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SI: EMOTION REGULATION AND PSYCHIATRIC COMORBIDITY IN ASD

Fear of Negative Evaluation Influences Eye Gaze in Adolescents with Autism Spectrum Disorder: A Pilot Study

Susan W. White · Brenna B. Maddox · Robin K. Panneton

Abstract Social anxiety is common among adolescents with Autism Spectrum Disorder (ASD). In this modest-sized pilot study, we examined the relationship between social worries and gaze patterns to static social stimuli in adolescents with ASD ($n = 15$) and gender-matched adolescents without ASD (control; $n = 18$). Among cognitively unimpaired adolescents with ASD, self-reported fear of negative evaluation predicted greater gaze duration to social threat cues (i.e., faces depicting disgust and anger). By comparison, there was no relationship between self-reported social fears and gaze duration in the controls. These findings call attention to the potential import of the impact of co-occurring psychopathology such as social anxiety, and particularly fear of negative evaluation, on social attention and cognition with adolescents who have ASD.

Keywords Autism · Social anxiety · Eye gaze · Adolescent · Fear

Introduction

It is estimated that almost half of children and adolescents who have Autism Spectrum Disorder (ASD) also struggle with anxiety that is problematic and impairing (van Steensel et al. 2011; White et al. 2009). Social anxiety, in particular, is common among adolescents on the spectrum (Kuusikko et al. 2008; Leyfer et al. 2006; Simonoff et al. 2008). The rate of co-occurrence is markedly higher than that seen in typically developing (non-ASD, or 'TD') adolescents, for whom the lifetime prevalence of Social Anxiety Disorder (SAD) is 9.1 % (Merikangas et al. 2010). Understanding the etiology, manifestation, and course of social anxiety in the context of ASD has clinical and scientific import. When present in a young person with ASD, social anxiety can intensify core social impairment (Bal et al. 2010; Kleinhans et al. 2010), and there is a growing body of work supporting the efficacy of psychosocial treatment for anxiety (including social anxiety) in adolescents with ASD (White et al. 2013). Symptom overlap between social anxiety and ASD, most often in the physical (e.g., physiological hyperarousal) and behavioral (e.g., avoiding eye contact, refusal to join peers) domains, can complicate accurate differential diagnosis. The cognitive component (e.g., fear of being judged negatively) may be a critical point of distinction in fractionating these two disorders. The purpose of this study was to explore the relationship between cognitions associated with social anxiety, namely fear of negative evaluation, and eye gaze in a sample of adolescents with ASD.

Understanding if, and how, socially anxious cognitions influence social attending and information processing in ASD may inform differential diagnosis of the two conditions (SAD and ASD), as well as treatment development. Perhaps adolescents with ASD who are fearful of being judged negatively by other people find social stimuli aversive, more so than do people with ASD who do not have socio-evaluative fears. As such, they might avert gaze more quickly from social stimuli. Alternatively, it is possible that fear of negative evaluation heightens attention to potential threat in the social environment, leading to

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increased gaze. Examination of the relationship between socially anxious cognitions and eye gaze toward social stimuli in adolescents with ASD may help us better understand the degree to which social anxiety affects social attention and selection. We propose that fear of negative evaluation may play a role in social orienting and allocation of attention among adolescents with ASD.

There is considerable convergence in the clinical presentation of young people with ASD and those with SAD. They share, in many cases, severe social problems (Inderbitzen-Nolan et al. 2007), alexithymia (Evren and Evren 2007), social avoidance, isolation, and loneliness (Beidel and Turner 2007; White and Roberson-Nay 2009). Despite these manifest similarities, these two disorders are arguably quite dissimilar with respect to their underlying mechanisms. Difficulty inferring others' points of view and interpreting others' behavioral intentions (Baron-Cohen 1995) are often considered hallmark features of ASD. Such difficulties may contribute to social avoidance if, for instance, the young person with ASD finds others' behavior confusing and, sometimes, frightening (Baron-Cohen 2008). In contrast, individuals with social anxiety often continuously (almost obsessively) engage in social comparison, ever-vigilant to what others may be thinking. Such individuals also tend to make negative assumptions and interpretations about others' evaluations and judgments of them (Cartwright-Hatton et al. 2005; Muris et al. 2000). Given this critical point of divergence in awareness and concern about others' judgments of self, it may be surprising that so many youth with ASD do in fact present with what we consider to be social anxiety symptoms (for full review of differential diagnosis see White et al. 2014).

Adolescence is an especially important developmental phase in which to study the influence of socially anxious cognitions in people with ASD, especially given that SAD tends to onset during the teenage years (Rapee and Spence 2004). For TD and ASD teens alike, adolescence is characterized by increased fear of negative social evaluation, in the context of decreases in non-social fears (Westenberg et al. 2007). In youth with ASD, social anxiety may be especially common among those without co-occurring intellectual disability (Bellini 2004; Kuusikko et al. 2008), emerging as the social milieu becomes more complex and the youth's awareness of his/her social differences comes to the forefront (White and Roberson-Nay 2009). There is little research, however, on the presence of age-normative social concerns or the socio-evaluative fears that characterize SAD in adolescents who have ASD (Kreiser and White 2014).

