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ORIGINAL ARTICLE

Gaze as an Indicator of Selective Attention in Adolescents with Social Anxiety Disorder

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Abstract

Attention bias, conceptualized to be involved in the development and maintenance of SAD, may differentiate teens with SAD from those without. Although SAD typically emerges during adolescence, eye-tracking research has not explicitly focused on biased attention in adolescents with SAD relative to healthy controls, using stimuli specifically developed for adolescents, thus prompting the rationale for the present study. Youth with SAD were quicker to fixate their gaze on angry faces and maintained their gaze longer toward both angry and neutral faces. Findings suggest that socially anxious teenagers demonstrate bias, relative to teens without SAD. The bias is marked by shortened latency to fixate on angry faces. Additionally, given that the adolescents with SAD also exhibited longer initial fixation duration to both angry and neutral faces, relative to controls, these results suggest the possibility of heightened reactivity to social stimuli regardless of emotional valence. Alternatively, it may be the case, that youth with SAD perceive neutral faces as threatening. Given the role attention bias plays in the etiology and maintenance of SAD, better understanding of the cognitive processes which underlie the disorder is warranted. The current study offers initial findings for informing treatment for adolescents with the condition.

Keywords Social anxiety disorder · Eye-tracking · Attention bias · Overt attention

Social anxiety disorder (SAD) is characterized by irrational and persistent fears of potential evaluation by others. Individuals with SAD often report excessive fear of negative evaluation and embarrassment when engaging in social or performance situations (e.g., eating in front of others, giving oral reports, joining in on a conversation, performing a sport). This fear often results in significant impairment, which may give rise to behavioral avoidance of social situations (APA 2013). Typically, SAD onsets during the teenage years (Spence and Rapee 2016), likely due to increased social demands (van den Bos et al. 2014; Westenberg et al. 2007), greater time spent with peers (Blöte et al. 2015), and heightened sensitivity to peer relationships and potential negative evaluation from peers (Blöte et al. 2015). Adolescents with SAD engage in frequent social comparison and are often vigilant to what others may be thinking about them. The cognitive processes underlying the developmentally normative increase in social fears during adolescence as well as the conditions under which these fears progress into a disorder for some, but not others, are not well understood. One candidate process is heightened attention to social threat, termed 'attention bias.'

Biased attentional processes have been implicated in the etiology and maintenance of anxiety disorders (Armstrong and Olatunji, 2012; Bar-Haim et al. 2007; Matthews and MacLeod 2002). Anxious people are often characterized by hypervigilance to threat and decreased ability to disengage attention from stimuli that are perceived as threatening, thus contributing to the onset and maintenance of their anxiety symptoms (Cisler and Koster 2010). From a theoretical perspective, focus on the initial stimulus presentation is important since attending selectively to threat leads one to overestimate the likelihood and imminence of harm (In-Albon et al. 2010) which likely prohibits subsequent attention to disconfirming or non-threatening stimuli. Hypervigilance to

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stimuli perceived as threatening has been most often studied through use of the dot probe which has served as a means to assess covert attention (i.e., shifts in attention without examining accompanying eye movements) in adults (Bradley et al. 2000). The typical pattern observed in anxious adults compared to non-anxious adults is quicker reaction times to prompts immediately following the presentation of angry faces (Bar-Haim et al. 2007). These attention biases have not, however, been uniformly observed in children and adolescents (Bar-Haim et al. 2007; Dudeney et al. 2015) and effects are frequently smaller relative to those obtained with adults (Dudeney et al. 2015). As noted by several researchers (e.g., Shechner et al. 2013), there are limitations of the dot probe. Broadly speaking, there is uncertainty regarding the psychometric properties of the dot probe, confusion as to what it precisely measures (e.g., overt vs covert attention; initial orienting vs disengagement), and lack of demonstrated sensitivity in its ability to detect change in attention bias (Price et al. 2019). Further, there are specific limitations for the use of the dot probe to examine biased attention within pediatric samples including the use of reaction times obtained via manual responses which limit the delineation of biases in initial orientation from subsequent disengagement or maintenance of attention (Armstrong and Olatunji 2012). As commented on previously by Shechner et al. (2013), the inference of attention biases through motor responses might vary across development. The use of gaze-tracking technology provides a direct means to study fixation patterns (i.e., how individuals overtly orient their attention to visual stimuli) and can serve as a complement to reaction time measures to measure attentional biases to socially threatening stimuli.

For adults, eye-tracking studies have demonstrated that social anxiety is related to attention toward threat cues, as well as greater difficulty disengaging attention from them (e.g., Armstrong and Olatunji 2012; Gamble and Rapee 2010; Schofield et al. 2012). In addition, Shechner et al. (2013) found that generally anxious youth (ages 8–17) were quicker to fixate during early exposure to angry, relative to neutral, faces compared to non-anxious youth. These findings suggest attentional bias toward threat is present during the earliest stages of stimulus exposure and is capable of being assessed by gaze tracking.

Although youth with an anxiety diagnosis broadly exhibit selective attention to threatening social stimuli, the direction of attention allocation is inconsistent, with some generally anxious youth demonstrating heightened attention towards angry faces and others demonstrating attention away from angry faces (Shechner et al. 2012). This may be a result of experimental paradigms using adult facial stimuli. Research suggests that children and adolescents demonstrate differential brain activation (Hoehl et al. 2010; Marusak et al. 2013) to adult versus adolescent affective stimuli. Scherf and Scott (2012) demonstrated that youth exhibit an overall processing bias toward same-age faces compared to adult faces, and youth have been found to be slower to respond to adult faces compared to child faces (Benoit et al. 2007; Gamble and Rapee 2009). Collectively, this research suggests that using same-age face stimuli may be useful to assess attention bias in socially anxious youth.

