Eye-Gaze Pattern Analysis as a Key to Understanding Co-Occurring Social Anxiety within Autism Spectrum Disorder

Brenna B. Maddox

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Susan W. White, Committee Chair
Thomas H. Ollendick
Robin K. Panneton
John A. Richey

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ABSTRACT

Emerging research suggests that many adults with Autism Spectrum Disorder (ASD) experience impairing Social Anxiety Disorder (SAD) or social anxiety symptoms (e.g., Joshi et al., 2013; Kleinhans et al., 2010), yet there is little guidance or agreement about how to best assess social anxiety in this population. Direct examination of overt eye gaze patterns may help determine if the attentional biases often reported in people with SAD also operate in those with ASD and co-occurring social anxiety. This study sought to assess the influence of social anxiety on gaze patterns in adults with ASD. An exploratory aim was to better understand the phenomenology of SAD within ASD. Three groups of participants were included: adults with ASD (n = 25), adults with SAD (n = 25), and adults without ASD or SAD (n = 25). As hypothesized, a large subset (n = 11; 44%) of the participants with ASD met diagnostic criteria for SAD. Contrary to study hypotheses related to gaze patterns, however, there was no evidence for gaze vigilance followed by avoidance for socially threatening stimuli in either the ASD or SAD groups, and there was no relationship between fear of negative evaluation and gaze duration toward socially threatening stimuli within the ASD group. Possible reasons for these null findings are considered. Clinical implications and suggestions for future research are also discussed.

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Chapter 1 – Introduction

Social anxiety, or excessive concern about social situations due largely to fear of potential negative evaluation by others, tends to present in adolescence and persist into adulthood (Alfano, Beidel, & Turner, 2006), developmental periods often overlooked in the research on Autism Spectrum Disorder (ASD). ASD is a chronic neurodevelopmental disorder characterized by social communication and social interaction deficits, in addition to restricted, repetitive patterns of behavior or interests (American Psychiatric Association [APA], 2013). The number of individuals diagnosed with ASD has increased dramatically in the last 20 years, with current prevalence estimates of 1 in 68 children (Centers for Disease Control and Prevention [CDC], 2014). Although ASD clearly affects people across the lifespan, and identification rates have risen most sharply among those with average to above average intelligence (e.g., Kim et al., 2011), cognitively unimpaired adults with ASD (i.e., without co-occurring intellectual disability) have been largely ignored in the extant research (Levy & Perry, 2011). Emerging research suggests that many cognitively unimpaired adults with ASD experience impairing social anxiety (e.g., Joshi et al., 2013; Lugnegård, Hallerbäck, & Gillberg, 2011). A better understanding of co-occurring social anxiety, including how it manifests and how to accurately assess it, is critical for adults with ASD.

1.1 - Social Anxiety Disorder

In the *Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition* (DSM-5; APA, 2013), Social Anxiety Disorder (SAD) is characterized by an excessive and persistent fear of social situations in which one might be scrutinized by others. An individual with SAD fears that he or she will experience embarrassment or negative evaluation by others in social or performance situations (e.g., attending a party, maintaining a conversation, giving a speech), which often leads to avoidance of these situations. The DSM-5 places an increased emphasis on the role of fear of negative evaluation by others in SAD, relative to prior versions of the manual (Heimberg et al., 2014). This fear can include concerns about rejection, ridicule, or offending others. In order for an individual to meet full diagnostic criteria for SAD, the social and/or performance fears must result in impairment in at least one significant life domain (e.g., social, occupational, or academic functioning) or cause the person significant distress. In addition, SAD symptoms must not be due to the physiological effects of a substance or medical condition or be

better accounted for by another psychiatric disorder (APA, 2013). Throughout this paper, 'SAD' refers to the clinical diagnosis of Social Anxiety Disorder based on the current DSM-5 criteria (APA, 2013), while 'social anxiety' refers to continuous symptoms of anxiety in social situations. Subclinical or subthreshold levels of social anxiety can also cause impairment and distress (Filho et al., 2010).

SAD is a relatively common anxiety disorder in the United States, with a 12-month prevalence estimate of 7% and a lifetime prevalence estimate of 13% (Kessler, Petukhova, Sampson, Zaslavsky, & Wittchen, 2012). Based on epidemiological data, the gender ratio of SAD in adults is approximately 3:2 women to men (e.g., Kessler et al., 2005). Evidence suggests that SAD is often a severe and chronic condition, although symptoms may wax and wane based on current life circumstances (Beidel & Turner, 2007). The mean duration of SAD in adults with a lifetime diagnosis is 16.3 years (Grant et al., 2005). When symptoms are present and interfering, they can negatively affect educational achievement, employment, and relationships throughout the lifespan. For example, SAD is associated with elevated rates of school dropout, decreased employment, and being single, unmarried, or divorced (APA, 2013).

SAD symptoms can be conceptualized along three dimensions (Mesa, Nieves, & Beidel, 2011): physical, behavioral, and cognitive. Physical symptoms of SAD relate to physiological arousal and include tachycardia (i.e., quickened heart rate), blushing, trembling, and sweating. The primary behavioral symptom of SAD is avoidance of social situations. Behavioral avoidance may be obvious (e.g., refusing to attend social functions, eating meals alone) or more subtle (e.g., avoiding eye contact, infrequently voicing opinions when doing so is warranted). Cognitive symptoms of SAD include negative thoughts and concerns related to self-embarrassment, negative evaluation by others, and the consequence of offending others. This tripartite model of SAD provides a framework to evaluate social anxiety assessment methods and determine whether a measure covers all three domains.