Phenomenologically, social anxiety comprises three related symptom clusters: behavioral, physical, and cognitive (see Mesa et al. 2011). With respect to the first domain, behavioral avoidance, lack of peer relationships, and abnormal social approach are among the diagnostic criteria for ASD (APA 2013). With regard to the second symptom domain, there is evidence that social anxiety, especially physiological reactivity, may influence social attending and information processing in ASD. Dalton et al. (2005), for instance, found that gaze fixation was significantly, positively related to amygdala activation in adolescent males with ASD, and hypothesized that direct eye gaze leads to heightened emotion resulting from attending to social stimuli. Joseph et al. (2008), in a study of face recognition and autonomic arousal in children and adolescents with ASD, found that autonomic reactivity to direct eye gaze was negatively correlated with facial recognition in children with ASD. In the only published study, to the authors' knowledge, to directly assess social anxiety and eye-gaze in ASD, greater levels of self-reported social anxiety symptoms predicted poorer fear recognition and less gaze toward the eye region in static facial stimuli among adults with ASD (Corden et al. 2008). However, there is no published research on the effects of SAD-specific cognitions, namely co-occurring fear of negative evaluation and social worries (Levinson and Rodebaugh 2012; Rapee and Heimberg 1997), on social attending in adolescents with ASD. Socio-evaluative cognitions would likely influence how one interprets heightened reactivity and, perhaps, lead to differential attending to social cues based on perceived threat or hostility of the cue.

Individuals with social anxiety, like those with ASD, tend to avoid direct eye contact (Garner et al. 2006; Hobson and Lee 1998; Jones et al. 2008; Pelphrey et al. 2002). It should be noted, however, that some studies have found no evidence for decreased visual attending to social stimuli in adults with ASD (Sawyer et al. 2011). There is also evidence for a temporal effect of social anxiety on gaze patterns in TD people, characterized by initial vigilance to socially threatening information, followed by disengagement or avoidance. Garner et al. (2006), for example, found that socially anxious adults oriented more quickly to emotional faces than to calm faces, and were also quicker to disengage from them, compared to non-socially anxious people. Gaze tracking research with ASD samples has not yet explored such temporal effects. Examination of the potential influence of social anxiety, and in particular anxious cognitions, on social attending behavior over time may help explain apparently contradictory findings in the extant research.

In this preliminary investigation, we examined the relationship between socially anxious cognitions, namely fear of negative evaluation and social worry, and gaze patterns in adolescents with and without ASD. Based on extant eye-tracking research on gaze patterns toward social stimuli, it is reasonable to expect that ASD severity would predict shorter gaze duration to social stimuli regardless of emotional

valence (e.g., Klin et al. 2002), or possibly that there would be no effect of ASD on gaze toward static social stimuli (e.g., Sawyer et al. 2011). Fear of negative evaluation (social anxiety), on the other hand, may be associated with longer gaze duration, especially brief presentations of potentially threatening social stimuli (e.g., Armstrong and Olatunji 2012). Given the pilot nature of this study, however, no specific, directional hypotheses were made regarding gaze duration by adolescents with ASD and social anxiety.

With respect to emotional valence, it was anticipated that facial expressions of disgust would have the strongest associations with social anxiety regardless of group membership (ASD, Control). Although anger is often considered a highly salient negative emotion, disgust is likely perceived as more negative or aversive by socially anxious people because it is associated with negative social evaluation or judgment (e.g., the teen interprets 'disgust' in another as evidence that s/he is incompetent or repulsive; Amir et al. 2005; Amir et al. 2010). If a relationship between gaze toward disgust cues, in comparison to anger, and fear of negative evaluation in ASD were to be seen, this could indicate a specific bias toward potential social threat. Additionally, to explore possible differences between adolescents with ASD and the Controls in their attention toward and disengagement from threatening social stimuli, gaze was examined over the course of socially threatening presentations, across eight sequential time epochs, for disgust face and anger face stimuli.

Method

Procedures

The study was approved by the institutional review board for human subject research. Participants were recruited through advertisements in the community, university-affiliated clinics specializing in the treatment of ASD and anxiety disorders, and the Department of Psychology's Child Participant Database. Controls were matched by gender to the ASD group. All participants received a small honorarium for participation. On initial contact, potential participants' parents completed a brief telephone screen to determine preliminary eligibility (i.e., between 12 and 17 years of age and no intellectual disability). Study advertisements indicated that shy or withdrawn teenagers and teenagers with ASD were being enrolled. Eligible families were emailed a parental consent document and a child assent document for review prior to the in-lab eye-tracking session. The parent and adolescent completed several questionnaires during the in-lab session, with an experimenter present to answer any questions about the items. Once the adolescent finished the questionnaires, he or she completed the eye-tracking task while the parent completed the battery. Although prior research indicates caution in sole reliance on self-report anxiety measures with adolescents who have ASD (Mazefsky et al. 2011; White et al. 2012), both child- and parent-reports were considered critical given the internal, covert nature of socially anxious cognitions.

Participants

To be eligible to participate in the study, participants had to be between the ages of 12 and 17 and not have co-occurring intellectual disability. Of the initial sample of 35 youth, one participant with ASD and one Control participant did not have valid eye-tracking data due to equipment malfunction, yielding 15 participants with a diagnosed ASD (8 males) and 18 without ASD (10 males) (total $n = 33$). All participants with ASD had prior diagnoses, based on comprehensive clinical assessment, and all diagnoses were supported by above-threshold scores on the Autism Diagnostic Observation Schedule (ADOS; Lord et al. 2002) or the Autism Diagnostic Interview—Revised (ADI-R; Lord et al. 1994). Thirteen of the 15 participants with ASD exceeded diagnostic threshold on the ADOS; the two who did not had above-threshold scores for diagnosis on the ADI-R. All ADOS and ADI-R administrations were completed by clinicians who were trained and research reliable on the instruments. Although IQ was not formally assessed in this study, parents of participants were asked during the telephone screening if their son or daughter had ever received an educational classification or clinical diagnosis of intellectual disability or mental retardation, and all indicated that their children did not have intellectual disability. In the ASD group, 11 participants had parent-reported problems with social anxiety, six of whom had been diagnosed with SAD per parent report. In the Control group, 8 participants had parent-reported problems with social anxiety, and one had an SAD diagnosis. Demographic data are reported in Table 1.