Recent eye-tracking studies have not found evidence for a group difference (anxious vs control) in initial hypervigilance to threat during the earliest stages of stimulus exposure in children (Dodd et al. 2015; Seefeldt et al. 2014). Dodd et al. (2015) reported that neither preschool aged children with or without an anxiety disorder (not specific to SAD) demonstrated initial hypervigilance towards angry faces relative to neutral faces. Further, the length of first fixation (i.e., initial maintenance of attention) towards angry faces over neutral faces did not differ significantly. Further, findings reported by Schmidtendorf et al. (2018) suggest that children (ages 9–13) with SAD, as well as non-anxious controls, fixated on angry faces more frequently than either group did to neutral faces. During induction of social threat, however, children with SAD demonstrated preferential visual attention directed towards angry faces relative to neutral faces during initial stimulus exposure. In addition, in a sample of youth (ages 9–14) with and without an anxiety disorder (i.e., not specific to SAD), eye-tracking indices (i.e., initial visual fixation and increased dwell time) of biased attention to fearful faces was associated with disturbed sleep patterns (Ricketts et al. 2018).

In sum, eye-tracking studies which report on attention bias in anxious child and adolescent samples are inconsistent in their findings. These inconsistencies could be a function of the sample composition variability; most prior studies have used non-clinical samples with high levels of anxiety, community samples, or pre-adolescent highly anxious (but not SAD) samples. All of these factors potentially limit our understanding of potential diagnosis-specific manifestations of biased attention allocation to threat in adolescents diagnosed with SAD, thus prompting our theoretical interest in and the empirical basis for the present study. To our knowledge, this study is the first of its kind which focuses on diagnosis specific manifestations of aberrant visual attention in adolescents with SAD, relative to a control group, through the use of adolescent facial stimuli.

In the present study, we sought to determine if adolescents with SAD, relative to non-anxious adolescents, would show selective attention towards socially threatening faces (e.g., angry) relative to neutral faces, as assessed by gaze patterns. Initial orienting to threat (i.e., hypervigilance) and subsequent maintenance of initial attention towards angry faces are considered indices of bias. As such, we focus explicitly on attention to angry faces

Table 1 Participant characteristics (n = 50)

	SAD ($n = 25$) Mean (SD)	Control ($n = 25$) Mean (SD)	t
Age (in years)	13.88 (1.17)	13.56 (1.45)	.86
SCARED—SAD Subscale	9.67 (3.91)	2.89 (2.30)	7.34*
SCARED—GAD Subscale	10.21 (5.73)	3.48 (3.06)	5.10*
SCARED-SEP Subscale	3.96 (2.56)	1.68 (2.08)	3.43*
SCARED-Panic or significant somatic symptoms Subscale	8.17 (5.46)	1.40 (1.47)	5.87*
SCARED-School Avoidance Subscale	2.67 (2.08)	.56 (.71)	4.79*
SCARED-Total Anxiety	34.67 (16.16)	10.00 (6.83)	6.91*
	n (% of total)	n (% of total)	x^2
Sex			
Male	9 (36.00)	10 (40.00)	.09
Female	16 (64.00)	15 (60.00)	
Race			
Caucasian	21 (84.00)	21 (84.00)	.86
Non-caucasian			
Other	0 (0.00)	3 (12.00)	
African American	2 (8.00)	1 (4.00)	
Hispanic	2 (8.00)	0 (0.00)	
Youth Prescribed Medication	1 (4.00)	NA	
Diagnoses		NA	
GAD	12 (48.00)		
ADHD-I	2 (8.00)		
ADHD-C	1 (4.00)		
MDD	3 (12.00)		
SEP	2 (8.00)		
SP	3 (12.00)		

Significant between-group differences are indicated by *($p < .01$)

NA not available for sample

Diagnoses based on ADIS-IV: *GAD* generalized anxiety disorder, *ADHD-I* attention deficit/hyperactivity disorder-primarily inattentive presentation, *ADHD-C* attention deficit/hyperactivity disorder-combined presentation, *MDD* major depressive disorder, *SEP* separation anxiety disorder, *SP* specific phobia

given this has been the most common stimuli used to assess social threat within the extant literature (Torrence and Troup 2018). We hypothesized that adolescents with SAD, relative to non-anxious controls, would demonstrate a shorter latency and more frequent first fixations toward angry relative to competing neutral faces during initial stimulus presentation, defined as initial hypervigilance to threat (Cisler and Koster 2010; Dodd et al. 2015; Schmidtendorf et al. 2018). We also hypothesized that adolescents with SAD, relative to non-anxious controls, would demonstrate longer dwell time toward the initially fixated angry faces compared to the initially fixated neutral faces which was conceptualized as maintenance of selective attention towards threat associated with SAD (Cisler and Koster 2010; Dodd et al. 2015; Schmidtendorf et al. 2018).

Method

Participants

The sample was comprised of two groups: treatment-seeking adolescents ($n = 25$; M age = 13.88 years; 64% female) with a diagnosis of SAD and non-anxious controls ($n = 25$; M age = 13.56 years; 60% female). All participants were between the ages of 12–16. Demographic information is presented in Table 1. There were no differences in sex ($x^2 = .09$, $p = .500$, phi = − .04) or age ($t = .861$ $p = .395$, Cohen's $d = .24$) between the two groups.

SAD Group

Adolescents met for a current diagnosis of SAD, per criteria outlined in the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition* (DSM-5; APA 2013) and met the following inclusion criteria: (a) average or above cognitive functioning (Full Scale IQ score ≥ 85), as the treatment for the SAD group required substantial cognitive processing (Britton et al. 2013); (b) if prescribed psychiatric medication ($n = 1$, prescribed anti-depressant), stable dosage of at least 4 weeks was required; and (c) not currently receiving psychological treatment for anxiety concerns. Participants who met criteria for an autism spectrum disorder, childhood schizophrenia, and/or psychopathology that warranted more immediate clinical care (i.e., suicidal intent) were excluded.

Control Group

Although cognitive ability was not formally assessed for the control group, parents of participants were asked during the telephone screener if their child has ever received a school classification or clinical diagnosis of intellectual disability. No parents endorsed that their children had a diagnosis of intellectual disability or mental retardation. Inclusion criteria included: (a) absence of psychiatric problems as determined by parent report on the initial telephone screener, and (b) absence of SA symptoms as assessed by a total score < 25 and < 8 on the social anxiety subscale of the Screen for Child Anxiety Related Disorders, Child Version (SCARED; Birmaher et al. 1997).