Theoretical models of SAD propose that attentional biases contribute to the maintenance of symptoms (Clark & Wells, 1995; Rapee & Heimberg, 1997). The Clark and Wells (1995) model of SAD includes four maintaining processes: (1) increased attention to self and decreased observation of other people, which results in a reduced ability to process the situation and other people's behavior, (2) awareness of somatic responses and other internal information, leading to excessively negative social-evaluative thoughts, (3) use of safety behaviors (also includes

cognitions) intended to prevent feared outcome (e.g., avoidance of hot drinks due to fear of face becoming red), and (4) negatively biased pre- and post-event processing (e.g., rumination). Based on this model, individuals with SAD give attention almost exclusively to internal processes (e.g., thoughts, somatic responses) during social situations. Rapee and Heimberg's (1997) model of SAD differs, however, by emphasizing that people with SAD also hyper-attend to external stimuli that are possibly indicative of negative evaluation. Thus, these two prominent cognitive-behavioral models of SAD make opposing predictions in terms of attentional biases toward threat cues (e.g., a disgusted or angry facial expression). Clark and Wells posit that external threat cues are largely avoided, whereas Rapee and Heimberg suggest that socially anxious people show hypervigilance toward threat cues and difficulty disengaging attention from them. As reviewed in a later section of this paper, eye-tracking studies have shed some light on the nature of these attentional biases in individuals with high social anxiety or SAD.

1.2 - Social Anxiety and ASD: Prevalence and a Bi-Directional Relationship

Social anxiety appears to be fairly common among cognitively unimpaired people with ASD, with the majority of extant research examining child and adolescent samples (e.g., Chang, Quan, & Wood, 2012; van Steensel, Bögels, & Perrin, 2011). Although no large-scale epidemiological studies have examined the comorbidity between ASD and SAD, community- and population-derived samples have shown that between 10.7% (Leyfer et al., 2006) and 29.2% (Simonoff et al., 2008) of youth with ASD experience impairing social anxiety. In fact, the recently released DSM-5 refers to social anxiety as a "hallmark" of ASD (p. 207) and reports a common comorbidity of social anxiety "in children. . .with high-functioning autism" (p. 208). However, few studies have examined the presence of SAD in adults with ASD. Joshi and colleagues (2013) compared the prevalence of SAD (based on a structured diagnostic interview) between clinically referred, age- and gender-matched adults with and without ASD (n = 126). The ASD group had significantly higher rates of lifetime (56%) and current (40%) SAD comorbidity, relative to the non-ASD group (19% and 16%, respectively). SAD was also the most common anxiety disorder diagnosis in the ASD group, a finding that has been replicated in other adult samples (Loveland & Bonnen, 2012; Lugnegård et al., 2011). Some studies have examined social anxiety symptoms in a continuous manner, finding greater social anxiety in adults with ASD compared to adults without ASD (e.g., Kleinhans et al., 2010), in addition to a significant positive relationship between social anxiety symptoms and ASD symptoms in non-

clinical college samples (e.g., Maddox, White, & Panneton, 2014; White, Ollendick, & Bray, 2011).

One reason for the limited information about SAD in adults with ASD is the widespread misconception that all individuals with ASD prefer social isolation, inherently lack interest in social interaction, and are indifferent to other people's opinions (Gaus, 2007). Although this holds true for some individuals with ASD, others are acutely aware of their social difficulties, place as much emphasis on the importance of peer approval as their typically developing peers, desire more social interactions and friendships, and experience a profound sense of isolation and loneliness (Müller, Schuler, & Yates, 2008; Williamson, Craig, & Slinger, 2008). Thus, their social isolation may be largely due to a lack of knowledge about how to initiate and maintain friendships, rather than a lack of desire for relationships.

When present, social anxiety and the social deficits associated with ASD likely have a bi-directional relationship (White et al., 2013). That is, anxiety about social situations and negative evaluation by others may be magnified by an awareness of one's social difficulties, and increased anxiety may lead to inaccurate processing and interpretation of social cues, avoidance of social encounters, and fewer opportunities to acquire new learning or practice social skills during interpersonal interactions. This cycle is particularly likely in individuals with average or above cognitive abilities, who tend to have greater (1) insight into personal social difficulties, (2) social awareness, and (3) social motivation, or desire to engage with other people for purely social reasons (Kuusikko et al., 2008; White, Schry, & Kreiser, 2014; Williamson et al., 2008). Taking this information into account, it is not surprising that individuals with ASD experience impairing social anxiety as they face increasing social complexities during adolescence and adulthood, perhaps leading to heightened arousal and sensitivity to social information (Müller et al., 2008). Indeed, a recent review of adolescent-specific development in ASD suggested that adolescence is an especially vulnerable period for individuals with ASD, during which they are at greater risk for developing comorbid anxiety or depression (Picci & Scherf, 2014). Research also indicates that co-occurring social anxiety exerts additional impairment above and beyond the core social deficits for people with ASD, including increased loneliness (White & Roberson-Nay, 2009) and aggression (Pugliese, White, White, & Ollendick, 2013).

1.3 - Social Anxiety and ASD: Assessment Challenges

Population-based studies of psychiatric comorbidity in adults with ASD are essential to achieve a better understanding of SAD prevalence in this population. However, some researchers (e.g., Tyson & Cruess, 2012) have argued that rates of SAD and ASD comorbidity cannot be accurately estimated with the available assessment measures. We currently lack consensus regarding the differentiation of anxiety and ASD characteristics (Ollendick & White, 2012; Wood & Gadow, 2010), with a heavy reliance on self- or parent-report anxiety measures that have not been validated for use with individuals with ASD (Kerns, Maddox, et al., 2014). The vast majority of existing social anxiety measures were created and standardized with typically developing individuals. Additional diagnostic challenges include the difficulties with introspective thinking, insight, and communication often seen in individuals with ASD (Reaven, 2009).

In a recent comprehensive review of the scientific literature on the assessment of social anxiety in children and adolescents with ASD and without co-occurring intellectual disability, questionnaires were found to be the most commonly utilized assessment method, followed by semi-structured interviews (Kreiser & White, 2014). Both methods may result in conflated estimates of social anxiety or SAD because they do not address the distinct etiologies for similar behaviors characteristic of both ASD and SAD. For example, an individual's lack of eye contact could be interpreted as impairment in nonverbal communication (characteristic of ASD) or as the result of fear of negative evaluation (characteristic of SAD). Current social anxiety measures fail to distinguish between social avoidance due to disinterest and social avoidance due to anxiety, which could lead to diagnostic overshadowing (Mason & Scior, 2004), meaning socially anxious behaviors are attributed to the diagnosis of ASD and not recognized as SAD symptoms. Another problem with existing measures is their reduced sensitivity to a potentially unique presentation of social anxiety in individuals with ASD, compared to individuals without ASD. For example, social anxiety may be expressed as increased repetitive behaviors, sensory-seeking or sensory-avoiding behaviors, and aggression in adults with ASD (Stoddart, Burke, & King, 2012), and these behaviors are not typically captured by current assessment tools. In addition, many of these measures rely on parent-report, which is often not feasible or appropriate for assessments with adults with ASD. In summary, there is little guidance or agreement about how to best assess social anxiety in adults with ASD. Existing measures may overestimate (i.e., symptoms of ASD

are misinterpreted as social anxiety) or underestimate (i.e., true social anxiety symptoms are misattributed to ASD) the prevalence of social anxiety in ASD samples.