Measures

Demographic Survey

The demographic survey, completed by the parent, obtained information about the child, including age, gender, race, educational services, and current medication use. The parent also indicated whether any biological relatives of the child have ASD or a related developmental or mental health disorder.

Brief Fear of Negative Evaluation Questionnaire (BFNE; Leary 1983)

A brief version of the full FNE (Watson and Friend 1969), this 12-item, self-report scale assesses the degree to which

Table 1 Group descriptive data

	ASD ($n = 15$) Mean (*SD*)	Control ($n = 18$) Mean (*SD*)	*t*
Age (in years)	14.88 (1.552)	4.33 (1.52)	1.02
SCQ[a]	15.40 (4.63)	4.39 (3.01)	8.23**
SRS[b]	87.53 (16.69)	47.33 (8.31)	8.91**
SWQ[c] (parent)	10.13 (4.79)	6.50 (5.97)	2.89^
SWQ[c] (child)	9.53 (4.58)	7.56 (5.13)	2.43
BFNE[d] (child)	22.53 (6.45)	20.72 (8.03)	.70
	n (% of group)		*n* (% of group)
Gender			
Male	8 (53.30)		10 (55.60)
Race			
Caucasian	12 (80.00)		17 (94.40)
Other	2 (13.30)		0 (0)
African-American	1 (6.70)		1 (5.60)

[a] SCQ: Social Communication Questionnaire total raw score

[b] SRS: Social Responsiveness Scale total *T* score

[c] SWQ: Social Worries Questionnaire total raw score

[d] BFNE: Brief Fear of Negative Evaluation Questionnaire (straightforward items) total score

* $p < .05$, ** $p < .01$, ^ $p < .10$

people experience apprehension at the prospect of being evaluated negatively by others. The BFNE correlates highly (.96) with the original, full scale and has excellent internal consistency (alpha = .90). Carleton et al. (2011) found that using only the eight items that have straightforward wording (i.e., not the four reverse-scored items) yields the best diagnostic sensitivity and reliability. As such, only these eight items were computed for the total BFNE score. Only adolescents, not parents, completed the BFNE, and alpha was high (.863) in this sample.

Social Worries Questionnaire (SWQ; Spence 1995)

The parent-report SWQ consists of 10 items that relate to fear and avoidance of social-evaluative situations, and the youth self-report SWQ has 13 items assessing cognitive and affective fear responses in social situations. Consistent with previous research (Spence 1995), derived internal consistency for this study's sample was acceptable (parent-report = .884; child-report = .816).

Social Responsiveness Scale (SRS; Constantino and Gruber 2005)

This 65-item questionnaire is a widely used (e.g., Constantino and Todd 2003) severity measure of autism spectrum symptoms as they occur in the natural social setting, as reported by the parent. Each item is rated as "0" (never true) to "3" (almost always true). More specifically, this measure assesses a child's social impairments, social awareness, social information processing, capacity for reciprocal social communication, social motivation, and restricted/repetitive behaviors and interests. In the present sample, alpha was .984.

Social Communication Questionnaire (SCQ; Berument et al. 1999; Rutter et al. 2003)

The SCQ is a 40-item parent-report questionnaire designed to aid in diagnosis of ASD. The SCQ has demonstrated acceptable validity (internal consistency ranging from .84 to .93; Rutter et al. 2003). Although the original suggested cutoff for screening purposes is 15 (Rutter et al. 2003), among high-functioning individuals a slightly lower cutoff (i.e., 12) has been recommended (Corsello et al. 2003). This lower cutoff was used in the present study.

Gaze Patterns

We were interested in fixation duration (FD), defined as the total length in milliseconds (ms) or seconds (s) that a participant fixated on the area of interest (AOI), based on the average of both eyes. To be included in the analyses, a fixation had to be at least 100 ms in duration. The total face region (i.e., all facial area including the eye region, stopping at hairline) was defined as the face AOI, and the eye region (i.e., both left and right eye areas including most of the bridge of the nose, as well as eyebrows) comprised the eye AOI. Gaze to the mouth AOI was not evaluated, as prior research on the relationship between social anxiety (Corden et al. 2008) and amygdala hyperactivation (Dalton et al. 2005) to gaze in ASD has found a relationship only with gaze toward the eye region. Also, prior research on the influence of social anxiety in non-ASD samples has focused primarily on gaze to the whole face (e.g., Garner et al. 2006). These AOI regions were defined prior to data analyses using the oval-shaped AOI tool available in the Tobii T60 (Studio Professional) platform. In addition, we applied an I-VT filter (velocity classifier 30°/s; velocity calculator window length 20 ms) prior to data analyses. This preliminary data processing included gap interpolation of breaks in gaze data shorter than 75 ms. The I-VT filter is provided in the Tobii Studio software, and no other noise reduction was used.

Apparatus and Stimuli

A Tobii T60 binocular eye-tracker with a 38 cm thin film transistor (TFT) monitor was used for the eye-tracking task. All participants were calibrated to the task before data

collection using 5-point calibration (with Studio v2.1 software at a rate of 60 Hz). The degree of accuracy with this calibration system is .5°, with <.3° of visual drift. The tracker maintains excellent calibration of the viewer, even under conditions of fairly wide-ranging head movement, in part because this is a two-camera (two pupil) system that allows for more rapid recovery of the track once the viewer returns to the functional window. The T60 is arm-mounted so that, depending on the participant, the monitor can be easily repositioned to maximize the quality of the tracking. Face stimuli were color photographs drawn from the NimStim Set of Facial Expressions (Tottenham et al. 2009). Facial expression stimuli represented both male and female actors, from different ethnic groups (White, Black, and Asian). All face stimuli used in the present study were selected to have at least 80 % rater agreement on the depicted emotion (per Tottenham et al. 2009), with the exception of calm faces, for which we selected stimuli with at least 50 % inter-rater agreement.