Procedure

The study was approved by the university's institutional review board for human subject research. All parents provided informed consent and youth gave assent prior to beginning the study. Participants were recruited through the psychology department's child participant database, university-affiliated clinics, pediatricians and family physicians, and advertisements in the community. Participants received a small payment for their time investment.

SAD Group

Adolescents with SAD were recruited as part of a larger NIMH-funded treatment outcome study (Ollendick et al. 2019). Upon contact, potential participants' parents completed a brief phone screen in order to determine initial eligibility. Following the phone screen, eligible families within the SAD group were invited to participate in a two-part pre-treatment assessment session within the lab. Parents and adolescents within the SAD group completed a clinical intake which consisted of a semi-structured clinical interview (described in further detail below), a test of cognitive ability (described in further detail below), the eye-tracking task, and a battery of questionnaires (e.g., SCARED; Birmaher et al. 1997).

Control Group

Upon contact, potential participants' parents completed a brief phone screen in order to determine initial eligibility. Following the phone screen, eligible families within the control group were invited to participate in a single assessment session. Control participants completed the same questionnaires (e.g., SCARED) and the same eye-tracking task as the SAD group.

Measures

Anxiety Disorders Interview Schedule for DSM-IV-Child and Parent Versions (ADIS-IV-C/P; Silverman and Albano 1996)

The ADIS-IV-C/P is a semi-structured diagnostic interview designed to assess anxiety and related disorders in childhood and adolescence. Trained and research-reliable clinicians, supervised by a licensed clinical psychologist, assigned a severity rating (CSR) on a 9-point scale (0–8, with any rating ≥ 4 indicating diagnostic presence) on both the child and parent interviews. Psychometric properties of the ADIS-IV-C/P are good (Silverman et al. 2001). Training on the ADIS-IV-C/P consisted of a workshop, practice interviews, and observation of administration conducted by a reliable clinician. Inter-rater agreement on the CSR score was high; across the child and parent interviews, agreement (i.e., CSR within one point of each other) was 94% and 100%, respectively.

Wechsler Abbreviated Scale of Intelligence, Second Edition (WASI-II; Wechsler 2011)

The WASI-II provides an estimate of cognitive ability. A trained clinician administered the two-subtest form to participants within the SAD group in order to derive a Full Scale IQ score (FSIQ). The four-subtest and two-subtest WASI-II scores correlate highly for youth 12 to 17 (Wechsler 2011). The two-subtests demonstrate strong reliability and validity (Wechsler 2011).

Screen for Child Anxiety Related Disorders, Child and Parent Version (SCARED; Birmaher et al. 1997)

The SCARED is a measure used to assess various facets of anxiety in youth. The SCARED consists of 41-items and yields scores for Panic Disorder, Generalized Anxiety,

Separation Anxiety, Social Anxiety, and School Avoidance, in addition to a Total Score. The test–retest reliability, internal consistency, and discriminant validity are well-established (Birmaher et al. 1997). In the current sample, internal consistency was good for both the SAD group ($\alpha = 0.94$) and the control group ($\alpha = 0.86$) for the SCARED total score.

Apparatus and Stimuli

Eye-tracking was completed using a Tobii T60 XL eye-tracker. Participants were seated at about 66 cm from the 18" monitor. In order to ensure gaze was detected, the eye-tracking system was calibrated for both eyes. The eye-tracker's calibration system was set to 0.5 degrees of accuracy with less than 0.3 degrees of visual drift. The five-point calibration procedure involved tracking a moving red circle located at five predefined locations. Participants were prompted to freely look at the stimuli (i.e., passive viewing) while keeping their head still. This paradigm allows for the examination of both vigilance towards threat and initial maintenance of attention towards threat (Armstrong and Olatunji 2012; Dodd et al. 2015).

Face stimuli were color photographs derived from the National Institute for Mental Health (NIMH) Child Emotional Faces Picture Set (NIMH-ChEFS; Egger et al. 2011), which consists solely of adolescent faces. All nonfacial features (e.g., background and clothing) were removed from the images and images were digitally standardized for consistency in size and luminescence (see Coffman et al. 2015). Each face was presented in an equally sized oval shape (each face 19.05 cm long × 16.51 cm wide, with 11.43 cm of grey space between the two faces, all subtending 37° visual angle) against a grey background. Each trial consisted of a pair of photographs of the same actor or actress, with one photo depicting an angry face and the other depicting a neutral facial expression. This methodology is consistent with previous social anxiety eye-tracking research (e.g., Garner et al. 2006; Schmidtendorf et al. 2018; Wieser et al. 2009) which posits that attentional biases are more likely to occur when more than one stimulus is competing for attention (In-Albon et al. 2010). Equal numbers of male and female faces were presented (i.e., eight different face-pairs), and the side of the screen depicting the emotional expression was counterbalanced across the stimuli set. Regarding the duration of stimulus presentation, a centered X (36 cm long by 36 cm wide) was presented for one second, immediately followed by a face-pair. The face-pair was shown for 3 s. After the face-pair, a gray screen was presented for 500 ms.

Using Tobii Studio, fixation metrics were calculated from the available raw eye movement data. The data were processed and quantified using an in-house MATLAB code. To be included in the analyses, a fixation had to be at least 100 ms in duration (Gamble and Rapee 2009; Shechner et al. 2013). Fixation data were excluded for off-task trials (i.e., when the participant was not gazing at the screen and/or the eye-tracker was not able to capture gaze). At the trial level, fixation data were excluded if less than the pre-determined 50% validity threshold for tracking across stimuli was determined. Consistent with the approach by Garner et al. (2006), trials were excluded if the participant did not center their visual attention on the centered "X" presented before the presentation of the paired stimuli, as determined by inspection of the raw data.

In order to examine potential bias in initial orientation to social stimuli, we used multiple indices of attentional bias (i.e., latency, first fixation direction, and duration for first fixation). Consistent with prior research (Garner et al. 2006), bias was defined as greater visual attention towards angry faces during initial stimulus presentation. Dwell time for first fixation, which has been used in past eye-tracking studies to assess disengagement and/or maintenance of attention (Buckner et al. 2010; Dodd et al. 2015; Garner et al. 2006), was also calculated.

