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Research paper

Delayed gaze shifts away from others' eyes in children and adolescents with social anxiety disorder

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A B S T R A C T

Background: Social anxiety disorder (SAD) is linked to atypical attention to other's eyes. Empirical literature about this phenomenon in childhood and adolescence is scarce. Previous studies in adults have suggested that SAD may be characterized by either rapid avoidance of eye contact, or by impaired shifting of attention away from eyes once eye contact has been established. SAD has also been linked to quick orienting towards eyes, indicating vigilant monitoring of perceived threat.
Methods: In the largest eye-tracking study of youth with SAD to date, 10 to 17 year-olds with SAD (n = 88) and healthy controls (n = 62) were primed to look at either the eyes or the mouth of human faces. The latency and likelihood of a first gaze shift from, or to the eyes, was measured.
Results: Individuals with SAD were slower to shift their gaze away from the eye region of faces than controls, but did not differ in orienting toward eyes.
Limitations: Participants were assessed once after the onset of SAD symptoms, meaning that the longitudinal predictive value of delayed gaze shifts from others' eyes could not be examined.
Conclusions: Youth with SAD may be impaired in shifting attention from other's eyes. This could contribute to the experience of eye contact as aversive, and may be a maintaining factor of childhood SAD.

Social anxiety disorder (SAD) is characterized by fear of being scrutinized or negatively evaluated in social situations. It has a life-time prevalence around 12% and is associated with a high degree of everyday impairment and multiple negative consequences, such as unemployment, academic underperformance, and comorbid psychopathology, including depression (Stein and Stein, 2008). SAD has a typical onset in late childhood or adolescence, and although there are evidence-based treatments for adolescent SAD, the treatment response rates are typically lower than for other anxiety disorders (Hudson et al., 2015). Thus, a better understanding of the cognitive and neural mechanisms underlying the development and maintenance of child and adolescent SAD is greatly needed to enhance treatments and prevent further negative development (Holmes et al., 2018).

Current models suggest that SAD may be partially maintained by maladaptive attention to faces and other social stimuli (Rapee and Heimberg, 1997; Wong and Rapee, 2016), and here the eyes may hold a prominent role. Typically developing humans are highly attentive to eye contact (Emery, 2000; Senju and Johnson, 2009), reflecting that information in the eye region is crucial for understanding others' intentions and mental states, including signals of affiliation or interpersonal aggression. While direct gaze may increase positive affect in healthy individuals (Hietanen, 2018), it may also lead to the perception of threat, particularly in individuals with SAD (Moukheiber et al., 2010; Schneier et al., 2011; Schulze et al., 2013). In line with this, individuals with SAD tend to avoid eye contact in real life settings (Schneier et al., 2011), show atypical autonomic arousal to faces with direct gaze (Kleberg et al., 2019), and have altered functioning of brain networks involved in face processing (Frick et al., 2013; Gentili et al., 2016). Gaze avoidance may have cascading consequences leading to maintenance of SAD symptoms, since it reduces opportunities to participate in positive social interaction and to challenge maladaptive beliefs about one's ability to manage social interaction. A better understanding of responses to eye contact may be informative about the underlying causes of SAD, and potentially lead to the development of more effective treatments aiming at normalizing atypical attention (Mogg et al., 2017).

Studies in humans and primates have suggested that a hard-wired network of brain regions, including the amygdala and superior temporal sulcus, trigger attention to others' eyes (Itier and Batty, 2009; Spezio et al., 2007). Eye contact affects neural responses and information processing already at a very short timescale. For example, electrophysiological studies show distinctive responses to eye contact within 200 ms (Nemrodov et al., 2014; Schwab and Schienle, 2017), and the mere presence of eyes triggers quick, involuntary gaze shifts (Adler and Orprecio, 2006; Kleberg et al., 2018) and amygdala responses (Sato et al., 2016). A full understanding of gaze avoidance in SAD is therefore likely to require temporally precise measurements of responses to eye contact during early stages of processing.

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So far, research about the mechanisms underlying atypical eye contact in child and adolescent SAD is limited. However, research in adults has led to the formulation of a number of hypotheses about disrupted attention processes in SAD. These theories have mainly been tested in studies that examined the relative allocation of attention to faces with threatening expressions and various control stimuli, and not in relation to eye gaze processing specifically (e.g. Chen and Clarke, 2017; Chen et al., 2020). First, a pattern of enhanced attention to disorder relevant stimuli such as angry faces at early stages of exposure has been described (typically < 2 s; Bögels and Mansell, 2004). This bias to attend to socially threatening stimuli could be driven by *vigilance*, i.e. a strong tendency to search for, and orient to potential threats (Bögels and Mansell, 2004; Chen and Clarke, 2017; Horley et al., 2003), a process linked to enhanced reactivity in a largely subcortical brain network including the amygdala (Henderson et al., 2015). An alternative theory suggests that attentional bias to threat during the earliest time stages of processing is not characterized by vigilance, but by *delayed disengagement* (Fox et al., 2002; Heeren and Mcnally, 2016; Salemink et al., 2007), a process that could be driven by reduced attentional flexibility (Thorell et al., 2004; White et al., 2011) and impaired top-down regulation from dorsal prefrontal brain regions (Fu and Pérez-Edgar, 2018; Henderson et al., 2015; Cisler and Koster, 2010). While both the vigilance and the delayed disengagement theories predict enhanced attention to threat, they hypothesize different underlying mechanisms.

Finally, it has been suggested that attention in SAD is characterized by *avoidance*, or reduced attention, to potential threats. Avoidance has been reported at a wide range of presentation times (Lisk et al., 2019; Chen and Clarke, 2017), although most consistently from around three seconds (Chen et al., 2020). According to the *vigilance-avoidance* hypothesis (e.g. Bögels and Mansell, 2004), attention in anxiety disorders has a biphasic time course with initial vigilance, followed by later avoidance.

The competing accounts of biased attention in SAD implicate different processes, but have been difficult to compare using methods with limited temporal resolution such as manual reaction time tasks (Bantin et al., 2016). Consequently, researchers have increasingly turned to methods with better temporal resolution, such as eye tracking (Chen and Clarke, 2017; Mueller et al., 2009).

Existing research in child and adolescent SAD gives some support for both the theories of an initial attention bias to faces with threatening expressions (e.g. Chen et al., 2020; Dudeney et al., 2015; Waters and Lau, 2017), and for avoidance (e.g. Chen et al., 2020; Lisk et al., 2019). However, the results are less consistent than in adults and only a small number of eye tracking studies have been conducted in child and adolescent SAD. Three studies reported vigilance for angry faces (Capriola-Hall et al., 2020; Schmidtendorf et al., 2018; Seefeldt et al., 2014). In contrast, a recent study found evidence for a vigilant-avoidant pattern of attention in adolescents with SAD as well as in healthy controls (Högström et al., 2019).