The eye-tracking task comprised two conditions, both structured similarly to paradigms used in prior studies (e.g., Corden et al. 2008; Garner et al. 2006). In the first condition, which was a passive viewing Posner-type task, participants were seated approximately 70 cm from the monitor screen, and instructed to "look at the cross on the screen." A centered "X" (16.7 cm long × 18.6 cm wide; 24° visual angle) appeared on the screen for 2 s, followed by a face-pair (each face 18.9 cm long × 14.1 cm wide, with 2.4 cm of black screen between the two faces; all subtending 27° visual angle) for 4 s, followed by a black, blank screen for 1 s before the next sequence (X–face-pair–blank) appeared. Face-pairs presented two different emotional expressions (from four emotions: happy, calm, disgust, anger) depicted side by side, and each pair was of the same actor (see example, Fig. 1). Face-pair presentations included one positive (happy, calm) and one negative (angry, disgust) face, as well as a disgust-anger pairing, for a total of ten face-set stimuli. It should be noted that calm, rather than neutral, faces were used from the NimStim set. Although most of the prior eye-tracking studies on social anxiety have used neutral as a comparator face, there is evidence that children do not always perceive such faces as emotionally neutral (e.g., Somerville et al. 2004). There is also evidence that adults with AD are more likely than adults without ASD to misattribute neutral faces as negatively angry or sad (Eack et al. 2014). The calm face, although similar to neutral, is thought to be perceived as less negative (Tottenham et al. 2009). Each stimulus was shown twice (20 face-pair presentations in total for Condition 1), such that the same face-pair was not presented consecutively, the negative emotion (e.g., disgust) was never on the same side of the screen more than twice in a row, each individual photo position was counterbalanced left versus right, and no more than two consecutive actors of the same sex were presented.

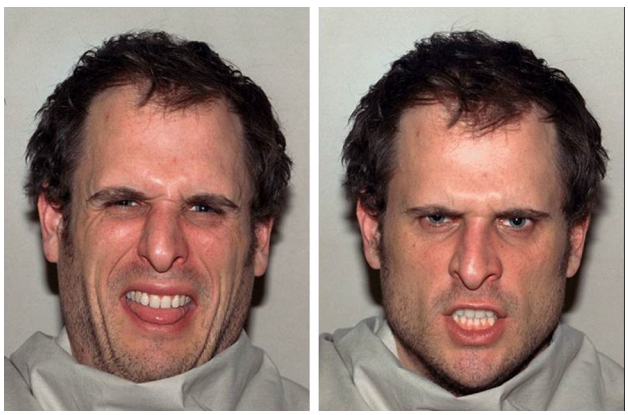

Fig. 1 Sample face presentation [disgust, calm] from Condition 1 (Model 40 from NimStim set, Tottenham et al. 2009)

In the second condition, a set of 12 stimuli of single faces, also drawn from NimStim [2 (sex) by 6 (emotion: happiness, sadness, fear, surprise, anger, disgust)], was presented. Participants were instructed to "look at the screen however you want." Each emotion was presented twice, such that no face was seen consecutively and no more than two negative or positive emotions were presented consecutively, for a total of 24 emotional face presentations. The face stimuli in the second condition were centered (22.2 cm long × 17.3 cm wide; all subtending a 31° visual angle) and shown for 4 s each, separated by a 1-s black screen. Three different tests of the same stimuli were created, with stimuli appearing in different orders following the presentation rules described, though always with the second condition (single faces) following the first condition (dual faces). At the end of each condition, brief (≤25 s) video clips were shown, of the same two actors engaged in an argument and a cheerful conversation, respectively. The brief videos were included to provide a brief break from the static emotional faces, and maintain participants' attention. Although gaze toward these dynamic stimuli may be examined in the future, only data from the static stimuli are reported in this study.

Analyses

Data analyses were conducted in IBM SPSS Statistics Version 20. Although we set alpha for statistical significance at .05 (two-tailed), given the preliminary nature of this study and the small sample we also indicate when test values exceed a more liberal alpha of .10. After preliminary analyses to explore possible group differences and zero-order correlations to assess the relationship

between ASD severity and social anxiety, we conducted split-plot Analyses of Variance (ANOVA) to examine differences in FD to the face and eye AOIs (AOIs examined separately) with group (ASD, Control) as a between-subject variable and stimulus emotion (disgust, angry, happy) as a within-subject variable. These three emotions were present across both conditions and were selected to allow us to compare valence (negative to positive emotion) and more specifically determine if disgust yields a different gaze pattern than anger, as they are both negative emotions. Split-plot ANCOVAs were then conducted to examine differences in FD to face and eye AOI, controlling for self-reported fear of negative evaluation. Bivariate and partial correlations were computed to assess the strength of relationship between socially anxious cognitions and FD to faces and eyes across the three emotions, for each group independently. Severity of ASD-related social deficits (SRS total score) was controlled for in the partial correlations. To examine patterns of attending and disengagement temporally, specifically with respect to the disgust and anger faces (i.e., social threat cues), using Condition 1 data only, we compared the groups on FD within each 500 ms epoch of the full stimulus presentation for (1) disgust faces paired with calm or happy face presentations, yielding a total of eight presentations (e.g., disgust–calm), and (2) angry faces paired with calm or happy face presentations, yielding a total of eight presentations (e.g., anger–happy). We also examined correlations between FD and fear of negative evaluation across the epochs, to explore how social anxiety specifically might influence gaze behaviors over time.