Data Analyses

Analyses were conducted in IBM SPSS Statistics Version 24.0. Descriptive statistics are provided in Table 1. Following assessment for normality and influential outliers, values were Winsorized to the level of the individual trial (i.e., relative to each individual's mean RT; Kuckertz and Amir 2015; Price et al. 2015). First, preliminary analyses determined whether fixation patterns were associated with age, race, medication usage, subscales from the SCARED, and sex. Significant predictors were included as covariates in the analyses. Three gaze metrics were calculated as indicators of bias: latency (i.e., time to first fixation on angry face region); probabilities of first fixation direction (i.e., number of trials gaze was first directed to angry face divided by total number of trials with eye movements to angry-neutral face pairs); and duration of first fixation on the angry face (i.e., duration of gaze on the initially fixated angry face before a shift in gaze away from it). Latency to fixate gaze towards neutral faces and duration of first fixation to the neutral face (i.e., duration of gaze on the initially fixated neutral face before a shift in gaze away from it) were also calculated. All gaze metrics were averaged across the task's trials as suggested by Shechner et al. (2013). Bivariate correlations for the primary study variables are included in Table 2.

A one-way multivariate analysis of variance (MANOVA) was used to examine group differences in the specified attention bias metrics between adolescents with SAD and the control group. Group was the independent variable and the indices of attention bias (i.e., first fixation direction

Table 2 Bivariate correlations

	2	3	4	5	6
1. Average latency to fixate on angry face	.48*	− .08	− .03	− .30*	− .49*
2. Average latency to fixate on neutral face	–	− .18	− .18	.30*	− .17
3. Fixation duration for first fixation to angry face	–	–	.87*	− .28*	.33*
4. Fixation duration for first fixation to neutral face	–	–	–	− .09	.24
5. Direction of first fixation toward angry face	–	–	–	–	− .05
6. SCARED	–	–	–	–	–

SCARED social anxiety scale total

*$p < .05$

Table 3 Means and standard deviations for attention bias variables by group

	SAD group (n = 25), M (SD)	Control group (n = 25), M (SD)	t (p)	d
Direction of first fixation toward angry face	.54 (.135)	.52 (.088)	.89 (.378)	.18
Latency to first fixation to angry face (ms)	443.44 (118.10)	639.70 (159.08)	4.95 (< .001)	1.40
Fixation duration for first fixation to angry face (ms)	618.36 (207.30)	425.71 (237.35)	3.05 (.004)	.86
Direction of first fixation toward neutral face	.46 (.14)	.48 (.09)	.89 (.378)	.18
Latency to first fixation to neutral face (ms)	578.05 (155.95)	688.70 (242.77)	2.86 (.006)	.54
Fixation duration for first fixation to neutral face (ms)	611.45 (173.20)	430.74 (263.96)	2.86 (.006)	.81

proportions towards angry faces,[1] latency to fixate on angry faces, latency to fixate on neutral faces, and fixation duration for first fixation with angry and neutral trials being calculated separately) were the dependent variables.

Results

Following winsorizing of two data values (two control participants for the latency to fixate on angry faces), skewness and kurtosis for all primary variables were within acceptable ranges, and visual inspection of the data distribution indicated no concerns with non-normality. Descriptive statistics for the sample's demographic variables and questionnaire measures are available in Table 1. Group level differences in participant age, race, and sex were statistically non-significant (Table 1). Neither sex, medication, nor age were related to gaze. As such, primary analyses were conducted without demographic covariates. All SAD and control participants were successfully calibrated for the eye-tracking task, meaning that the tracker detected gaze within all five predefined areas. There were no significant differences in the amount of data used for analyses between groups, $t(48) = .80$, $p = .431$, $d = .23$, suggesting data loss was not systematic based on group. Further, there was not a significant group difference in number of trials during which participants did not fixate on the centered "X" before stimulus onset, $t(48) = 1.13$, $p = .265$, $d = .32$. Descriptive statistics for the bias metrics are available in Table 3. The Box's M test of equality of covariance matrices was significant demonstrating that the model assumption of homogeneity of covariances was indeed violated. Given the violation, Pillai's trace was used to evaluate whether there were statistically significant differences among the groups on the linear combination of the dependent variables given that it is more robust and not linked to assumptions about the normality of the data (Tabachnick and Fidell 2007).

There was a statistically significant group difference between the SAD and control groups on the combined dependent variables, Pillai's Trace = .49, $F(5,43) = 8.33$, $p < .001$, $\eta_p^2 = .49$. When the dependent variables were considered separately, the univariate *F*-tests showed significant differences between groups for latency to first fixate on the angry face, $F(1,49) = 24.53$, $p < .001$, $\eta_p^2 = .34$, duration of first fixation to angry face, $F(1,49) = 9.30$, $p = .004$, $\eta_p^2 = .16$, and duration of first fixation to neutral face, $F(1,49) = 8.19$, $p = .006$, $\eta_p^2 = .15$ (see Fig. 1). For latency to fixate on the angry face, an inspection of the mean scores indicated that the SAD group was quicker to fixate (i.e., shorter latency) toward angry faces relative to the control group. There was

[1] Given that first fixation direction toward angry faces was expressed as a proportion (i.e., number of trials gaze was first directed to angry face *divided* by total number of trials with eye movements to angry-neutral face pairs) which equaled 100%, there was no need to enter first fixation direction proportion to neutral faces given that the proportion was calculated with this percentage already included (i.e., exclusion of redundant information because derived from other variable retained in the data set). .