While the studies reviewed above have examined attention to angry faces compared to control stimuli, the literature about eye gaze processing is surprisingly scarce. As noted above, the eye region is highly important in multiple aspects of social interaction and understanding, and eyes with direct gaze may therefore constitute a particularly disorder relevant stimulus in SAD. Eye-tracking studies in adult SAD have found evidence for a vigilant-avoidant attention pattern to others' eyes (Boll et al., 2016; Horley et al., 2003; Chen et al., 2015; Weeks et al., 2013), but the literature in child and adolescent populations is very limited. Kleberg et al. (2017) reported that a higher degree of social anxiety in an adolescent SAD sample predicted quicker reorienting from images of human eyes, i.e., avoidance. Keil et al. (2018) found that adolescents with SAD followed a hypervigilant-avoidant gaze pattern by orienting quicker to the eyes of images of faces, but also looking less at the eyes during later time stages, in line with adult findings. The majority of studies reporting atypical eye gaze processing in SAD did not find this effect to be modulated by emotional expression (Boll et al., 2016; Keil et al., 2018; Weeks et al., 2013, *but see* Horley et al., 2003), which suggests that the eye region of others is a disorder relevant stimulus per se in SAD (Moukheiber et al., 2010; Schneier et al., 2011).

A limitation of most studies is that participants initial point of gaze relative to the eye region was not systematically manipulated in a way that allows for independent measures of vigilance and delayed disengagement. Instead, stimuli have been presented so that participants always looked at a constant point at the center or the side of stimuli when they appeared (e.g. Horley et al., 2003; Keil et al., 2018; Kleberg et al., 2017; but see Boll et al., 2016). This means that gaze shifts to, or from the eyes were not independent of previous eye movements. An exception is the adult study by Boll et al. (2016), where participants were primed to look so that their point of gaze was either at the eye region or at the mouth region of faces as they appeared. In this study, adults with SAD were quicker than controls to orient to eyes (*hypervigilance*), but did not differ in the latency to orient from eyes.

To sum up, the previous literature in SAD has suggested that the disorder may be characterized by three types of atypical attention to perceived threats – initial hypervigilance, delayed disengagement, and/or later stage avoidance. Few studies have used experimental paradigms which can distinguish between these accounts with regards to attention to other's eyes. In addition, previous studies have mainly been conducted with adults, and sample sizes have been small. In the present study, we examined attention to direct gaze in the largest youth eye-tracking study to date. The aim was to differentiate between the *vigilance, avoidance*, and *delayed disengagement* accounts of atypical responses to eye gaze in child and adolescent SAD.

Hypotheses and preregistration

If children and adolescents with SAD are *vigilant* to eyes with direct gaze, they should be 1) quicker; and 2) more likely to orient their gaze to the eyes when primed to look at the mouth as compared to healthy controls (hypothesis 1).

If they are *avoidant* of eyes, they should be 1) quicker; and 2) more likely to reorient *from the eyes* when primed to look at them than controls (hypothesis 2).

If children and adolescents with SAD are instead slower to *disengage* from eyes, they should look *longer at the eyes* before reorienting, and be less likely to reorient away from the eyes, than controls (hypothesis 3).

All these hypotheses were tested. Whereas hypotheses 2 and 3 are mutually exclusive, both are in principle compatible with hypothesis 1. The hypotheses and the analysis plan were preregistered in the Open Science Framework (https://osf.io/c3xqr). We varied the emotional expression of the stimuli to examine the generalizability of the effects, but did not hypothesize specific effects of emotion.

Because of the relatively wide age range of the participants (10–17), exploratory post hoc analyses were conducted to examine whether observed results were related to age. Moderating effects of comorbid conditions in the SAD group were also examined in exploratory analyses that were not pre-registered.

Method

Participants

The final sample included 147 individuals, of which 84 were treatment-seeking youth with SAD, and 62 were healthy controls. The SAD group was recruited from two clinical trials examining the efficacy of internet based cognitive behavioral therapy (CBT) for SAD. The experimental paradigm was completed after the initial assessment, but before treatment onset. In the first cohort, 30 individuals with SAD were initially invited to participate in the study. Of these, 27 agreed and were tested. In the second cohort, 107 individuals with SAD were invited and 69 of these accepted to participate in the trial. Due to an equipment failure, all data from six individuals in the SAD group were missing. In addition, 12 participants were excluded due to a lack of valid data (see *Data collection and processing*). A principal diagnosis of SAD was confirmed by an experienced clinical psychologist using either

the Mini International Neuropsychiatric Interview (MINI-KID; Sheehan et al., 2010; first cohort), or the Anxiety Disorders Interview Schedule (ADIS; Silverman, 1996); second cohort). The assessor rated clinical severity in the first cohort using the Clinical Global Impression Scale-Severity (CGI-S; Guy, 1976), with scores ranging from 1 to 8, where higher scores indicate higher symptom severity. Symptom severity ratings in the second cohort were conducted using the Clinical Severity Rating (CSR) from the ADIS (Silverman, 1996) which ranges from 1 to 8 with a diagnostic cut off of four or above. Symptom severity ratings were also completed by participating children in both groups using the Social Phobia and Anxiety Inventory (SPAI; Beidel et al., 2000; first cohort), or the child and adolescent version of the Liebowitz social anxiety scale (LSAS; Masia-Warner et al., 2003; second cohort). Self-ratings were missing for five children in the SAD group. Non-verbal cognitive ability was assessed using the Matrix Reasoning subtest from the Wechsler Intelligence Scale for Children, 5th Ed. (WISC-5; Wechsler, 2014) or the Wechsler Adult Intelligence Scale, 4th Ed. (WAIS-IV; Wechsler, 2008) depending on the child's age. This measure was missing for ten children in the SAD group. Demographic and clinical information is shown in Table 1.

Comorbid diagnoses and medication status are shown in Table 2. In line with previous research (e.g. Mahommadi et al., 2020), relatively high rates of comorbidity with other mood and anxiety disorders were observed. Generalized anxiety disorder (GAD; $n = 15$), specific phobia ($n = 13$), and major depressive disorder ($n = 7$) were the most common comorbid conditions. Exclusion criteria were the following: initiation or dose modification of psychotropic drug within the past six weeks, current psychosis, eating disorder, severe depression, suicidal behavior or other current severe mental disorder including autism spectrum disorder, or substance or alcohol abuse.