Results

ASD-Control Group and Emotion Differences

The two groups were equivalent in age ($t(31) = 1.02$, $p = .314$), and scores across the measures were generally normally distributed. The ASD group obtained significantly higher scores on measures of ASD severity than the Control group, but the groups did not differ significantly on any of the self-report or parent-report measures of social anxiety (Table 1). All Controls obtained below-cutoff SCQ scores and 15 had scores below threshold (T-score <60) on the SRS, whereas three obtained scores of 60 or higher. In the ASD group, 11 obtained scores above the SCQ cutoff (four were below cutoff) and all 15 had SRS Total T-scores above 60. The seven participants with parent-reported SAD diagnoses had higher scores on all measures of social anxiety than did the 26 without prior SAD diagnoses (self-report SWQ, $t = 2.08$, $p = .046$; parent-report SWQ, $t = 3.59$, $p = .001$; BFNE, $t = 2.46$, $p = .020$).

Split-plot ANOVAs revealed no interaction effect for FD to the face AOI (averaged across condition), $F(2,30) = .48$, $p = .625$, or main effect of group, $F(1,31) = 3.42$, $p = .074$. There was, however, a significant main effect of emotion, $F(1,31) = 6.49$, $p = .016$. Pairwise comparisons with Bonferroni correction revealed that average FD was significantly shorter toward both disgust faces (M = 1.45 s; SD = .46) and anger faces (M = 1.46 s; SD = .46) relative to happy faces (M = 1.64 s; SD = .52), but the difference in FD was not significant between disgust and anger. Similar to the face AOI results, the interaction between emotion and group was not significant for FD to the eye AOI, $F(2,30) = .12$, $p = .885$ was not significant, nor was the main effect of group, $F(1,31) = 3.80$, $p = .060$. There was a significant main effect of emotion, $F(1,31) = 5.79$, $p = .005$. Pairwise comparisons showed shorter FD to the disgust eye AOI (M = .72 s; SD = .45), relative to both happy (M = .87 s; SD = .48) and anger (M = .80 s; SD = .47) eye AOIs. There was not a significant difference in FD between happy and anger eye AOIs. These analyses were repeated, controlling for self-reported fear of negative evaluation (BFNE score). For the face AOI and the eye AOI, the interaction was not significant, $F(2,30) = .50$, $p = .628$; $F(2,30) = .05$, $p = .915$, respectively. When controlling for fear of negative evaluation the main effect of emotion was no longer significant for face or eye AOI, $F(2, 30) = 1.67$, $p = .206$ and $F(2,30) = .93$, $p = .400$, respectively. However, there was a significant group effect for both face AOI, $F(1, 30) = 5.10$, $p = .031$, and eye AOI, $F(1,30) = 4.74$, $p = .038$. The ASD group demonstrated shorter FD to both AOIs (face M = 1.37, SD = .52; eye M = .64, SD = .52) than did the Control group (face M = 1.64, SD = .32; eye M = .93, SD = .33).

Fear of Negative Evaluation, Social Threat, and Gaze Duration

In the ASD group, there were no significant correlations between ASD symptom severity, as measured by the parent-report SRS, and any of the social anxiety measures (Table 2). In the Control group, however, SRS total score was significantly correlated with the parent-reported SWQ, but neither of the child-report measures. Within the ASD group, neither parent-reported nor youth self-reported social worry (SWQ) was correlated with FD, summed across condition, to either AOI (i.e., face or eye) for any emotion (happy, anger, disgust). Child-reported fear of negative evaluation (BFNE scores), however, significantly predicted duration of gaze to anger and disgust faces, but not happy faces (Table 2). FD to the eye AOI followed a similar pattern, although correlations only approached significance (for anger and disgust, not happy). These relationships continued to be statistically significant, and in

Table 2 Correlation matrix (bivariate/partial) within ASD group (n = 15)

	Parent		Child		FD					
	SRS	SWQ	SWQ	BFNE	Face (H)	Face (D)	Face (A)	Eye (H)	Eye (D)	Eye (A)
Parent										
SWQ	.354	–	*.202*	*.362*	*.342*	*.129*	*.169*	*.258*	*.103*	*.168*
Child										
SWQ	.044	−.205	–	*−.395*	*−.181*	*−.177*	*−.103*	*−.317*	*−.377*	*−.338*
BFNE	.167	.393	.396	–	*.398*	*.680***	*.747***	*.434*	*.459^*	*.471^*
FD										
Face (H)	.323	.188	−.185	.318	–	*.584**	*.660**	*.622**	*.353*	*.422*
Face (D)	−.292	.012	−.182	.593*	.623*	–	*.956***	*.531^*	*.732***	*.701***
Face (A)	−.404	.002	−.112	.606*	.702**	.955**	–	*.585**	*.736***	*.730***
Eye (H)	.006	.244	−.316	.429	.587*	.506^	.532*	–	*.813***	*.854***
Eye (D)	.007	.099	−.377	.454^	.332	.698**	.671**	.813**	–	*.976***
Eye (A)	−.168	.095	−.341	.430	.448^	.710**	.726**	.841**	.961**	–

Bivariate, zero-order correlations; partial (in italicized cells), controlling for ASD symptoms (SRS Total score)

SRS = total T-score on Social Responsiveness Scale; SWQ = Social Worries Questionnaire total score; BFNE = Brief Fear of Negative Evaluation (straightforward) total score; FD = fixation duration; Face (H) = total duration to face AOI across condition for happy faces only; Face (D) = total duration to face AOI across condition for disgust faces only; Face (A) = total duration to face AOI across condition for angry faces only; Eye (H) = total duration to eye AOI across condition for happy faces only; Eye (D) = total duration to eye AOI across condition for disgust faces only; Eye (A) = total duration to eye AOI across condition for angry faces only

* $p < .05$; ** $p < .01$; ^ $p < .10$

fact were stronger, when controlling for ASD severity. In the Control group, there were no significant correlations between parent- or child-reports of social anxiety and FD to face or eye AOIs (Table 3). Figure 2 depicts the relationship between fear of negative evaluation and gaze toward the disgust and anger face AOIs for the ASD group.

