM for changes in (attentional and interpretive) biases. Subgroup analyses revealed that the effect sizes on targeted biases were significant for CBM-I, but not for CBM-A. There were nonsignificant effects of CBM on mental health outcomes ($g=0.12$) and on anxiety outcomes in particular ($g=0.17$). Both subgroups, CBM-I and CBM-A, did not differ regarding the effect of intervention on outcome measures. While Cristea et al. did not found a significant effect of CBM on anxiety leading to serious concerns over the implementation of CBM-I and CBM-A in the treatment of anxious youth, a more recent study (Pergamin-Hight et al. 2016) indeed reported a significant reduction in pediatric social anxiety after the implementation of a CBM-A technique. Social anxiety symptoms were significant lower after both a CBM-A intervention and an attention control training intervention. However, moderating effects of age and attention control were found, suggesting a greater benefit of CBM-A in older children and in children with relatively poorer attention control. Considering the presence of "biases" in anxious and non-anxious children, irrespective of its direction, the meaning of attention processes in child anxiety is less understood than in adult anxiety. Future research may first aim for replication of previous findings to better understand biased attention processing related to SAD in children. Existing inconsistencies of results therefore recommend caution in the deduction of clinical implications.

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Compliance with Ethical Standards

Conflict of Interest This work should be part of the cumulative dissertation of Steffen Schmidtendorf, which is supervised by Nina Heinrichs.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Animal Rights Statement This article does not contain any studies with animals performed by any of the authors.

Informed Consent Informed consent was obtained from all individual participants included in the study.

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