Healthy controls were randomly selected from the Swedish tax registry and invited to participate in the study. In total, 65 individuals choose to participate and were included in the study. Twenty-four individuals were recruited and tested using the same experimental setup as patient cohort 1, and 41 using the same setup as in cohort 2. All controls were assessed by a clinical psychologist using the MINI-KID to rule out presence of any psychiatric disorder or use of any psychotropic medication. One individual recruited to the control group had symptoms of SAD according to the clinical interview, and was therefore excluded. No other participant in the control group had a psychiatric condition according to the clinical assessment. Five participants in the control group were excluded due to a lack of valid data (see *Data collection and processing)*. As can be seen in Table 1, social anxiety levels were significantly higher in children with SAD than in controls in both cohorts, but no group differences were found in number of valid trials, non-verbal cognitive ability, age, or gender proportion. Over 90% of participants in both groups were born in Sweden and had two parents born within the European Union.

Table 2
Comorbid diagnoses and medication in the SAD group ($n = 88$).

Diagnosis	*n*
Attention deficit/hyperactivity disorder (ADHD)	3
Generalized anxiety disorder (GAD)	15
Obsessive compulsive disorder (OCD)	2
Major depressive disorder (MDD)	7
Separation anxiety	2
Specific phobia	13
Drug	
SSRI	5
Ritaline	3
Melatonine	3
Promethazine	1

Ethical approval

The study was approved by the Stockholm regional research ethics committee (decision number 2017/1142-31/4).

Experimental paradigm

Stimuli were images of human adult faces from the Karolinska Directed Emotional Faces dataset (Flykt et al., 1998). The stimulus images were cropped to include only the inner region of the face to prevent participants attention from being drawn to idiosyncratic features outside the core regions of the face, such as hair and outer contour (see Fig. 1). The depicted actors (5 male, 5 female) displayed an angry, happy, or neutral facial expression. Each actor appeared an equal number of times displaying each emotion. The experimental paradigm included 60 trials, equally distributed between two conditions. Trials began with a fixation cross presented on a uniform gray background for 1000 ms before the stimulus image appeared. In 50% of the trials, stimulus images were subsequently presented so that participants' initial point of gaze was within the eye region. In the other 50% of the trials, stimuli were instead presented so that participants' point of gaze was within the mouth. Stimulus images remained on screen for 1500 ms. Participants were asked to attend to the screen, but were not given any further instructions. The stimuli covered approximately 5.6° of the visual field horizontally, and 13.9° vertically.

Data collection and processing

Stimuli were presented on a 17" monitor. Participants were seated at a distance of approximately 60 cm, and were instructed to attend to the stimuli, but not given any other instructions.Stimuli were presented interleaved with stimuli from other experiments, including faces, which are not analyzed here.

Table 1
Demographic information.

	SAD ($n = 88$)		CONTROL ($n = 62$)		
	M (SD)	MIN-MAX	*M* (SD)	MIN-MAX	*P*
Sex (%Female)	77%		75%		.698
Age	14.68 (1.89)	10.00–17.90	14.69 (2.05)	10.30–18.00	.994
CSR	5 (0.97)[1]	4–7	–	–	–
CGI-S	4.65 (0.75)[2]	4–6	–	–	–
LSAS total score	80.50 (28.21) [3]	24–136	19.10 (11.92) [4]	2–47	<.001
SPAI total score	34.52 (7.86)[5]	19.88–49.30	9.26 (8.15)[6]	0–27.93	<.001
Matrix reasoning scaled score	10.45 (2.54)[7]	5–15	10.97 (2.89)	5–18	.263
Valid trials					
Eyes primed	24.18 (4.94)	8–30	24.59 (4.45)	12–30	.601
Mouth primed	21.59 (5.95)	8–30	22.57 (4.66)	10–30	.285

CSR = Clinical Severity Scale; CGI-S = Clinical Global Impression – Severity; LSAS = Liebowitz social anxiety scale; SPAI = Social phobia and anxiety inventory; 1) $n = 62$; 2) $n = 27$; 3) $n = 58$: 4) $n = 40$; 5) $n = 25$; 6) $n = 22$; 5) $n = 78$ to 7) $n = 78$.

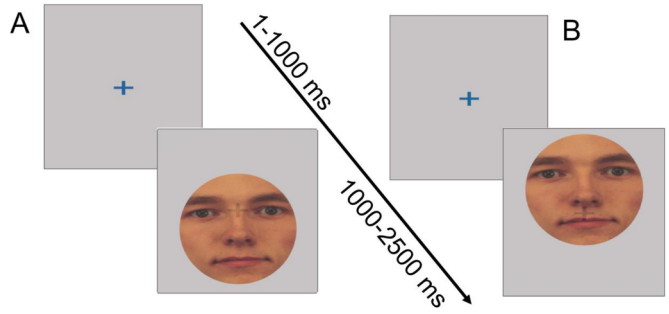

Fig. 1. Overview of the experiment. In 50% of trials (A), a fixation cross presented for 1500 ms was followed by an image of a face with the eyes aligned to the fixation cross. On 50% of the trials (B), the face was instead presented with the mouth in the position of the fixation cross. The position of the fixation cross is shown on the stimulus images for illustrative purposes, but did not remain on screen after the onset of the stimulus images.

Eye tracking data were recorded using a corneal reflection eye tracker at 120 HZ. In cohort 1, a Tobii T120 (Tobii inc, Danderyd, Sweden) system was used. The equipment was changed to a Tobii X3-120 in cohort 2. Fixations were identified using an I-VT filter (Salvucci and Goldberg, 2000) implemented in MATLAB. Gaps in the data shorter than 100 ms were interpolated. After this, the *X*- and *Y*-coordinates were smoothed using a moving average filter with a window size of four samples (~30 ms). Fixations were identified as periods of between-sample velocity below 30°/second for at least 50 ms. Subsequent fixations within 0.5° of the visual field were merged. Participants contributing less than eight valid trials (~25% of the total number of trials) for each primed region (n = 17, 12 with SAD) were excluded. A minimum of eight valid trials was chosen as inclusion criterion in order to balance the risks of excluding valid data and of including potentially invalid recordings. However, results did not change when a range of other limits between 2 and 10 valid trials were applied. No differences in valid trials was observed between groups in any of the conditions (Table 2) or for any of the emotional expressions (all p > .25). Since the saccadic latency data were positively skewed, outlier values defined as >1.5 times the interquartile range (3% of the trials) in each condition were excluded.