Vigilance and Disengagement

To examine eye gaze patterns indicative of possible vigilance and disengagement over time toward disgust and anger faces in Condition 1 (dual faces), we divided each of the 4-s face presentations into eight 500 ms epochs, focusing on those trials during which a disgust or angry face was paired with a happy or calm face (8 face-pairs for disgust, and 8 for anger). As depicted in Figs. 3 and 4, both groups spiked in FD to anger and disgust faces during the second epoch (500–1,000 ms) and then progressively disengaged their attention. The only group difference for the anger faces occurred during the first epoch, with the Controls showing longer FD to angry faces ($t(31) = 2.17$, $p = .038$). Progressive disengagement (i.e., decreasing FD over time) was most apparent in the ASD group to the disgust faces. There was a group difference in the first 500 ms block, $t(31) = 2.20$, $p = .035$, as well as in the seventh and eighth 500 ms blocks, $t(31) = 3.17$, $p = .003$ and $t(31) = 3.60$, $p = .001$, respectively, at each period with the Control group attending more to the disgust faces than the ASD group. In the final 500 ms of the disgust face presentation, mean FD for the ASD participants was 71.98 ms ± 69.56, compared to 161.50 ms ± 72.45 for the Controls. Figures 5 and 6 show the relationship between fear of negative evaluation and FD to anger and disgust faces, respectively. Although the relationship between fear of negative evaluation and gaze duration was stronger for the ASD group overall, the strength of this association varied over the course of stimulus presentation.

Discussion

This was a preliminary study on the potential influence of social fears and worries, characteristic of social anxiety, on patterns of eye gaze to social stimuli among adolescents with ASD. Consistent with previous research (Bellini 2004; Klin and Volkmar 2000; Kreiser and White 2014; Kuusikko et al. 2008), results suggest that social anxiety is common among more cognitively able adolescents with ASD. We cannot, however, draw firm conclusions regarding the degree of co-occurrence of social anxiety given our sample ascertainment approach (i.e., recruiting for shy adolescents) and sample size. Neither ASD (diagnostically or dimensionally with respect to severity of symptoms) nor social anxiety, based on parent-report,

Table 3 Correlation matrix (bivariate/partial) within control group (n = 18)

	Parent		Child		FD					
	SRS	SWQ	SWQ	BFNE	Face (H)	Face (D)	Face (A)	Eye (H)	Eye (D)	Eye (A)
Parent										
SWQ	.744**	–	*.549**	*.393*	*−.424^*	*−.082*	*.016*	*−.070*	*.081*	*.213*
Child										
SWQ	.346	.602**	–	*.782**	*−.067*	*.143*	*.175*	*−.214*	*−.003*	*−.006*
BFNE	.262	.448^	.799**	–	*.162*	*.252*	*.325*	*−.085*	*.133*	*.157*
FD										
Face (H)	.320	−.030	.051	.232	–	*.753**	*.762**	*.429^*	*.392*	*.391*
Face (D)	−.038	−.083	.120	.233	.701**	–	*.877**	*.354*	*.618**	*.488**
Face (A)	−.214	−.148	.086	.250	.637**	.864**	–	*.299*	*.470^*	*.532**
Eye (H)	.456^	.298	−.021	.047	.507*	.297	.163	–	*.850**	*.894**
Eye (D)	.007	.059	.000	.130	.374	.618**	.457^	.760**	–	*.865**
Eye (A)	.008	.148	−.003	.154	.373	.487*	.518*	.799**	.865**	–

Bivariate, zero-order correlations; partial (in italicized cells), controlling for ASD symptoms (SRS Total score)

SRS = total T-score on Social Responsiveness Scale; SWQ = Social Worries Questionnaire total score; BFNE = Brief Fear of Negative Evaluation (straightforward) total score; FD = fixation duration; Face (H) = total duration to face AOI across condition for happy faces only; Face (D) = total duration to face AOI across condition for disgust faces only; Face (A) = total duration to face AOI across condition for angry faces only; Eye (H) = total duration to eye AOI across condition to happy faces only; Eye (D) = total duration to eye AOI across condition for disgust faces only; Eye (A) = total duration to eye AOI across condition for angry faces only

* $p < .05$; ** $p < .01$; ^ $p < .10$

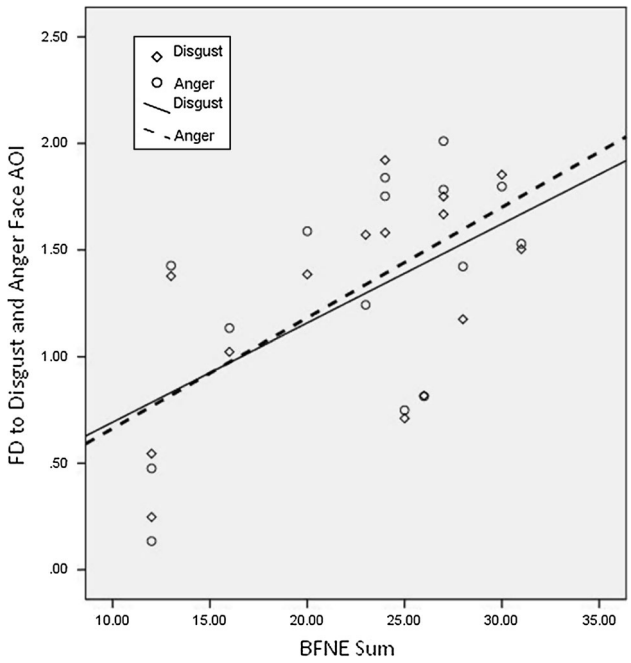

Fig. 2 Scatterplot with Regression Line between Mean Fixation Duration (FD) across both conditions to Disgust Face AOI and Anger Face AOI for the ASD group