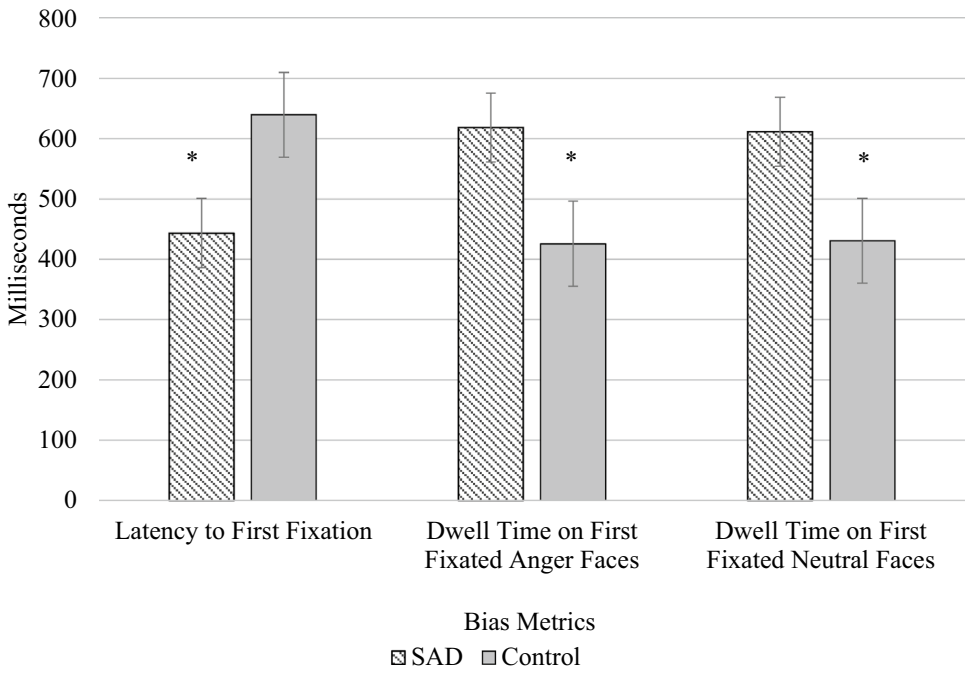

Fig. 1 Group differences in bias metrics. An asterisk indicates significant between-group difference

no group level difference for latency to fixate on the neutral face. For duration of first fixation to the angry face, the SAD group looked longer at the angry face relative to the control group. Furthermore, for duration of first fixation to the neutral face was longer for the SAD group relative to the control group. Regarding first fixation direction, the SAD group did not demonstrate a significantly greater percentage of first fixations towards angry faces relative to the control group, $F(1,49) = .792$, $p = .378$, $\eta_p^2 = .02$. Percentage of first fixations to the angry face was greater than chance (50%) for both groups (Table 3).

Discussion

To our knowledge, this is the first study to examine attention bias using eye-tracking in adolescents with and without SAD. All three calculated gaze metrics were conceptualized as indices of attentional preference. Our hypotheses were partially supported. We found a significant between group difference in average latency to fixate on angry faces as well as in duration of initial fixation to angry faces. However, there was not a significant difference in percentage of first fixations to angry faces, indicating that those with SAD were not more likely to fixate to angry faces, when angry was paired with neutral, than those without SAD. Both groups tended to fixate to angry more than neutral faces. In addition, there was a group level difference in duration of initial fixation to neutral faces, suggesting that for youth with SAD attention was also sustained to the neutral face if it was the target of initial attention allocation.

Similar to research by Shechner et al. (2013) which demonstrated between group differences in initial attention towards threat within a sample of 18 anxious and 15 non anxious teenagers, our findings indicate attention bias towards threat during initial stimulus presentation for anxious youth. Specifically, youth with SAD were quicker to fixate to angry faces, relative to neutral faces, compared to non-anxious controls. As such, findings from the present study are consistent with prior research indicating that attention bias toward threat is present early during stimulus exposure (Gamble and Rapee 2009; Shechner et al. 2013). However, not all studies have found evidence for bias using eye-tracking. Dodd et al. (2015) and Seefeldt et al. (2014), with anxious and SAD samples of children ($n = 73$), found that the anxious youth did not demonstrate significant differences in initial hypervigilance to threat during earliest stages of stimulus exposure relative to controls. Findings within the present study were also partially inconsistent to those reported by Schmidtendorf et al. (2018) who reported that children with SAD ($n = 37$) demonstrated preferential visual attention directed towards angry faces relative to neutral faces during initial stimulus exposure only after stress induction. Differences in latency to angry faces, as noted in the present study, could be a function of the sample composition given that the aforementioned samples did not focus on diagnosis specific manifestations of biased attention allocation to threat within adolescents diagnosed with SAD.

Our results are especially important since SAD typically onsets during adolescence (Spence and Rapee 2016).

From a theoretical perspective, these findings suggest that relative to non-anxious controls, adolescents with SAD demonstrate atypical involuntary attention within the context of a perceived threatening context. In light of the aforementioned inconsistencies in attention bias studies within anxious youth and the uncertain landscape of attention bias modification treatment (ABMT) studies (Dudeney et al. 2015), integration of gaze tracking to monitor attention bias might be successfully implemented into bias modification protocols. For example, efficacy trials for gaze contingent ABMT protocols show promising results. These studies posit that biased attention can be trained successfully through the use of gaze contingencies (e.g., cues are provided based on participant's eye position). Specifically, findings by Lazarov et al. (2017) demonstrated reductions in SAD symptoms and dwell time on socially threatening faces following a randomized control trial of gaze contingent music reward therapy for adults with SAD.

The present study's findings also indicate that initial maintenance of attention towards angry faces was sustained for adolescents in the SAD group. Specifically, the SAD group looked longer to the first fixated angry faces relative to the control group. As such, the SAD attentional pattern was characterized by both selective processing coupled with maintenance of gaze, the latter of which might be suggestive of sustained attention or possibly deficits in inhibition (see Posner and Petersen 1990; Armstrong and Olatunji 2012). One interpretation of these findings could be that the negative emotionality associated with possible evaluation may capture and sustain the attention of adolescents with SAD, making it more difficult to disengage gaze from socially threatening faces. There may be a developmental process for the deployment of attention biases in SAD, although longitudinal studies have not yet examined the course of bias in relation to anxiety. We note that this pattern was not observed by Shechner et al. (2013) who found that anxious youth did not sustain their attention towards angry faces. Although we cannot account for these differences, differences in sample composition may play a role; the Shechner et al. sample was comprised of youth with multiple anxiety diagnoses (e.g., GAD) whereas our sample was restricted to youth with SAD as the primary disorder.