Statistical analysis and dependent variables

The dependent variables were 1) the latency to orient to the eyes when primed to the mouth; 2) the latency to orient away from the eyes and to the mouth; 3) the proportion of trials during which a gaze shift to the eyes was registered, when participants were primed to the mouth; and 4) the proportion of trials with a gaze shift to the mouth (i.e., away from the eyes) when the eyes were primed. Trials were discarded if the gaze was not within the primed region when the stimulus image appeared. Preliminary analyses showed that the latency to reorient from the primed region to the non-primed area was highly correlated with the latency to reorient anywhere (r = 0.874; p <.0001), suggesting that first fixations outside the eyes or mouth were very rare. In line with previous studies (e.g. Kliemann et al., 2012) we therefore examined the latency to orient from the primed facial region to the non-primed region, rather than the latency to reorient to any location.

Data were analyzed using linear mixed effects models with random intercepts for individual (equal to treating multiple observations from the same individual as repeated measures) and random slope for condition (the effect of experimental condition nested within individuals). The statistical significance of fixed effects was tested by comparing a model including the effect in question to a model without it using likelihood ratio tests (LRT; Baayen et al., 2008). This approach is more robust to type I and type II errors than traditional analyses of variance (ANOVAs) in experimental data with multiple trials per individual (Baayen et al., 2008). Statistical analyses were conducted in MATLAB version 2019a (Mathworks, Inc.) and R version 3.5.2 (R Development Core Team et al., 2015). The alpha level was set to 0.05. Bonferroni corrected p-values are reported for follow-up tests. Unstandardized effect sizes (*b)* are reported for all reported effects. Differences between categorical variables are expressed as the standard effect size d for mixed effects models, calculated as the difference in estimated marginal means divided by the square root of the pooled variance of the fixed and random effects according to procedures described by Westfall et al. (2014). This effect size is conceptually similar to Cohens d, although the absolute values are typically lower since variance in both fixed and random effects are accounted for.

Power analysis

A power analysis was conducted using the SIMR (Green and Macleod, 2016) package in R version 3.5.2 (R Development Core Team et al., 2015). Based on this power analysis, the study had above 80% power to detect between- and within group effects equivalent to d = 0.3 or higher in the analyses related to the pre-registered hypotheses. This is equal to the effect sizes found in previous meta-analyses of eye tracking studies in child and adolescent anxiety disorders (Lisk et al., 2019).

Results

Preliminary analyses

No main effect of cohort, or interaction effect between cohort and primed region were found in either of the two groups (all p >.25).

Main analyses

Latency to first gaze shifts. Results are shown in Table 3, Fig. 2, and summarized here.

Effects of primed region. Participants shifted their gaze slower from the eyes than from the mouth. This effect was significant in both groups.

Effects of group: A main effect of group was found, driven by slower gaze shifts in the SAD group (χ^2 = 5.70, p = .017). There was also a significant interaction effect between group and primed region (χ^2 = 3.97 p = .046), driven by a stronger effect of primed region in the SAD group (longer relative latencies from the eyes than from the mouth).

Bonferroni corrected follow-up tests were conducted to address the three hypotheses.

Hypothesis 1: Children with SAD and controls did not differ in the latency to *orient* to eyes when primed to the mouth (χ^2 = 0.02, p >.50), contradicting the *vigilance hypothesis* (hypothesis 1).

Hypothesis 2–3: Children with SAD were slower to orient their gaze from eyes than healthy controls (χ^2 = 5.65, p = 0.034), a finding that supports the *delayed disengagement hypothesis* (hypothesis 3), but is the opposite of what would be predicted under the *avoidance hypothesis* (hypothesis 2). In an exploratory analysis, we tested whether the group difference in latency to orient from eyes was modulated by age by adding a fixed effect of age and a group × age interaction to the model. No main effect of age (χ^2 = 2.24, p = .135) or group × age interaction were found (χ^2 = 0.61, p = .435). Further exploratory analyses showed no differences between SAD participants with and without GAD, or with and without depression in latency from eyes (all p >.25).

Effects of emotion. Significant main effects of emotion were found in both conditions. Bonferroni corrected follow-up analyses showed that participants were slower to orient from the mouth to the eyes of happy, compared to neutral or angry faces. They were also faster to orient away from the eyes and towards the mouth of happy compared to neutral and angry faces. No other effects were significant.

Proportion of gaze shifts away from eyes and mouth

Results are shown in Table 4, and summarized here. As can be seen, no main or interaction effects involving group were found. Participants were more likely to shift their gaze from the mouth to the eyes, than vice versa (χ^2 = 314.46, p <.001).There was also a significant effect of

Table 3
Results from mixed effects models of latency to first gaze shift to, and away from eyes.

Effect	χ^2	*P*	*b*	SE	*d*
All trials (eyes or mouth primed)					
Group (SAD > control)	5.70	.017*	32.25	13.40	0.14
Emotion (angry vs. happy vs. neutral)	2.42	.297			
Primed region (Eyes > Mouth)	168.00	<.001***	334.44	19.18	1.41
Group × Primed region	3.97	.046*	76.96	38.36	
Group × Emotion	0.81	.666			
Group × Emotion × Primed region	0.25	.883			
Emotion × Primed region	38.08	<.001***			
Eyes primed condition					
Group (SAD > Control)[a]	5.65	.034*	76.26	31.76	0.25
Emotion (main effect)	19.00	<.001***			
Happy < Neutral[b]	11.58	.003**	60.89	17.07	0.20
Happy < Angry[b]	6.74	.027*	42.39	15.84	0.14
Neutral > Angry[b]	0.79	>.50	14.74	16.10	0.05
Mouth primed condition					
Group[a]	0.02	>.50	−1.82	12.97	0.01
Emotion	21.56	<.001***			
Happy > Neutral[b]	17.50	<.001***,[b]	24.79	5.57	0.20
Happy > Angry[b]	13.67	.003[b]	21.51	5.52	0.17
Angry > Neutral[b]	0.57	>.50[b]	4.35	5.73	0.04

*** p <.001; ** p <.01; * p <.05.
[a] Bonferroni corrected for two comparisons.
[b] Bonferroni corrected for three comparisons.

Table 4
Results from mixed effects models of the proportion of gaze shifts to, and away from eyes.