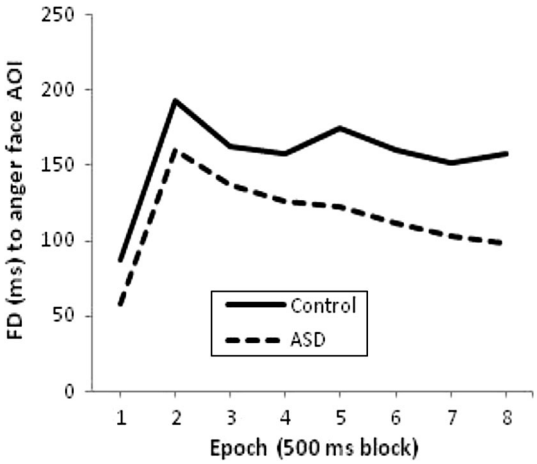

Fig. 3 Average fixation duration (FD) to anger faces for each 500 ms epoch

predicted fixation duration to social cues collapsed across emotion type. It is probable that our lack of a group effect is related to the high degree of social anxiety in this sample as well as our use of static social cues (e.g., Sawyer et al. 2011). When we controlled for self-reported fears of negative evaluation, however, a group effect was evident. The adolescents with ASD showed lower FD toward social stimuli relative to the adolescents without ASD. When fear of negative evaluation was not controlled for, the effect of emotion was significant for both groups, with less cumulative gaze toward faces depicting anger or disgust, relative to happy faces, and more gaze toward the eye region of

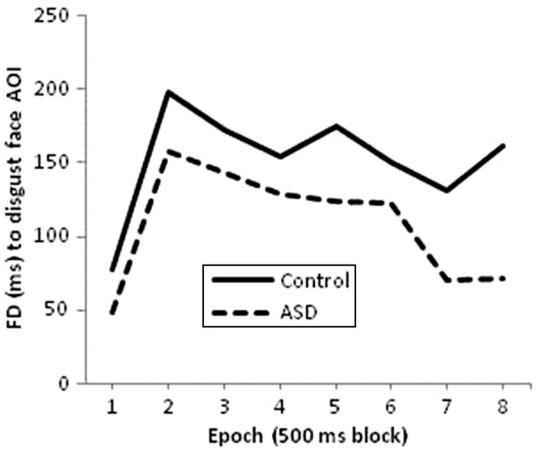

Fig. 4 Average fixation duration (FD) to disgust faces for each 500 ms epoch

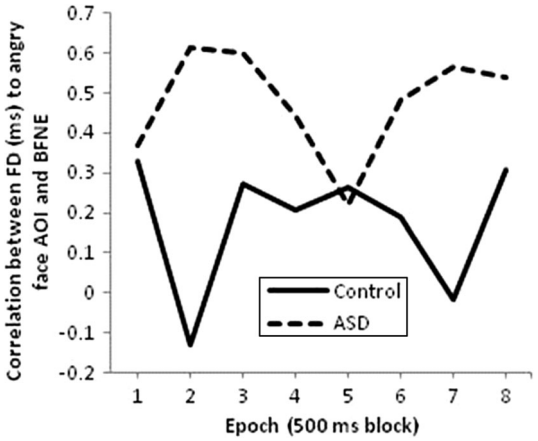

Fig. 5 Correlation between fixation duration (FD) to anger faces and fear of negative evaluation each 500 ms epoch

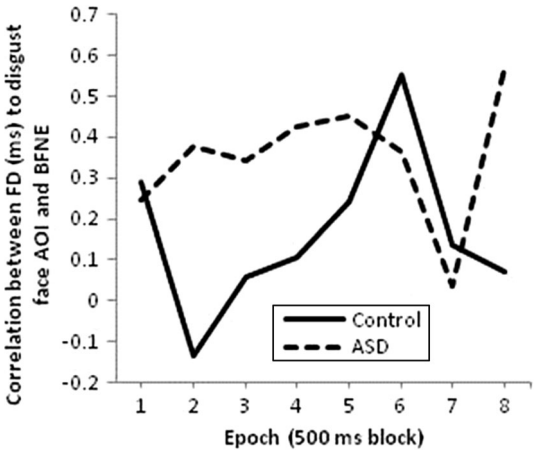

Fig. 6 Correlation between fixation duration (FD) to disgust faces and fear of negative evaluation each 500 ms epoch

angry or happy faces than to the eye regions of faces depicting disgust.

This is the first study, to our knowledge, to demonstrate that socially anxious cognitions (fears of negative evaluation by others), as self-reported by adolescents with ASD, predicted greater visual attention, but only in response to socially threatening stimuli. The relationship between social fears and increased gaze was not present for happy faces, rather only for disgust and anger, which have historically been considered socially threatening cues (e.g., Amir et al. 2010). No such relationship between social fears and eye gaze was seen among the teens without ASD. Contrary to what we expected, the effect of fear of negative evaluation on gaze was not stronger for disgust faces, relative to anger faces. However, youth with ASD seemed to more readily disengage visual attention from the disgust faces, relative to peers without ASD.