These measurement issues relate to an even broader debate, regarding the question of whether SAD is a true comorbidity in individuals with ASD (e.g., Wood & Gadow, 2010). True comorbidity, or the co-occurrence of two separable conditions in the same individual, can result from: (1) shared or associated risk factors, (2) a distinctive syndrome when both disorders are present, or (3) an increased risk for developing one disorder in the presence of the other disorder (Caron & Rutter, 1991). As already mentioned, ASD and SAD often share certain behavioral indicators (e.g., avoidance of social interactions, reduced eye contact), which raises the question of whether the socially anxious behaviors are simply manifestations of ASD (Kerns & Kendall, 2012). However, recent research suggests that the constructs of ASD and social anxiety or SAD are unique and separable (e.g., Kerns, Kendall, et al., 2014; Renno & Wood, 2013), with explanations for true comorbidity primarily based on shared biological risk factors and the contributions of ASD symptomatology to the emergence of SAD (Tyson & Cruess, 2012; White, Bray, & Ollendick, 2012).

Cath, Ran, Smit, van Balkom, and Comijs (2008) conducted the first study to explore the phenomenological overlap between SAD and ASD in adults. They compared adults with only SAD (n = 12) to adults with SAD and co-occurring ASD (n = 6) and found that self-reported deficits in social skills, attention switching, and communication best discriminated the participants with comorbid ASD from the participants with "pure" SAD. However, this study was limited by the small sample size and the reliance on the Autism Spectrum Quotient (AQ; Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001) subscales, which have poor psychometric properties (e.g., Kloosterman, Keefer, Kelley, Summerfeldt, & Parker, 2011).

Additional research on differentiating ASD and SAD has produced some helpful guidelines, mostly related to differences in the chronological course of the disorder, pervasiveness of symptoms, and quality of social skills or relationships (Tyson & Cruess, 2012; White & Schry, 2011; White, Schry, et al., 2014). Chronologically, SAD and the associated social impairments generally begin and intensify during adolescence or young adulthood, whereas ASD-related social deficits are present from an early age. In addition, all individuals with ASD have social skill disability, which is pervasive across situations. They have few same-age friendships, and these relationships are usually not reciprocal in nature. Individuals with

SAD may or may not demonstrate clear social skill impairment; when present, these abnormalities (e.g., not speaking, avoiding eye contact) are not seen across contexts, but rather are specific to anxiety-producing social or performance situations. People with SAD typically have reciprocal, although perhaps not intimate, friendships. Another area of distinction is social initiation. Individuals with ASD may demonstrate awkward, socially inappropriate attempts to initiate with others or completely avoid initiations due to not knowing what to do or say, whereas individuals with SAD avoid social initiations due to anxiety about embarrassing themselves or making a negative impression.

Clearly, the accurate assessment and differential or dual diagnoses of ASD and SAD are challenging. Considering the tripartite model of SAD (Mesa et al., 2011), the cognitive domain (e.g., fear of negative evaluation by others) may be especially important to distinguish between ASD and SAD, given that these two disorders can significantly overlap in the physical and behavioral domains (White, Maddox, & Panneton, 2014). More research in this area is greatly needed, particularly with adults. An Autism Speaks work group including experts in the assessment of anxiety in ASD recently named eye-tracking as one of several novel tools that may be useful as "surrogate outcome measures" for anxiety treatments (Lecavalier et al., 2014, p. 1138). Based on the research reviewed below, eye-tracking methodology may prove particularly useful in identifying and characterizing co-occurring social anxiety in adults with ASD.

1.4 - Social Anxiety Eye-Tracking Research

Modern eye-tracking technology is used to determine where in a visual field an individual foveates, by recording reflected infrared light from the person's eye or eyes (Oakes, 2010). Eye-tracking methodology offers a direct, objective way to observe and quantify eye-gaze patterns, from which we can determine what an individual overtly attends to or avoids (e.g., social or non-social cues) in his or her environment. Visual attention has been likened to an information filter, determining which salient stimuli are selected and which interfering stimuli are suppressed in a demanding visual world (e.g., Desimone & Duncan, 1995). Eye-tracking data can shed light on visual attention processes by measuring fixations to small regions of interest, such as specific facial features (Haith, 2004; Hayhoe, 2004). Human eye-gaze behavior is particularly important in social contexts, as it can provide information to social partners, enhance communication efficiency, and be used to express feelings of intimacy (Kleinke, 1986). A person's interest in, as well as ability and willingness to attend to, socially relevant stimuli affect

their perception of the environment and others' perceptions of them. In addition, according to models of SAD (Clark & Wells, 1995; Rapee & Heimberg, 1997), attentional biases play an important role in the etiology and maintenance of social anxiety symptoms.