Effect	χ^2	*P*	*b*	*SE*	*d*
All trials (eyes or mouth primed)					
Group	1.84	.175	0.04	0.03	0.15
Emotion	7.13	.028*			
Primed region	314.46	<.001***	0.30	0.02	1.26
Group × Primed region	1.34	.247	0.04	0.03	
Group × Emotion	0.19	.911			
Group × Emotion × Primed region	0.01	.993			
Emotion × Primed region	16.58	.001**			
Eyes primed condition					
Emotion	33.93	<.001***			
Happy > Neutral‡	32.62	<.001***	0.12	0.02	0.41
Happy >Angry‡	1.84	>.50	0.03	0.02	0.10
Angry > Neutral‡	17.07	<.001***	0.09	0.02	0.34
Mouth primed condition					
Emotion	8.77	.013*	0.03	0.01	0.19
Neutral > Happy‡	6.97	.024*	0.03	0.01	0.20
Angry > Happy‡	4.84	.084	0.03	0.01	0.19
Neutral > Angry‡	0.03	>.50	<0.01	0.01	0.01

‡ Bonferroni corrected for three comparisons; *** p <.001; ** p <.01; * p <.05.

emotion (χ^2 = 7.13, p =.028), and an interaction effect between emotion and primed region (χ^2 = 16.58, p <.001). Follow-up tests showed that gaze shifts from the eyes and towards the mouth were more likely for happy and angry than from neutral faces, with no difference found between happy and angry faces. Gaze shifts from the mouth and towards the eyes were in turn more likely neutral than for happy faces.

Discussion

We tested three competing hypotheses about visual attention to others eyes in children and adolescent SAD in the largest eye- tracking study to date. Treatment-seeking children and adolescents with SAD were slower to reorient from eyes than healthy controls in line with the *delayed disengagement* hypothesis, but contradicting the *avoidance hypothesis*. We did not find evidence for the hypothesis of initial hypervigilance, since children with SAD and healthy controls were equally quick and likely to orient towards eyes. These results are discussed in turn.

Delayed disengagement from eyes in child and adolescent SAD

Our results point to delayed disengagement from eyes as a marker of child and adolescent SAD. As pointed out in the introduction, studies in adults with anxiety disorders have suggested that delayed or impaired disengagement from threat contributes to symptom maintenance (Cisler and Koster, 2011; Fox et al., 2002). Possible underlying mechanisms are inhibited attentional flexibility in the presence of threat,

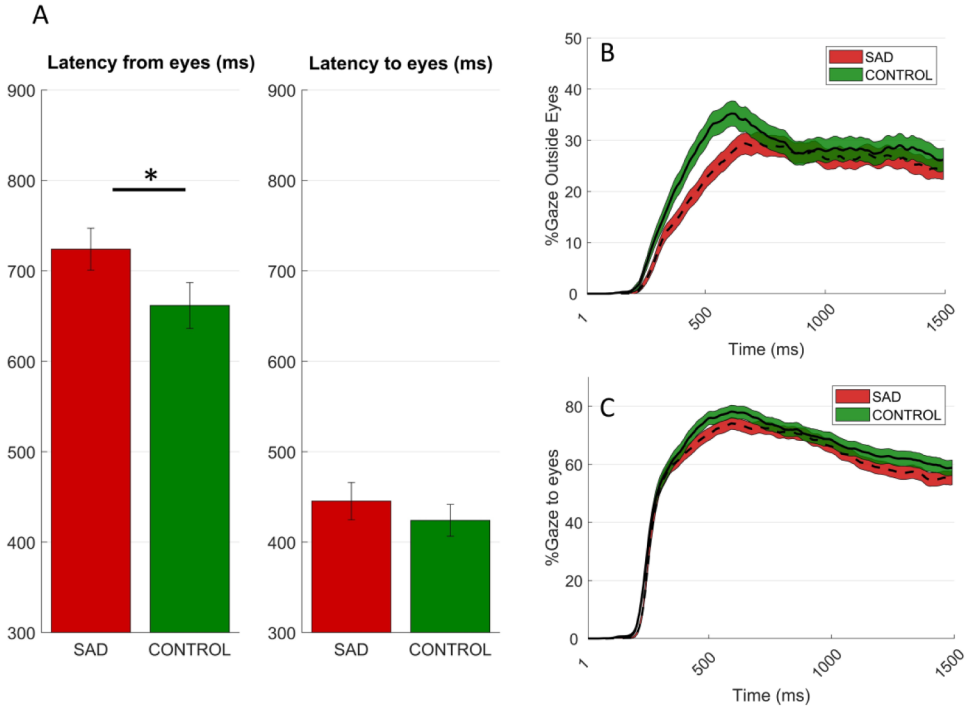

Fig. 2. A. Mean latencies to orient from eyes (left) and to eyes (right) with 95% confidence intervals. B,C. Probability of fixation outside the eyes (eyes primed condition; B) and at the eyes (mouth primed condition; C) as a function of time (ms) in the SAD and control group. Curves show means of all valid gaze points. Shaded areas cover 95% confidence intervals.

or prolonged monitoring of aversive stimuli (Lau and Waters, 2017; Schmidtendorf et al., 2018). Difficulties with attentional disengagement from others eyes could potentially lead to an increase in arousal, that in turn exacerbates negative feelings associated with eye contact and social interaction. It is also possible that prolonged monitoring of other's eyes could cause children with SAD to miss out on other aspects the social environment and thereby lead to social interaction difficulties.

These results are strengthened by the fact that we utilized an experimental paradigm that allowed for independent measures of disengagement and orienting during the earliest stages of the visual scanpath.

The vigilance hypotheses

In contrast to disengagement, *orienting* to eyes (social orienting) was highly typical in children with SAD. Our results do therefore not give support to the vigilance hypothesis, at least not for eyes with direct gaze, a stimulus typically perceived as threatening in SAD (Moukheiber et al., 2010). As noted in the introduction, a number of studies in children found evidence for vigilance towards angry faces when they were presented with other stimuli (Capriola-Hall et al., 2020; Schmidtendorf et al., 2018; Seefeldt et al., 2014; but see Högström et al., 2019). Our study suggest that this pattern of hypervigilance is not characteristic of how children with SAD attend to others eyes.

Two previous studies in adults (Boll et al., 2016) and adolescents (Keil et al., 2018) reported initial hypervigilance for eyes in experimental paradigms that were able to separate the earliest gaze shifts from later aspects of the scanpath. The differences between these results and the present study may be related to age, since our sample was younger. The fact that a typical tendency to orient to eyes was found in SAD can also be contrasted with autism spectrum disorder, which has been linked to atypical social orienting in the other direction – i.e. a reduced tendency to spontaneously seek eye contact (Kleberg et al., 2017; Kliemann et al., 2012).