Inconsistent with our hypothesis, results from the present study suggested that adolescents with SAD also demonstrated longer duration of initial maintenance of attention to neutral faces, if it was the target of initial attention allocation. Our findings are partially consistent to those reported by Dodd et al. (2015) who found that preschool aged anxious children ($n = 37$) did not demonstrate significant differences in their initial maintenance of attention to angry over neutral faces. However, in our study, the effect of group (adolescents with SAD vs controls) was significant.

Regarding group level differences for duration of first fixation to neutral faces, one potential explanation for this finding is that the adolescents with SAD interpreted the neutral face as threatening. From a cognitive-motivational framework, anxiety affects the participant's reactivity of the 'valence evaluation system' which results in ambiguous cues being readily appraised as threatening, therefore affecting subsequent allocation of attention (Cooney et al. 2006; Dodd et al. 2015) and perhaps resulting in increased visual attention relative to controls. As reported by Cooney et al. (2006) neutral stimuli are disproportionately interpreted as threatening within the context of SAD relative to control participants. As such, our findings might be indicative of neutral stimuli being perceived as more threatening for participants with SAD versus controls. This explanation is, of course, speculative, and further research is needed given that our study is one of two studies within the child and adolescent anxiety eye-tracking literature which currently report on initial maintenance of attention. As argued by Dodd et al. (2015), perhaps the free viewing paradigm, as used in the current study, was not ideal methodologically for the measurement of potential disengagement of attention. Thus, a more sophisticated gaze tracking paradigm which requires participants to rapidly disengage and shift away their attention will be especially important for future research. Contrary to our hypothesis, results reported for length of first fixation (i.e., initial maintenance of attention) are not indicative of 'attention bias' given that the pattern of attention observed in the present study applied to socially threatening as well as to neutral faces. Bias would imply differential attention based on the emotional value of the stimulus. Another hypothesis for these seemingly paradoxical findings could that for adolescents with SAD, the lack of differences between angry and neutral faces in length of initial maintenance of attention is indicative of heightened social reactivity, thus resulting in increased attention allocation during these longer temporal stages for social stimuli, regardless of emotional content. Thus, social reactivity might be mistaken as 'biased attention'. This interpretation is of course speculative as we did not assess social reactivity within the current study. This finding clearly warrants further replication.

As noted, to our knowledge, this is the first study to examine attention bias via eye-tracking in adolescents with SAD. Our findings indicate that teens with SAD are both faster to orient and fixate longer on socially threatening stimuli. However, they may not be more prone to direct their attention to threat, over neutral, faces initially. These findings support a pattern of attention allocation marked by vigilance in initial orientation and sustained vigilance over time; however, this sustained vigilance was not unique to angry faces.

Limitations, Implications, and Future Directions

Given the nature of our sample (e.g., Caucasian sample with moderate to high socioeconomic status), these results might not readily generalize to other samples. Another noteworthy limitation is that the sample size was relatively small. Further, biased attention has been reported for individuals with other anxiety disorders (in addition to SAD), and therefore, the comorbid psychiatric disorders in our sample (i.e., other anxiety disorders, attention deficit hyperactivity disorder) may have influenced our findings. While the majority of the SAD adolescents presented with at least one comorbid anxiety disorder, the primary presenting concern was always social anxiety. Future research should include a clinical control group with a primary anxiety-related condition other than SAD. Additionally, the present study did not include a clinical interview or a test of cognitive ability for the control group which might affect the study's findings. Still, all youth in the control group completed the SCARED and were below clinical threshold on the social anxiety subscales as well as on reported total anxiety level which suggests that they were unlikely to meet diagnostic criteria for an anxiety disorder. Further, the control group's reported scores on the anxiety subscales as well as on reported total anxiety level was comparable to mean level scores reported in past studies of healthy comparison samples (Rappaport et al. 2017). Future research should include more rigorous phenotyping of the control sample including both a clinical interview and test of cognitive ability in the battery for both groups. Data loss was due primarily to technical problems associated with the eye-tracking task, which is a limitation in the current study as well as in eye-tracking research more generally (Staugaard and Rosenberg 2011; Wieckowski and White 2017). Data loss is a common occurrence in eye-tracking work among both adolescents and clinical groups (e.g., Louwerse et al. 2013; Staugaard and Rosenberg 2011; White et al. 2015), although many studies do not report on rates or ranges of typical data loss.

It is also possible that the stimuli used in the study were insufficiently potent to evoke socio-evaluative fear. For example, Garner et al. (2006) included a social stress induction, telling participants that they would be videotaped while giving a speech after the eye-tracking task. The current study did not include such a manipulation of social-evaluative stress. Future research should evaluate the associations between attention bias through use of dynamic stimuli and or social stress induction tasks which are often more ecologically valid and representative of real word social interactions within a sample of adolescents with SAD (Garner et al. 2011; Schmidtendorf et al. 2018; Weeks et al. 2013). Future research should also solicit valence and arousal ratings rather than assuming that neutral faces are genuinely non-threatening (e.g., Eack et al. 2014; Tottenham et al. 2014) which is especially important given our findings demonstrated that both anger and neutral faces were associated with sustained visual processing for the SAD group relative to the control group. As noted by Egger et al. (2011), most of the actors included as part of the NIMH-ChEFS stimulus set were Caucasian. Future research should determine whether these findings replicate with the use of more racially and ethnically diverse stimuli. It is important to note that given the stimulus set used in our study, we were not able to explore whether utilization of disgust stimuli as opposed to anger stimuli would have resulted in different outcomes. Since disgust has also been found to be associated with attention in social anxiety (e.g., Amir et al. 2010; Buckner et al. 2010), further exploration of this socially threatening emotion within the context of biased attention in SAD is clearly warranted.

Despite these limitations, this study used a well-characterized SAD sample as well as a carefully matched, non-anxious control sample. Use of adolescent faces, as was done in this study, may be critical to sorting out the biases evidenced in youth with SAD. Although speculative, it might be the case that some youth with SAD are more reactive to adult facial stimuli (e.g., look of criticism, disapproval) whereas others are more sensitive to the social responses of peers (e.g., social rejection). Such possibilities are intriguing and await further inquiry.

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Compliance with Ethical Standards

Conflict of Interest Nicole N. Capriola-Hall, Thomas H. Ollendick and Susan W. White declare that they have no conflict of interest.