Indeed, a growing body of eye-tracking research demonstrates that social anxiety can alter eye-gaze patterns in adults without ASD, although the precise nature and specificity of these attentional biases are still equivocal (e.g., Armstrong & Olatunji, 2012). Some research findings support the prediction from the Clark and Wells (1995) SAD model; namely, increased social anxiety is related to the *avoidance* of threat cues, or reduced gaze toward potentially threatening stimuli, as a way to reduce the threat (e.g., Chen, Ehlers, Clark, & Mansell, 2002; Horley, Williams, Gonsalvez, & Gordon, 2004; Moukheiber et al., 2010). Other studies have found support for Rapee and Heimberg's (1997) SAD model; that is, increased social anxiety is related to *vigilance*, or more attention, toward threat cues, and possibly greater difficulty disengaging attention from them (e.g., Gamble & Rapee, 2010; Mogg, Philippot, & Bradley, 2004; Schofield, Johnson, Inhoff, & Coles, 2012). Given these inconsistent results, a more sophisticated and integrative two-stage model of attention in SAD has been proposed: the *vigilance-avoidance* model, which posits that attentional biases vary over the time-course of a stimulus presentation (Mogg & Bradley, 1998). Specifically, the model predicts that a socially anxious person initially attends more toward a threat-related stimulus, relative to a non-socially anxious person (early vigilance), but then diverts attention after the threat is detected (avoidance). This avoidance is theorized to serve a defensive function (e.g., to reduce discomfort elicited by the stimulus, to minimize perceived danger of the situation). The vigilance-avoidance model has prompted innovative and novel research studies about the time-course of attentional bias. However, this two-stage model does not specify whether an initial orienting period precedes the vigilance stage or when the transition between vigilance to avoidance exactly occurs (In-Albon, Kossowsky, & Schneider, 2010).

Although several different experimental paradigms (e.g., the modified dot-probe task, visual search tasks) have been used to examine vigilance-avoidance patterns, eye-tracking methodology has been described as the most direct and naturalistic assessment of visual attention, with the benefit of not relying on manual reaction time (e.g., Armstrong & Olatunji, 2012; Bögels & Mansell, 2004). Fixation duration, or the time when the eyes are relatively stable between saccadic movements, has demonstrated reliability as a measure of individual differences

in attention across test-retest intervals (e.g., Peterson & Eckstein, 2013) and across different tasks (e.g., Castelhano & Henderson, 2008; Rayner, Li, Williams, Cave, & Well, 2007). Eye-tracking technology is able to capture multiple components of attention, such as initial orienting, engagement, and disengagement, all within a single trial (Calvo & Avero, 2005). For example, the latency and location of an initial fixation can be simultaneously assessed, providing both a temporal and spatial index of orienting. In addition, eye-tracking has the advantage of providing a continuous measure of attention, concurrent with the presentation of threatening stimuli, which is necessary for assessing the vigilance-avoidance model.

Based on their review of experimental studies on the relationship between attention and social anxiety, Bögels and Mansell (2004) concluded that the vigilance-avoidance model of SAD has reasonable evidence from ecologically valid paradigms. They also noted that this pattern can result in both (1) enhanced initial processing of stimuli that are interpreted as threatening (e.g., a scowling face), and (2) diminished opportunities to habituate (i.e., experience a natural decrease in anxiety that results from spending enough time in the feared situation repeatedly) or reevaluate stimuli as non-threatening. These outcomes highlight why the vigilance-avoidance pattern has been described as a key maintenance factor in SAD (Bögels & Mansell, 2004).

Most adult eye-tracking studies of the vigilance-avoidance model have used social stimuli (e.g., human faces), simultaneously presented in contrasting threatening and nonthreatening (e.g., angry vs. neutral) pairs, with gaze duration toward the threatening stimulus serving as the measure of attention to threat. In a non-clinical college sample, Garner, Mogg, and Bradley (2006) found that students (n =16) with high levels of social anxiety (as measured by the Brief Fear of Negative Evaluation Scale [BFNE]; Leary, 1983) were quicker to initially orient toward emotional faces and also quicker to subsequently divert attention from emotional faces, relative to students with low levels of social anxiety (n = 15), when the participants were under social-evaluative stress (i.e., told they would be giving a videotaped speech after the eye-tracking task). Similar results were found by Wieser, Pauli, Weyers, Alpers, and Mühlberger (2009), using computer generated emotional-neutral face pairs. The high-social anxiety participants (also determined by the BFNE; n = 14) demonstrated longer gaze duration toward the emotional faces within the first second of the 3 s presentation, relative to the low-social anxiety participants (n = 15). During the next 500 ms, however, the high-social anxiety participants showed a significant

reduction in gaze duration toward the emotional faces, indicative of the vigilance-avoidance pattern.

Both of these studies used non-clinical college student samples, rather than clinical samples with confirmed SAD diagnoses. In addition, the two groups in the Wieser et al. (2009) study were formed using a median split on the BFNE, but the groups did not significantly differ on their Social Phobia and Anxiety Inventory (SPAI; Turner, Beidel, Dancu, & Stanley, 1989) scores. This finding raises questions about differences in the BFNE and SPAI items. The BFNE items focus more on the cognitive domain of social anxiety (e.g., "I am afraid that others will not approve of me"), instead of the physical or behavioral domains. Another limitation of the Wieser et al. study is that the computer generated facial stimuli may be perceived by participants as artificial, and therefore not trigger socially anxious thoughts or feelings as readily as natural human faces (Staugaard & Rosenberg, 2011).

1.5 - Eye-Tracking Research on Individuals with ASD

Although eye-gaze has been fairly well-studied among people with social anxiety, there has been little integration of this body of research with the more nascent research on gaze patterns among adults with ASD. In the ASD literature on social attention, eye-tracking has quickly become one of the most popular tools used in research with participants from early infancy to adulthood (Guillon, Hadjikhani, Baduel, & Rogé, 2014). Importantly, recent studies have demonstrated good to excellent test-retest reliability of eye-gaze measures in individuals with ASD (McDermott et al., 2012; Parish-Morris et al., 2013). Certain differences in gaze patterns between individuals with and without ASD are widely documented (e.g., Dalton et al., 2005; Hernandez et al., 2009; Klin, Jones, Schultz, Volkmar, & Cohen, 2002; Norbury et al., 2009; Spezio, Adolphs, Hurley, & Piven, 2007). One of the most frequently reported differences is that participants with ASD fixate significantly less on faces than do typically developing control participants (e.g., Riby & Hancock, 2008; Rice, Moriuchi, Jones, & Klin, 2012).