The lack of evidence for avoidance contradict previous studies in adult samples with SAD (Boll et al., 2016; Horley et al., 2003; Weeks et al., 2013). It should be noted that most studies reporting evidence for avoidance studied attention to eyes during longer presentation times (e.g. Chen et al., 2020). Therefore, while the present study did not find evidence for avoidance of eyes with direct gaze at the time scale studied, it is still possible that avoidance would be seen during extended time periods (Chen and Clarke, 2017; Chen et al., 2015). A limitation of the present study is that patients were only seen after the development of SAD symptoms, meaning that etiological models of SAD (e.g., Rapee and Spence, 2004) could not be directly tested.

In line with adult studies of SAD (e.g. Horley et al., 2003), facial emotion led to similar effects in both groups – i.e. faster orienting to the mouth of happy faces, and to the eyes of angry faces. These effects are commonly found in face perception research, and are likely to be driven by differences in relative salience of these regions between emotions (Fox and Damjanovic, 2006; Rossion, 2009). The lack of group differences in the effects of emotion is consistent with the theory that direct gaze can be an aversive stimulus for children with SAD, independent of emotional expression (e.g. Moukheiber et al., 2010; Weeks et al., 2013).

Child and adolescent SAD is commonly comorbid with other mood and anxiety disorders, and the comorbidity rates in the current study are largely consistent with existing prevalence estimates in clinical populations (Mahommadi et al., 2020). While this suggests that the studied sample was representative, it also means that the results may not be specific for SAD. A limitation is that we were not able to compare children with SAD to groups with other conditions commonly co-occurring with SAD such as depression and other anxiety disorders. Symptoms of the two most common comorbid conditions (GAD and depression) were not related to latency to reorient form the eyes in the present study. However, given the relatively small groups with comorbidity, power in these analyses were low. An additional limitation is that the clinical assessments were conducted using different instruments in the two cohorts.

Future studies are also needed to directly test the relations between the current findings and everyday behavior in more naturalistic setting or in anxiety provoking situations. Finally, it should be noted that more research is needed to determine whether the observed results generalize from treatment-seeking individuals with SAD to the population as a whole.

Despite these limitations, the present study contributes to our understanding by testing influential hypotheses about social attention in SAD in the largest child and adolescent sample to date.

The findings of the present study have potential consequences for everyday behavior of those affected by social anxiety. It is possible that an impaired ability to flexibly shift attention from others' eyes leads to increased anxiety when eye contact is unavoidable. In real life settings, this could contribute to a tendency to avoid situations in which eye contact is likely to occur (Price et al., 2016). Attention training has been attempted as treatment for anxiety disorders, but the efficacy of these approaches is under discussion (Mogg et al., 2017). Our results suggest that training in flexible shifting of attention could be a feasible treatment goal for child and adolescent SAD.

Contributors

Johan Lundin Kleberg, Jens Högström and Eva Serlachius designed the study. Johan Lundin Kleberg analyzed the data and drafted the manuscript. Karin Sundström contributed to data collection. Andreas Frick contributed to the interpretation of results. All authors contributed to and have approved the final manuscript.

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Declaration of Competing Interest

The authors have no conflicts of interest.

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References

Adler, S.A., Orprecio, J., 2006. The eyes have it: visual pop-out in infants and adults. Dev. Sci. 9 (2), 189–206.

Baayen, R. H., Davidson, D. J., & Bates, D. M. (2008). Mixed-Effects Modeling With Crossed Random Effects for Subjects and Items. doi:10.1016/j.jml.2007.12.005.

Bantin, T., Stevens, S., Gerlach, A.L., Hermann, C., 2016. What does the facial dot-probe task tell us about attentional processes in social anxiety? A systematic review. J. Behav. Therapy Exp. Psychiatry 50, 41–50. https://doi.org/10.1016/j.jbtep.2015.04.009.

Bögels, S.M., Mansell, W., 2004. Attention processes in the maintenance and treatment of social phobia: hypervigilance, avoidance and self-focused attention. Clin. Psychol. Rev. 24, 827–856. https://doi.org/10.1016/j.cpr.2004.06.005.

Boll, S., Bartholomaeus, M., Peter, U., Lupke, U., Gamer, M., 2016. Attentional mechanisms of social perception are biased in social phobia. J. Anxiety Disord. 40, 83–93. https://doi.org/10.1016/j.janxdis.2016.04.004.