Ethics Approval All procedures performed in this study were in accordance with the ethical standards of the overseeing Institutional Review Board and with the 1964 Helsinki declaration and its later amendments.

Informed Consent All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (national and institutional). Informed consent was obtained from all individual subjects participating in the study.

Human and Animal Rights All institutional and national guidelines for the care and use of laboratory animals were followed.

References

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC: American Psychiatric Association.

Amir, N., Najmi, S., Bomyea, J., & Burns, M. (2010). Disgust and anger in social anxiety. *International Journal of Cognitive Therapy, 3,* 3–10.

Armstrong, T., & Olatunji, B. O. (2012). Eye tracking of attention in the affective disorders: A meta-analytic review and synthesis. *Clinical Psychology Review, 32,* 704–723.

Bar-Haim, Y., Lamy, D., Pergamin, L., Bakermans-Kranenburg, M. J., & Van Ijzendoorn, M. H. (2007). Threat-related attentional bias in anxious and nonanxious individuals: A meta-analytic study. *Psychological Bulletin, 133,* 1–24.

Benoit, K. E., McNally, R. J., Rapee, R. M., Gamble, A. L., & Wiseman, A. L. (2007). Processing of emotional faces in children and adolescents with anxiety disorders. *Behaviour Change, 24,* 183–194.

Birmaher, B., Khetarpal, S., Brent, D., Cully, M., Balach, L., Kaufman, J., et al. (1997). The Screen for Child Anxiety Related Emotional Disorders (SCARED): Scale construction and psychometric characteristics. *Journal of the American Academy of Child and Adolescent Psychiatry, 36,* 545–553.

Blöte, A. W., Miers, A. C., Heyne, D. A., & Westenberg, P. M. (2015). Social anxiety and the school environment of adolescents. *Social anxiety and phobia in adolescents* (pp. 151–180). Cham: Springer.

Bradley, B. P., Mogg, K., & Millar, N. H. (2000). Covert and overt orienting of attention to emotional faces in anxiety. *Cognition and Emotion, 14,* 789–808.

Britton, J. C., Bar-Haim, Y., Clementi, M. A., Sankin, L. S., Chen, G., Shechner, T.,… & Pine, D. S. (2013). Training-associated changes and stability of attention bias in youth: implications for attention bias modification treatment for pediatric anxiety. *Developmental Cognitive Neuroscience*, *4*, 52–64.

Buckner, J. D., Maner, J. K., & Schmidt, N. B. (2010). Difficulty disengaging attention from social threat in social anxiety. *Cognitive Therapy and Research, 34,* 99–105.

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

Coffman, M. C., Trubanova, A., Richey, J. A., White, S. W., Kim-Spoon, J., Ollendick, T. H., et al. (2015). Validation of the NIMH-ChEFS adolescent face stimulus set in an adolescent, parent, and health professional sample. *International Journal of Methods in Psychiatric Research, 24,* 275–286.

Cooney, R. E., Atlas, L. Y., Joormann, J., Eugène, F., & Gotlib, I. H. (2006). Amygdala activation in the processing of neutral faces in social anxiety disorder: Is neutral really neutral? *Psychiatry Research: Neuroimaging*, *148*, 55–59.

Dodd, H. F., Hudson, J. L., Williams, T., Morris, T., Lazarus, R. S., & Byrow, Y. (2015). Anxiety and attentional bias in preschool-aged children: An eyetracking study. *Journal of Abnormal Child Psychology, 43,* 1055–1065.

Dudeney, J., Sharpe, L., & Hunt, C. (2015). Attentional bias towards threatening stimuli in children with anxiety: A meta-analysis. *Clinical Psychology Review, 40,* 66–75.

Eack, S. M., Mazefsky, C. A., & Minshew, N. J. (2014). Misinterpretation of facial expressions of emotion in verbal adults with autism spectrum disorder. *Autism, 19,* 308–315.

Egger, H. L., Pine, D. S., Nelson, E., Leibenluft, E., Ernst, M., Towbin, K. E., et al. (2011). The NIMH Child Emotional Faces Picture Set (NIMH-ChEFS): A new set of children's facial emotion stimuli. *International Journal of Methods in Psychiatric Research, 20,* 145–156.

Gamble, A. L., & Rapee, R. M. (2009). The time-course of attentional bias in anxious children and adolescents. *Journal of Anxiety Disorders, 23,* 841–847.

Gamble, A. L., & Rapee, R. M. (2010). The time-course of attention to emotional faces in social phobia. *Journal of Behavior Therapy and Experimental Psychiatry, 41,* 39–44.

Garner, M., Clarke, G., Graystone, H., & Baldwin, D. S. (2011). Defensive startle response to emotional social cues in social anxiety. *Psychiatry Research, 186,* 150–152.

Garner, M., Mogg, K., & Bradley, B. P. (2006). Orienting and maintenance of gaze to facial expressions in social anxiety. *Journal of Abnormal Psychology, 115,* 760–770.

Hoehl, S., Brauer, J., Brasse, G., Striano, T., & Friederici, A. D. (2010). Children's processing of emotions expressed by peers and adults: An fMRI study. *Social Neuroscience, 5,* 543–559.

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

Kuckertz, J. M., & Amir, N. (2015). Attention bias modification for anxiety and phobias: Current status and future directions. *Current Psychiatry Reports, 17,* 9.

Lazarov, A., Pine, D. S., & Bar-Haim, Y. (2017). Gaze-contingent music reward therapy for social anxiety disorder: A randomized controlled trial. *American Journal of Psychiatry, 174,* 649–656.

Louwerse, A., Van Der Geest, J. N., Tulen, J. H. M., van der Ende, J., Van Gool, A. R., Verhulst, F. C., et al. (2013). Effects of eye gaze directions of facial images on looking behaviour and autonomic responses in adolescents with autism spectrum disorders. *Research in Autism Spectrum Disorders, 7,* 1043–1053.

Marusak, H. A., Carré, J. M., & Thomason, M. E. (2013). The stimuli drive the response: An fMRI study of youth processing adult or child emotional face stimuli. *NeuroImage, 83,* 679–689.