Different explanations exist for why individuals with ASD exhibit atypical gaze behaviors in social contexts. One hypothesis suggests that decreased visual attending to social cues stems from a general lack of appreciation for the social significance of these stimuli, meaning that social stimuli do not carry inherent meaning and therefore have decreased salience for people with ASD (e.g., Klin, Jones, Schultz, & Volkmar, 2003). This explanation is closely related to the social motivation hypothesis, which posits that faces have significantly less reward

value for individuals with ASD (Chevallier, Kohls, Troiani, Brodkin, & Schultz, 2012; Dawson, 2008). Another hypothesis suggests that social stimuli are aversive to individuals with ASD, leading to a state of overarousal and an active avoidance of fixating on these areas (e.g., Dalton et al., 2005; Kliemann, Dziobek, Hatri, Baudewig, & Heekeren, 2012; Tottenham et al., 2014).

It is important to note that not all eye-tracking studies have found differences in gaze behavior between individuals with ASD and individuals without ASD (see Guillon et al., 2014, for a review). Although a great deal of previous research has been based on the assumption that individuals with ASD demonstrate a deficit in social orienting and decreased attention to social stimuli, relative to typically developing individuals, this assumption has been increasingly challenged in recent months. For example, Fischer, Koldewyn, Jiang, and Kanwisher (2014) summarized the inconsistent findings in the ASD eye-tracking literature and concluded: "It remains unclear whether social orienting is truly impaired in ASD, and whether social orienting impairments may have any role in the development of the signature characteristics of autism" (p. 215). Their eye-tracking study with cognitively unimpaired children with ASD (n = 44) and age- and IQ-matched typically developing children (n = 40) revealed no group differences in social orienting or attentional disengagement from social stimuli.

Offered explanations for contradicting eye-tracking results across ASD research include the nature of the stimuli (e.g., static or dynamic), the complexity of the presented social scene (e.g., single person or multiple people), the demands of the task (e.g., emotion recognition or gender identification), and the characteristics of the sample (e.g., cognitive functioning level or diagnosis), which vary between studies (e.g., Hanley, McPhillips, Mulhern, & Riby, 2013; Hannigen, Best, Rump, Minshew, & Strauss, 2009; Speer, Cook, McMahon, & Clark, 2007). However, eye-tracking studies with an ASD sample have rarely accounted for the presence of social anxiety or examined the vigilance-avoidance pattern. It seems quite possible that the presence or absence of social anxiety could help explain some of the variability seen in gaze patterns of individuals with ASD. Similarly, the vast majority of eye-tracking studies in ASD have centered on group comparisons between an ASD sample and a typically developing comparison sample (Hanley et al., 2014). No previous eye-tracking studies have directly compared individuals with ASD to individuals with SAD, despite the high degree of phenotypic overlap between these two disorders. Including both groups in a well-designed study would allow researchers to make cross-syndrome comparisons, which could clarify the issue of

syndrome-specificity and elucidate the specific relationship between social attention and ASD symptomatology.

The research team for the current study has previously utilized eye-tracking to explore how co-occurring social anxiety affects gaze patterns in people with ASD. In one study, greater self-reported fear of negative evaluation (as measured by the BFNE) was associated with longer gaze duration to socially threatening cues (i.e., human faces expressing disgust or anger) in cognitively unimpaired adolescents (n = 15) with ASD (White, Maddox, et al., 2014). These relationships were even stronger when controlling for ASD severity (as measured by a parent-report measure). A significant relationship between self-reported social anxiety and duration of gaze toward faces displaying disgust or anger was not seen in a gender-matched comparison sample (n = 18) of adolescents without ASD. It is important to note that the ASD participants' gaze duration was significantly related to self-reported fear of negative evaluation only, and not to parent-reported social anxiety or self-reported scores on the Social Worries Questionnaire (Spence, 1995), which assesses behavioral avoidance. This distinction highlights the need to consider the cognitive domain (e.g., fears of rejection) when conceptualizing social anxiety in the context of ASD. A closer examination of the temporal patterns of attending and disengagement also revealed interesting findings in this sample. The positive relationship between fear of negative evaluation and gaze duration to threatening faces within the ASD group was most pronounced early on in stimulus presentation, possibly suggesting heightened vigilance related to social anxiety. In addition, the ASD group, with relatively high levels of social anxiety, more rapidly disengaged visual attention from disgust faces, compared to the non-ASD group.

In a second eye-tracking study, with a sample of young adults without diagnosed ASD (n = 45), greater self-reported ASD characteristics was positively associated with gaze duration to the eye region in a free-viewing (i.e., uninstructed) task, whereas greater self-reported social anxiety strongly negatively related to eye region fixation duration (Maddox et al., 2014). This finding that ASD characteristics and social anxiety exerted unique effects on gaze duration to the eye region may reflect dissociable mechanisms with respect to social attention and orienting. It is important to note, however, that this study treated ASD characteristics as a continuous variable and used a high-functioning college sample without ASD diagnoses. In addition, this study did not examine the time-course of attention within stimuli. Nevertheless, results from these two preliminary studies, using clinical and non-clinical samples of adolescents and adults,

respectively, suggest that social anxiety exerts its impact on gaze patterns in the presence of ASD.

1.6 – Specific Aims and Hypotheses

Collectively, the reviewed research indicates that social anxiety is fairly common in ASD, that it may affect social attending and processing, and that it exerts additional impairment above and beyond the core ASD symptoms. In addition, social anxiety in non-ASD adult samples has been associated with a vigilance-avoidance gaze pattern, but this type of eye-tracking analysis has not been applied to adults with ASD and co-occurring social anxiety. This study sought to assess the influence of co-occurring social anxiety on gaze patterns in adults with ASD. Specifically, we compared gaze patterns in a group of adults with ASD to those of a clinical comparison group (adults with SAD and without ASD: SAD group) and a non-clinical comparison group (non-socially anxious adults without ASD: NC group). Based on previous research (e.g., Joshi et al., 2013; Kreiser & White, 2014), it was expected that at least one-third (33%) of individuals in the ASD group would meet diagnostic criteria for SAD, a rate higher than what is found in non-ASD samples (Hypothesis 1).