Capriola-Hall, N.N., Ollendick, T.H., White, S.W., 2020. Gaze as an indicator of selective attention in adolescents with social anxiety disorder. Cognit. Ther. Res. 44 (1), 145–155.
Chen, N.T.M., Thomas, L.M., Joseph, P., Clarke, F., Hickie, I.B., Guastella, A.J., 2015. Hyperscanning and avoidance in social anxiety disorder: The visual scanpath during public speaking. Psychiatry Res. 225, 667–672. https://doi.org/10.1016/j.psychres.2014.11.025.
Chen, N.T.M., Clarke, P.J.F., 2017. Gaze-based assessments of vigilance and avoidance in social anxiety: a review. Curr. Psychiatry Rep. 19 (59). https://doi.org/10.1007/s11920-017-0808-4.
Chen, J., Van Den Bos, E., Westenberg, P.M., 2020. A systematic review of visual avoidance of faces in socially anxious individuals: Influence of severity, type of social situation, and development. J. Anxiety Disord. https://doi.org/10.1016/j.janxdis.2020.102193.
Cisler, J.M, Koster, E.H.W., 2010. Mechanisms of attentional biases towards threat in anxiety disorder: An integrative review. Clin. Psychol. Rev. 30 (2), 203–216. https://doi.org/10.1016/j.cpr.2009.11.003.
Dudeney, J., Sharpe, L., Hunt, C., 2015. Attentional bias towards threatening stimuli in children with anxiety: a meta-analysis. Clin. Psychol. Rev. 40, 66–75.
Emery, N.J., 2000. The eyes have it: The neuroethology, function and evolution of social gaze. Neurosci. Biobehav. Rev. 24 (6), 581–604. https://doi.org/10.1016/S0149-7634(00)00025-7.
Flykt, A., Lundqvist, D., Flykt, A., Öhman, A., 1998. The Karolinska Directed Emotional Faces (KDEF). CD ROM from Department of Clinical Neuroscience, Psychology Section, Karolinska Institutet.
Fox, E., Damjanovic, L., 2006. The eyes are sufficient to produce a threat superiority effect. Emotion 6 (3), 534–539. https://doi.org/10.1037/1528-3542.6.3.534.
Fox, E., Russo, R., Dutton, K., 2002. Attentional bias for threat: Evidence for delayed disengagement from emotional faces. Cognit. Emot. 16 (3), 355–379. https://doi.org/10.1080/02699930143000527.
Frick, A., Howner, K., Fischer, H., Kristiansson, M., Furmark, T., 2013. Altered fusiform connectivity during processing of fearful faces in social anxiety disorder. Transl. Psychiatry 3. https://doi.org/10.1038/tp.2013.85.
Fu, X., & Pérez-Edgar, K. (2018). Threat-Related Attention Bias in Socioemotional Development: A Critical Review and Methodological Considerations. doi:10.1016/j.dr.2018.11.002.
Gentili, C., Cristea, I.A., Angstadt, M., Klumpp, H., Tozzi, L., Phan, L., Pietrini, P., 2016. Beyond emotions: A meta-analysis of neural response within face processing system in social anxiety. Exp. Biol. Med. 241, 225–237. https://doi.org/10.1177/1535370215603514.
Green, P., Macleod, C.J., 2016. SIMR: An R package for power analysis of generalized linear mixed models by simulation. Methods Ecol. Evol. 7 (4), 493–498. https://doi.org/10.1111/2041-210X.12504.
Heeren, A., Mcnally, R.J., 2016. An integrative network approach to social anxiety disorder: The complex dynamic interplay among attentional bias for threat, attentional control, and symptoms. J. Anxiety Disord. 42, 95–104. https://doi.org/10.1016/j.janxdis.2016.06.009.
Henderson, H.A., Pine, D.S., Fox, N.A., 2015. Behavioral inhibition and developmental risk: a dual-processing perspective. Neuropsychopharmacology 40, 207–224. https://doi.org/10.1038/npp.2014.189.
Hietanen, J.K., 2018. Affective eye contact: An integrative review. Front. Psychol. https://doi.org/10.3389/fpsyg.2018.01587. Frontiers Media S.A.
Högström, J., Nordh, M., Larson Lindal, M., Taylor, E., Serlachius, E., Lundin Kleberg, J., 2019. Visual attention to emotional faces in adolescents with social anxiety disorder receiving cognitive behavioral therapy. PloS One 14 (11), e0225603. https://doi.org/10.1371/journal.pone.0225603.
Holmes, E.A., Ghaderi, A., Harmer, C.J., Ramchandani, P.G., Cuijpers, P., Morrison, A.P., … Craske, M.G., 2018. The Lancet Psychiatry Commission on psychological treatments research in tomorrow's science Executive summary Background. Lancet Psychiatry 5 Retrieved from. https://www.nvgzp.nl/wp-content/uploads/2018/03/The-Lancet-Psychiatry-Commission-on-psychological.pdf.
Horley, K., Williams, L.M., Gonsalvez, C., Gordon, E., 2003. Social phobics do not see eye to eye: A visual scanpath study of emotional expression processing. J. Anxiety Disord. 17, 33–44.
Hudson, J.L., Rapee, R.M., Lyneham, H.J., McLellan, L.F., Wuthrich, V.M., Schniering, C.A., 2015. Comparing outcomes for children with different anxiety disorders following cognitive behavioural therapy. Behav. Res. Ther. 72, 30–37. https://doi.org/10.1016/j.brat.2015.06.007.
Itier, R.J., Batty, M., 2009. Neural bases of eye and gaze processing: The core of social cognition. Neurosci. Biobehav. Rev. 33 (6), 843–863. https://doi.org/10.1016/j.neubiorev.2009.02.004.
Keil, V., Hepach, R., Vierrath, S., Caffier, D., Tuschen-Caffier, B., Klein, C., Schmitz, J., 2018. Children with social anxiety disorder show blunted pupillary reactivity and altered eye contact processing in response to emotional faces: Insights from pupillometry and eye movements. J. Anxiety Disord. 58 (December 2017), 61–69. https://doi.org/10.1016/j.janxdis.2018.07.001.
Kleberg, J.L., del Bianco, T., Falck-Ytter, T., 2018. How infants' arousal influences their visual search. Child Dev. https://doi.org/10.1111/cdev.13198.
Kleberg, J.L., Hanqvist, C., Serlachius, E., Högström, J., 2019. Pupil dilation to emotional expressions in adolescent social anxiety disorder is related to treatment outcome. J. Anxiety Disord. https://doi.org/10.1016/J.JANXDIS.2019.04.006.
Kleberg, J.L., Högström, J., Nord, M., Bölte, S., Serlachius, E., Falck-Ytter, T., 2017. Autistic traits and symptoms of social anxiety are differentially related to attention to others' eyes in social anxiety disorder. J. Autism Dev. Dis. 47 (12), 3814–3821. https://doi.org/10.1007/s10803-016-2978-z.
Kliemann, D., Dziobek, I., Hatri, A., Baudewig, J., Heekeren, H.R., 2012. The role of the amygdala in atypical gaze on emotional faces in autism spectrum disorders. J. Neurosci. 32 (28), 9469–9476. https://doi.org/10.1523/JNEUROSCI.5294-11.2012.
Lau, J.Y.F., Waters, A.M., 2017. Annual Research Review: An expanded account of information-processing mechanisms in risk for child and adolescent anxiety and depression. J. Child Psychol. Psychiatry Allied Discip. 58 (4), 387–407. https://doi.org/10.1111/jcpp.12653.
Lisk, S., Vaswani, A., Linetzky, M., Bar-Haim, Y., Lau, J.Y.F., 2019. Systematic review and meta-analysis: eye-tracking of attention to threat in child and adolescent anxiety. J. Am. Acad. Child Adolesc. Psychiatry. https://doi.org/10.1016/j.jaac.2019.06.006.
Masia-Warner, C., Storch, E.A., Pincus, D.B., Klein, R.G., Heimberg, R.G., Liebowitz, M.R., 2003. The Liebowitz social anxiety scale for children and adolescents: an initial psychometric investigation. J. Am. Acad. Child Adolesc. Psychiatry 42 (9), 1076–1084.
Mohammadi, M.R., Salehi, M., Khaleghi, A., Hooshyari, Z., Mostafavi, S.A., Ahmadi, N., Amanat, M., 2020. Social anxiety disorder among children and adolescents: A nationwide survey of prevalence, socio-demographic characteristics, risk factors and co-morbidities. J. Affect. Disord. 263, 450–457.
Mogg, K., Waters, A.M., Bradley, B.P., 2017. Attention bias modification (ABM): review of effects of multisession ABM training on anxiety and threat-related attention in high-anxious individuals. Clin. Psychol. Sci. 5 (4), 698–717. https://doi.org/10.1177/2167702617696359.
Moukheiber, A., Rautureau, G., Perez-Diaz, F., Soussignan, R., Phanie Dubal, S., Jouvent, R., Pelissolo, A., 2010. Gaze avoidance in social phobia: Objective measure and correlates. Behav. Res. Ther. 48, 147–151. https://doi.org/10.1016/j.brat.2009.09.012.
Mueller, E.M., Hofmann, S.G., Santesso, D.L., Meuret, A.E., Bitran, S., Pizzagalli, D.A., 2009. Electrophysiological evidence of attentional biases in social anxiety disorder. Psychol. Med. 39 (7), 1141–1152. https://doi.org/10.1017/S0033291708004820.
Nemrodov, D., Anderson, T., Preston, F.F., Itier, R.J., 2014. Early sensitivity for eyes within faces: A new neuronal account of holistic and featural processing. NeuroImage 97, 81–94. https://doi.org/10.1016/j.neuroimage.2014.04.042.
Price, R.B., Allen, K.B., Silk, J.S., Ladouceur, C.D., Ryan, N.D., Dahl, R.E., … Siegle, G.J., 2016. Vigilance in the laboratory predicts avoidance in the real world: A dimensional analysis of neural, behavioral, and ecological momentary data in anxious youth. Dev. Cognit. Neurosci. 19, 128–136. https://doi.org/10.1016/j.dcn.2016.03.001.
R Development Core Team, R Development Core Team, (R), & Team, R. D. C, 2015. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna, Austria Retrieved from. http://www.r-project.org.
Rapee, R.M., Heimberg, R.G., 1997. A cognitive-behavioral model of anxiety in social phobia. Behav. Res. Ther. 35 (8), 741–756.
Rapee, R.M., Spence, S.H., 2004. The etiology of social phobia : Empirical evidence and an initial model. Clin. Psychol. Rev. 24, 737–767. https://doi.org/10.1016/j.cpr.2004.06.004.
Rossion, B., 2009. Distinguishing the cause and consequence of face inversion: The perceptual field hypothesis. Acta Psychol. 132, 300–312. https://doi.org/10.1016/j.actpsy.2009.08.002.
Salemink, E., Van Den Hout, M.A., Kindt, M., 2007. Selective attention and threat: Quick orienting versus slow disengagement and two versions of the dot probe task. Behav. Res. Ther. 45, 607–615. https://doi.org/10.1016/j.brat.2006.04.004.
Salvucci, D.D., Goldberg, J.H., 2000. Identifying fixations and saccades in eye-tracking protocols. In: Proceedings of the Eye Tracking Research and Applications Symposium. ACM Press, New York.
Sato, W., Kochiyama, T., Uono, S., Toichi, M., 2016. Neural mechanisms underlying conscious and unconscious attentional shifts triggered by eye gaze. NeuroImage 124, 118–126. https://doi.org/10.1016/j.neuroimage.2015.08.061.
Schmidtendorf, S., Wiedau, S., Asbrand, J., Tuschen-caffier, B., Heinrichs, N., 2018. Attentional bias in children with social anxiety disorder. Cognit. Therapy Res. 42 (3), 273–288. https://doi.org/10.1007/s10608-017-9880-7.
Schneier, F.R., Rodebaugh, T.L., Blanco, C., Lewin, H., Liebowitz, M.R., 2011. Fear and avoidance of eye contact in social anxiety disorder. Comprehens. Psychiatry 52, 81–87. https://doi.org/10.1016/j.comppsych.2010.04.006.
Schulze, L., Renneberg, B., Lobmaier, J.S., 2013. Gaze perception in social anxiety and social anxiety disorder. Front. Hum. Neurosci. 7, 872. https://doi.org/10.3389/fnhum.2013.00872.
Schwab, D., Schienle, A., 2017. Facial affect processing in social anxiety disorder with early onset: evidence of an intensity amplification bias. Soc. Neurosci. 13 (3), 1–10. https://doi.org/10.1080/17470919.2017.1304990.
Seefeldt, W.L., Krämer, M., Tuschen-Caffier, B., Heinrichs, N., 2014. Hypervigilance and avoidance in visual attention in children with social phobia. J. Behav. Ther. Exp. Psychiatry 45, 105–112. https://doi.org/10.1016/j.jbtep.2013.09.004.
Senju, A., Johnson, M.H., 2009. The eye contact effect: mechanisms and development. Trends Cognit. Sci. 1311 (133), 127–134.
Sheehan, D.V, Sheehan, K.H., Shytle, R.D., Janavs, J., Bannon, Y., Rogers, J.E., … Wilkinson, B., 2010. Reliability and validity of the mini international neuropsychiatric interview for children and adolescents (MINI-KID). J. Clin. Psychiatry 71 (3), 313–326. https://doi.org/10.4088/JCP.09m05305whi.
Silverman, W. (1996). Anxiety Disorders Interview Schedule for DSM-IV.: Parent Interview Schedule.
Spezio, M. L., Huang, P.-Y. S., Castelli, F., & Adolphs, R. (2007). Brief Communications Amygdala Damage Impairs Eye Contact During Conversations with Real People. doi:10.1523/JNEUROSCI.3789-06.2007.
Stein, M.B., Stein, D.J., 2008. Social anxiety disorder. The Lancet 371, 1115–1125. https://doi.org/10.1016/S0140-6736(08)60488-2.
Thorell, L.B., Bohlin, G., Rydell, A.-M., 2004. Two types of inhibitory control: Predictive relations to social functioning. Int. J. Behav. Dev. 28 (3), 193–203. https://doi.org/10.1080/01650250344000389.