Among the adolescents with ASD, only self-reported socially anxious cognitions predicted gaze to social stimuli. This finding underscores the importance of considering the cognitive domain (e.g., fears of rejection) in phenotyping and diagnosing social anxiety in the context of ASD, along with behavioral and physical indicators of possible anxiety. In addition to considering the role of socially anxious cognitions on attentional processes in ASD, these findings highlight the need to better understand how to validly assess social anxiety, clinically and multi-factorially (e.g., behaviorally, cognitively), in people with ASD (cf. Kreiser and White 2014). Given evidence that even verbal, higher functioning adolescents with ASD tend to under-report their own psychiatric symptoms (Mazefsky et al. 2011; White et al. 2012), more research on alternative approaches for measuring socio-evaluative cognitions is warranted.

The eye gaze pattern often reported in the social anxiety literature, characterized by initial vigilance (or bias) to threat cues followed by disengagement from the stimulus (e.g., Garner et al. 2006; Wieser et al. 2009), was not clearly evident in this fairly anxious sample, for either the ASD or Control youth. It appears that fear of negative evaluation by others is more predictive of sustained visual attending to both angry and disgust faces for the adolescents with ASD, relative to those without ASD. Temporally, this group difference was most pronounced early on in stimulus presentation (during the first 500 ms), possibly suggesting heightened vigilance related to fear of negative evaluation among the youth with ASD. These results, though preliminary, also indicate that youth with ASD (regardless of fear of negative evaluation) disengaged more rapidly from disgust faces than did adolescents without ASD. It is not possible, however, to determine the root of the apparent 'disengagement' (e.g., loss of interest or active avoidance of the stimuli), and further research on the possibility of hastened disengagement is

needed since disengagement from social stimuli could affect social cognition and behavior, which in turn may contribute to the development of anxiety (i.e., avoidance of the feared stimulus negatively reinforcing subsequent avoidance). In addition, the positive relationship between fear of negative evaluation and gaze during early presentation of the faces supports the possibility that such fear promotes vigilance to potential threat in the social environment.

The observed pattern of relationships between different measures of social anxiety, namely the SWQ (Spence 1995) and the BFNE (Leary 1983), and gaze duration also requires further exploration. Youth self-reported scores on the SWQ, which assesses both social worry and behavioral avoidance (every item begins with "I avoid *or* get worried about…") did not predict duration of fixation to social stimuli, whereas the self-reported BFNE scores predicted greater duration of fixation to threatening stimuli within the ASD group. It is possible that social avoidance behaviors are quite distinct and separable from socially anxious cognitions, such that a young person who experiences heightened fear of negative evaluation may not necessarily *avoid* the social situation or threat cue. An alternate explanation is that the SWQ's items, with their focus on behavioral avoidance, do not assess the cognitive-emotional aspects of social anxiety as it manifests in ASD. The BFNE, on the other hand, does not contain any items related to actual avoidance of situations, as the items exclusively focus on cognition and emotion (e.g., "I am afraid that others will not approve of me."). There was a negative though non-significant relationship between parent- and youth-reports on the SWQ within the ASD sample. Although speculative, this may be attributed to the question stems (avoid *or* worry about), as an observer (such as a parent) cannot easily infer another's internal cognitions.

The main limitation of this study is the modest sample size and limited power to detect anything but fairly large effects (Cohen 1992). A four-group design (ASD high and low in social anxiety, and non-ASD high and low in social anxiety) would have bolstered our ability to make clear group comparisons. We also did not have cognitive and verbal ability assessments of participants. Nevertheless, this is a preliminary study with a well-characterized sample diagnosed with state of the art tools. The fact that there were no significant differences between the ASD and Control groups on our measures of social anxiety allows us to examine the effects of fear of negative evaluation, distinct from ASD. Finally, our measures of social anxiety and fear of negative evaluation have not been widely used with ASD samples, so their validity for this use remains an outstanding question. Owing to these limitations, conclusions must be made tentatively, and the findings should be replicated.

These findings underscore the utility of considering the potential influence of co-occurring psychopathology, including social anxiety, on gaze patterns in ASD. Comorbidity is common in people with ASD (Volker et al. 2010; Witwer and Lecavalier 2010) and, when present, may affect social orienting and attending, as well as clinical conceptualization. Specifically, among more able adolescents, social anxiety may confound (cf. MacKinnon et al. 2000) observed relationships between severity of ASD and gaze patterns. Indeed, as demonstrated here, the group difference was not apparent when fear of negative evaluation was not controlled for. Why is the relationship between fear of negative evaluation and gaze toward social threat cues not seen in the adolescents without ASD? Although further inquiry is needed to fully answer this question, it is possible that although fears of social evaluation, a hallmark of social anxiety disorder, are present in some youth with ASD, such fears are expressed and experienced differently in this population (cf. Kerns and Kendall 2012). One possibility is that fear of social evaluation has greater relative influence upon social engagement/disengagement patterns in adolescents with ASD. It is also possible that these fears affect social attending differently in youth with ASD relative to those without ASD.

Another implication for subsequent research involves the potential utility of examining gaze patterns sequentially, over time, during presentation of static social stimuli. Considering only cumulative fixation duration may mask subtle changes in patterns of attending. Finally, considerable research has addressed difficulties in facial emotion recognition in people with ASD (for review, see Harms et al. 2010), and some research (Pelphrey et al. 2002) has found that people with ASD tend to misidentify negative emotions in faces (e.g., identifying a fearful face as angry). This study's findings highlight the importance of considering the emotional valence of the stimulus, as negative emotions may yield different gaze patterns than do positive ones. In conclusion, we found that fear of negative evaluation by others, the primary cognitive component of social anxiety, predicts gaze toward socially threatening stimuli in adolescents with ASD and that there may be something in particular about faces exhibiting disgust that affects attentional disengagement. The potential effects of social anxiety, and in particular fear of negative evaluation, on the social behavior and sociocognitive reasoning of young people with ASD should be further explored.

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