Consistent with the vigilance-avoidance model, we hypothesized that the ASD group and SAD group would both initially demonstrate shorter latency and greater fixation duration toward socially threatening stimuli (as metrics of *vigilance*), but subsequently less gaze toward the threat cues (*avoidance*), relative to the NC group (Hypothesis 2). Secondarily, following a more dimensional approach and examining variability within the ASD group, it was predicted that fear of negative evaluation (the primary cognitive component of social anxiety) would be positively associated with gaze duration to faces depicting disgust or anger (Hypothesis 3). We expected no group differences in participants' arousal or valence ratings of the face stimuli (Hypothesis 4), which would be consistent with previous research comparing ASD, SAD, and NC groups (Richey et al., 2014).

An exploratory aim of this study was to better understand the phenomenology of SAD within ASD. Specifically, we sought to investigate whether the manifestation of SAD in the ASD group differed in any meaningful ways from that in the non-ASD, SAD group. For example, were individuals with ASD more likely to endorse social interaction anxiety (e.g., anxiety about attending a party with peers or talking to unfamiliar people) than performance-based social anxiety (e.g., anxiety about writing in front of others or reading aloud in class), relative to

individuals in the SAD-only group? This difference may be apparent because individuals with ASD display social deficits in situations with other people; on the other hand, it may be that a lack of insight into their difficulties leads to lower social interaction anxiety. Due to the lack of literature about the manifestation of SAD in adults with ASD, no specific hypotheses were proposed for this exploratory aim.

Chapter 2 - Method

2.1 - Participants

To be eligible for the study, participants had to demonstrate at least low average intellectual abilities (i.e., an IQ score greater than 80) and be between the ages of 16 and 45. The lower and upper limits of this targeted age range were based on theoretical and scientific rationale, mostly related to the typical life course of SAD. SAD tends to first present and intensify in later adolescence (e.g., Alfano et al., 2006; Kuusikko et al., 2008), which is how the lower age limit of 16 was determined. The upper age limit of 45 was chosen because (1) results from several national surveys suggest that social anxiety symptoms tend to wane when individuals reach their mid-40's (e.g., Blanco et al., 2011; Ruscio et al., 2008), and (2) 45 is (or is close to) the maximum age of participants in previous eye-tracking studies testing the SAD vigilance-avoidance hypothesis (e.g., Mogg et al., 2004; Staugaard & Rosenberg, 2011).

Three groups of participants were recruited: adults with ASD, adults with SAD, and adults without ASD or SAD (i.e., NC group). All participants in the ASD group met diagnostic criteria for ASD, as supported by the Autism Diagnostic Observation Schedule, Second Edition (ADOS-2; Lord et al., 2012) and clinical interview (with questions specific to ASD diagnostic criteria, assessing for current and childhood behaviors). All participants in the SAD group met diagnostic criteria for SAD, as assessed by the Anxiety Disorders Interview Schedule for DSM-IV (ADIS-IV; Brown, DiNardo, & Barlow, 1994). Groups were not matched on gender because ASD diagnoses are more common in males than females (gender ratio of 5:1; CDC, 2014), whereas SAD is more common in females than males (gender ratio of 3:2 in adults; Kessler et al., 2005). In addition, the research team was unaware of any research suggesting that gaze patterns to facial stimuli differ between males and females (e.g., Moukheiber et al., 2010).

Recruitment of university students was campus-wide, with undergraduate and graduate academic advisers from each department alerting their respective students to the research opportunity (see Appendices A, B, C, and D for recruitment materials). The study was also advertised via flyers distributed around campus and electronically on the psychology department's online experiment management system. In addition, flyers were posted in the community and university-affiliated clinics to increase recruitment of individuals who were not students. Adults with ASD were recruited via the university-affiliated Autism Clinic and its

research registry database, the university's office for Services for Students with Disabilities, and local adult ASD support groups.

All participants eligible for course extra credit (17% of the sample) received two credits for study participation. Any participant not eligible for extra credit received a small honorarium. For the first 3 months of data collection, this honorarium was $10 (provided to 28% of the total sample). After receiving additional grant funding for the study, the honorarium was increased to $20 for participants not receiving course credit (55% of sample). This $20 payment was accompanied by gas mileage reimbursement (if applicable) during the last 4 months of data collection, to bolster participant ascertainment.

No previous studies have investigated the vigilance-avoidance eye gaze pattern in adults with ASD and social anxiety. Given the lack of information in this research area, the expected effect size was unknown, so a medium effect size of 0.15 was used in the a priori power analysis. A power analysis using G*Power software (Faul, Erdfelder, Lang, & Buchner, 2007) for a 3 (group: ASD vs. SAD vs. NC) X 3 (emotion: angry vs. disgust vs. happy facial expression) X 8 (time: 0-500 ms vs. 500-1000 ms vs. 1000-1500 ms vs. 1500-2000 ms vs. 2000-2500 ms vs. 2500-3000 ms vs. 3000-3500 ms vs. 3500-4000 ms) repeated-measures ANOVA was conducted, with an alpha of .10 (because directional hypotheses are proposed, and $\alpha = 0.10$ results in $\alpha = 0.05$ for a one-tailed test). The power analysis indicated that $n = 63$ would achieve adequate power (0.82) to detect a medium effect of the interaction, assuming a conservative correlation ($r = 0.3$) among the repeated measures. For the current study, a target sample size of 60 participants (20 per group) was determined to be reasonable and feasible. However, the investigator planned to recruit more participants (up to 30 per group) if possible.

Of the initial sample of 82 participants, 2 participants with SAD and 3 participants with ASD were excluded due to difficulty in obtaining stable eye-tracking (e.g., poor calibration, apparatus malfunction), and 2 participants with ASD were excluded due to IQ scores below 80. Thus, the final sample consisted of 75 participants (25 in each group). Demographic information is presented in Table 1.

2.2 - Measures

Demographic questionnaire. The demographic questionnaire was used to obtain information about the participant's gender, age in years and months, race/ethnicity, educational setting/background, and, if applicable, employment (Appendix E).

Brief clinical intake. During a brief, structured clinical intake, the investigator obtained information about the participant's current functioning and mental health history, including psychological diagnoses, medication use, and behaviors that are diagnostic of ASD (Appendix F).