Wechsler, D., 2008. Wechsler Adult Intelligence Scale, 4th. Pearson Assessment, San Antonio, TX.
Wechsler, D., 2014. Wechsler Intelligence Scale for Children, 5th. NCS Pearson, San Antonio, TX.
Weeks, J.W., Howell, A.N., Goldin, P.R., 2013. Gaze avoidance in social anxiety disorder. Depress. Anxiety 30 (8), 749–756. https://doi.org/10.1002/da.22146.
Westfall, J., Kenny, D.A., Judd, C.M., 2014. Statistical power and optimal design in experiments in which samples of participants respond to samples of stimuli. J. Exp. Psychol.: Gen. 143 (5), 2020–2045. https://doi.org/10.1037/xge0000014.
White, L.K., McDermott, J.M., Degnan, K.A., Henderson, H.A., Fox, N.A., 2011. Behavioral inhibition and anxiety: the moderating roles of inhibitory control and attention shifting. J. Abnorm. Child Psychol. 39, 735–747. https://doi.org/10.1007/s10802-011-9490-x.
Wong, Q.J.J., Rapee, R.M., 2016. The aetiology and maintenance of social anxiety disorder: A synthesis of complementary theoretical models and formulation of a new integrated model. J. Affect. Disord. 203, 84–100. https://doi.org/10.1016/j.jad.2016.05.069.