Matthews, A., & MacLeod, C. (2002). Induced processing biases have causal effects on anxiety. *Cognition and Emotion, 16,* 331–354.

Ollendick, T. H., White, S. W., Richey, J., Kim-Spoon, J., Ryan, S. M., Wieckowski, A. T., ... & Smith, M. (2019). Attention bias modification treatment for adolescents with social anxiety disorder. *Behavior Therapy, 50*, 126–139.

Posner, M., & Petersen, S. (1990). The attention system of the human brain. *Annual Review Neuroscience, 13,* 25–42.

Price, R. B., Brown, V., & Siegle, G. J. (2019). Computational modeling applied to the dot-probe task yields improved reliability and mechanistic insights. *Biological Psychiatry, 85,* 606–612.

Price, R. B., Kuckertz, J. M., Siegle, G. J., Ladouceur, C. D., Silk, J. S., Ryan, N. D.,… & Amir, N. (2015). Empirical recommendations for improving the stability of the dot-probe task in clinical research. *Psychological Assessment*, *27*, 365–376.

Rappaport, B. I., Pagliaccio, D., Pine, D. S., Klein, D. N., & Jarcho, J. M. (2017). Discriminant validity, diagnostic utility, and parent-child agreement on the Screen for Child Anxiety Related Emotional Disorders (SCARED) in treatment-and non-treatment-seeking youth. *Journal of Anxiety Disorders, 51,* 22–31.

Ricketts, E. J., Price, R. B., Siegle, G. J., Silk, J. S., Forbes, E. E., Ladouceur, C. D.,… & McMakin, D. L. (2018). Vigilant attention to threat, sleep patterns, and anxiety in peripubertal youth. *Journal of Child Psychology and Psychiatry*, *59*, 1309–1322.

Scherf, K. S., & Scott, L. S. (2012). Connecting developmental trajectories: Biases in face processing from infancy to adulthood. *Developmental Psychobiology, 54,* 643–663.

Schmidtendorf, S., Wiedau, S., Asbrand, J., Tuschen-Caffier, B., & Heinrichs, N. (2018). Attentional bias in children with social anxiety disorder. *Cognitive Therapy and Research, 42,* 273–288.

Schofield, C. A., Johnson, A. L., Inhoff, A. W., & Coles, M. E. (2012). Social anxiety and difficulty disengaging threat: Evidence from eye-tracking. *Cognition and Emotion, 26,* 300–311.

Seefeldt, W. L., Krämer, M., Tuschen-Caffier, B., & Heinrichs, N. (2014). Hypervigilance and avoidance in visual attention in children with social phobia. *Journal of Behavior Therapy and Experimental Psychiatry, 45,* 105–112.

Shechner, T., Britton, J. C., Pérez-Edgar, K., Bar-Haim, Y., Ernst, M., Fox, N. A., et al. (2012). Attention biases, anxiety, and development: Toward or away from threats or rewards? *Depression and Anxiety, 29,* 282–294.

Shechner, T., Jarcho, J. M., Britton, J. C., Leibenluft, E., Pine, D. S., & Nelson, E. E. (2013). Attention bias of anxious youth during extended exposure of emotional face pairs: An eye-tracking study. *Depression and Anxiety, 30,* 14–21.

Silverman, W. K., & Albano, A. M. (1996). *Anxiety disorders interview schedule for DSM-IV (child and parent versions)*. San Antonio, TX: Psychological Corporation.

Silverman, W. K., Saavedra, L. M., & Pina, A. A. (2001). Test-retest reliability of anxiety symptoms and diagnoses with the anxiety disorders interview schedule for DSM-IV: Child and parent versions. *Journal of the American Academy of Child and Adolescent Psychiatry, 40,* 937–944.

Spence, S. H., & Rapee, R. M. (2016). The etiology of social anxiety disorder: An evidence-based model. *Behaviour Research and Therapy, 86,* 50–67.

Staugaard, S. R., & Rosenberg, N. K. (2011). Processing of emotional faces in social phobia. *Mental Illness, 3,* 14–20.

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics*. Boston: Allyn & Bacon/Pearson Education.

Torrence, R. D., & Troup, L. J. (2018). Event-related potentials of attentional bias toward faces in the dot-probe task: A systematic review. *Psychophysiology, 55,* e13051.

Tottenham, N., Hertzig, M. E., Gillespie-Lynch, K., Gilhooly, T., Millner, A. J., & Casey, B. J. (2014). Elevated amygdala response to faces and gaze aversion in autism spectrum disorder. *Social Cognitive and Affective Neuroscience, 9,* 106–117.

van den Bos, E., De Rooij, M., Miers, A. C., Bokhorst, C. L., & Westenberg, P. M. (2014). Adolescents' increasing stress response to social evaluation: Pubertal effects on cortisol and alpha-amylase during public speaking. *Child Development, 85,* 220–236.

Wechsler, D. (2011). *WASI-II: wechsler abbreviated scale of intelligence* (2nd ed.). London: Pearson.

Weeks, J. W., Howell, A. N., & Goldin, P. R. (2013). Gaze avoidance in social anxiety disorder. *Depression and Anxiety, 30,* 749–756.

Westenberg, P. M., Gullone, E., Bokhorst, C. L., Heyne, D. A., & King, N. (2007). Social evaluation fear in childhood and adolescence: Normative developmental course and continuity of individual differences. *British Journal of Developmental Psychology, 25,* 471–483.

White, S. W., Maddox, B., & Panneton, R. (2015). Fear of negative evaluation influences eye gaze in adolescents with Autism Spectrum Disorder: A pilot study. *Journal of Autism and Developmental Disorders*, *45*, 3446–3457.

Wieckowski, A. T., & White, S. W. (2017). Eye-gaze analysis of facial emotion recognition and expression in adolescents with ASD. *Journal of Clinical Child & Adolescent Psychology, 46,* 110–124.

Wieser, M. J., Pauli, P., Weyers, P., Alpers, G. W., & Mühlberger, A. (2009). Fear of negative evaluation and the hypervigilance-avoidance hypothesis: An eye-tracking study. *Journal of Neural Transmission, 116,* 717–723.