Cognitive functioning. All participants completed the Wechsler Abbreviated Scale of Intelligence (WASI; Psychological Corporation, 1999), which provides an estimate of verbal, performance, and full scale IQ. The WASI is comprised of four subtests: Vocabulary, Similarities, Block Design, and Matrix Reasoning. It has demonstrated good reliability with individuals aged 6 to 89 years and can be completed in 30 minutes or less.

Gaze patterns. The primary measure of gaze pattern was fixation duration (FD), defined as the total length of time (in ms or s) that a participant fixated on a particular area of interest (AOI), based on the average of both eyes. Consistent with previous eye-tracking studies, a fixation was defined as at least six consecutive data samples, providing a minimum FD of 100 ms. Total FD is regularly used as a measure of preference for looking at one stimulus type over another (e.g., Klin et al., 2002; Rice et al., 2012). To control for individual variations in overall on-screen fixation time, we calculated the proportion of total FD by dividing the time spent fixating on each AOI by the total amount of time fixating on the screen during the corresponding trial.

Based on prior eye-tracking research related to social anxiety (e.g., Buckner, Maner, & Schmidt, 2010; Wieser et al., 2009), we were primarily interested in the proportion of FD to the face AOI,[1] defined as the total face region (i.e., all facial area including the eye region, stopping at hairline). The face AOI was defined prior to data analyses using the oval-shaped AOI tool available in the Tobii T60 (Studio Professional) platform. In addition, an I-VT filter (velocity classifier: 30º/s; velocity calculator window length: 20ms) was applied 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. Although there are some concerns about applying these types of fixation detection algorithms to eye-tracking data from infants, toddlers, or preschoolers due to head movements and other factors (Guillon et al., 2014), the I-VT filter is well-accepted and commonly used for adolescent and adult participants (e.g., Bekele et al., 2013; Swanson & Siller, 2014).

In addition to FD, several other eye gaze metrics were explored as dependent variables.

The area on the stimulus where the participant first fixated was recorded, in order to provide information about what the individual attended to first. Initial orienting towards threat at stimulus onset can provide a measure of vigilance (Armstrong & Olatunji, 2012). Many eye-tracking studies have looked at the direction of initial orienting, analyzing how frequently threatening images capture initial fixations, relative to a neutral image, to calculate the percentage of first fixation on the target picture (e.g., Schofield, Inhoff, & Coles, 2013; Shechner et al., 2013). Speed of initial orienting to particular AOIs, referred to as latency, provides another measure of vigilance. For the current study, latency was defined as the time from stimulus onset to first fixation on a face region, or how long it took for a participant to fixate on a face region for the first time. We also recorded the duration of initial fixation to examine the maintenance of attention to potentially threatening stimuli. Lastly, we recorded fixation count, defined as the number of times the participant fixated on a particular AOI, to capture alternating fixations or switching between two AOIs.

Autism Diagnostic Observation Schedule, Second Edition (ADOS-2; Lord et al., 2012). All participants in the ASD group completed the ADOS-2, a semi-structured, observational assessment of ASD characteristics. Algorithm scores for the Communication and Reciprocal Social Interaction domains support the likelihood of an ASD diagnosis. The ADOS-2 also includes the domains of Imagination/Creativity and Stereotyped Behaviors and Restricted Interests. Module 4 of the ADOS-2, which is designed for verbally fluent adults and older adolescents, was administered by a clinician with established research reliability. A second research reliable rater reviewed a random selection of 7 of the 25 (28%) ADOS-2 videotaped administrations to confirm diagnostic agreement.

Social Responsiveness Scale, Second Edition, Adult Version (SRS-2-A; Constantino & Gruber, 2012). The SRS-2-A is a 65-item self-report measure of ASD-related social impairments, including social awareness, social information processing, reciprocal social communication, social motivation, and restricted interests/repetitive behaviors. Originally validated only for use with children (Constantino & Gruber, 2005), the second edition of the SRS has been modified to include an adult self-report (SRS-2-A), specifically normed for individuals age 19 and up. According to the primary author of the SRS-2 (J. N. Constantino, personal communication, February 9, 2013), the adult self-report form can also be used with older adolescents who do not have intellectual disability. For participants under the age of 19, three of

the SRS-2-A items were slightly re-worded to maintain the original meaning. Specifically, instead of *adults*, the following substitutions (in italics) were made: I interact appropriately with other *people my age*; I avoid starting social interactions with other *people my ag*e; I have difficulty relating to *people my age* outside of my family. The SRS-2-A provides a total T-score and subscale T-scores about the degree of interference in everyday life situations. The SRS-2-A has a T-score range of 59 or less (normal range), 60 to 65 (mild range), 66 to 75 (moderate range), and 76 or greater (severe range). The internal consistency of the SRS-2-A for this study's sample was excellent (alpha = .970).

Autism Spectrum Quotient (AQ; Baron-Cohen et al., 2001). The AQ is a 50-item self-report measure of ASD characteristics that has been used extensively with adults, demonstrating internal consistency and reliability across time and culture (e.g., Austin, 2005; Wheelwright, Auyeung, Allison, & Baron-Cohen, 2010; Appendix G). It assesses behaviors across five domains that are commonly problematic for individuals with ASD: social skills, attention switching, attention to detail, communication, and imagination. All items are rated on a 4-point scale regarding how strongly the respondents agree or disagree that a given statement accurately describes them. AQ items are typically scored in a binary manner, meaning that a response is scored as a one if it is characteristic of ASD (i.e., poor social skill, poor attention-switching, exceptional attention to detail, poor communication skill, and poor imagination) and a zero if it is not characteristic of ASD. Item scores are then summed for a total score that ranges from 0 to 50. Higher scores on the AQ signify more ASD characteristics, and Baron-Cohen et al. (2001) determined the clinical cut-off to be 32 or higher, indicating characteristics in the range of a clinical diagnosis of ASD. This cut-off score was used in the current study to exclude participants in the SAD and NC groups from data analyses, in order to verify that the non-ASD group participants did not have significant ASD symptoms. The AQ was chosen for this purpose instead of the SRS-2 because recent research warns against relying on the SRS to accurately differentiate between ASD and SAD (Cholemkery, Mojica, Rohrmann, Gensthaler, & Freitag, 2014). In the present sample, alpha was .905 for the AQ.

Mini International Neuropsychiatric Interview – Social Phobia module (MINI: Sheehan & Lecrubier, 2006). The MINI is a brief structured diagnostic screening interview developed for the major psychological disorders. The MINI was designed to be an efficient diagnostic screener for current psychiatric problems, for use in research and clinical practice, but

is not intended to be used for diagnostic purposes. The current study utilized the Social Phobia module of the MINI, administered by the study investigator, who had prior experience with using the MINI in a research setting. The Social Phobia section, which includes five "yes" or "no" questions about social concerns and fear of negative evaluation, can be administered in less than 5 minutes. Based on the participant's responses, the interviewer made a rating (No or Yes) as to likelihood of SAD diagnosis.

When compared to a SAD diagnosis on the Structured Clinical Interview for DSM-IV (SCID; First, Spitzer, Gibbon, & Williams, 1997), the MINI demonstrated good sensitivity (.81) and specificity (.86) (Sheehan et al., 1998). The MINI Social Phobia module also has good agreement with diagnoses generated by general practitioners and expert psychiatrists (kappa = 0.66), and it demonstrates excellent interrater reliability (kappa = 0.94).

Anxiety Disorders Interview Schedule for DSM-IV – Social Phobia module (ADIS-IV; Brown et al., 1994). A semi-structured diagnostic interview, the ADIS-IV is one of the most established tools with which to assess anxiety in adults. Although the psychometric properties of the ADIS-IV have not been investigated for adults with ASD, the child and parent version of the ADIS (ADIS-C/P; Silverman & Albano, 1996) has demonstrated reliability and validity in several studies of youth with ASD (Lecavalier et al., 2014). In the current study, the SAD section of the ADIS-IV was administered by clinicians trained to reliability and knowledgeable of distinctions between ASD characteristics and social anxiety symptoms (specific training plan detailed in the Procedures section below). Clinicians assigned a Clinical Severity Rating (CSR) ranging from 0 to 8, with higher scores indicating greater severity and impairment. A CSR ≥ 4 exceeds diagnostic threshold, while a CSR of three is considered sub-threshold. Information about the age of onset of social anxiety symptoms was also collected during the ADIS-IV. One question was added to the module, at the end of the interview, asking the participant to estimate the point in his/her life when social anxiety symptoms were most intense and impairing, to characterize the experience of social anxiety phenomenologically in ASD (exploratory aim).

Brief Fear of Negative Evaluation Scale (BFNE; Leary, 1983). A brief version of the full FNE (Watson & Friend, 1969), this 12-item self-report scale assesses the degree to which people experience worry or fear about negative evaluation from others (Appendix H). Respondents indicate how characteristic each statement is of them on a 5-point scale (from "not at all" to "extremely"). The BFNE correlates highly (.96) with the original scale and has

excellent internal consistency (alpha = .90). The BFNE has frequently been used in previous eye-tracking studies to measure social anxiety (e.g., Buckner, DeWall, Schmidt, & Maner, 2010; Chen & Yoon, 2011; Garner et al., 2006; White, Maddox, et al., 2014). Carleton, Collimore, McCabe, and Antony (2011) found that using only the eight BFNE items with straightforward wording (i.e., not the four reverse-scored items) yields the best diagnostic sensitivity and reliability. As such, only these eight items were summed for the total BFNE score in the current study (alpha = .943).

Social Anxiety Scale for People with ASD (SASPA; Kreiser & White, 2011). The SASPA is an empirically based self-report measure designed explicitly to assess symptoms of social anxiety as they manifest in adolescents and adults with ASD without confounding by core ASD symptoms, such as social avoidance due to disinterest (Appendix I). The SASPA total score is the sum of 31 items, with higher scores indicating greater social anxiety. Items are rated from 1 to 4 regarding the degree to which the respondent experiences each symptom. Although developed based on structured expert opinion and feedback (Kreiser & White, 2011), the SASPA is a new measure and, as such, there are no data available yet on its psychometric properties. In the present sample, internal consistency was excellent (.969).

Social Interaction Anxiety Scale (SIAS; Mattick & Clarke, 1998). A reliable and valid self-report measure of social anxiety in adults, the SIAS assesses general fears of social interaction, such as speaking with someone in authority or saying something embarrassing (Appendix J). The SIAS consists of 20 items that are rated from 0 to 4 regarding the degree to which the respondent feels the given statement is characteristic or true of him or her, with higher scores indicating greater levels of social interaction anxiety. A total score of 34 on the SIAS has been established as the cut-off for clinically significant social anxiety (Heimberg, Mueller, Holt, Hope, & Liebowitz, 1992). Excellent internal consistency ($\alpha = 0.90$) and test-retest reliability (0.92), along with good convergent validity and discriminant validity, have been reported (Mattick & Clarke, 1998; Osman, Gutierrez, Barrios, Kopper, & Chiros, 1998). Consistent with these previous reports, derived internal consistency for the current sample was high (alpha = .953).

Depression Anxiety Stress Scales (DASS-21; Lovibond & Lovibond, 1995). The DASS-21 (Appendix K) is an abbreviated version of the original 42-item DASS. It is a self-report instrument designed to measure the three related negative emotional states of depression

(e.g., dysphoria, hopelessness, anhedonia), anxiety (e.g., physiological hyperarousal, social-evaluative concerns, feelings of panic), and stress (e.g., difficulty relaxing, irritability, impatience) in adolescents and adults. Respondents use a 4-point scale to rate the severity or frequency of each emotional state over the past week. Scores for the Depression, Anxiety, and Stress scales are calculated by summing the scores for the relevant items (7 items per scale). The DASS-21 scales have shown good internal consistency, convergent validity, and discriminant validity (e.g., Henry & Crawford, 2005). In the present sample, internal consistency estimates were acceptable for the Depression scale (alpha = .893), Anxiety scale (alpha = .823), Stress scale (alpha = .859), and Total scale (alpha = .932). All participants completed the DASS-21 because previous eye-tracking research suggests that depression symptoms are associated with attentional biases toward social stimuli (e.g., reduced orienting to positive stimuli; see Armstrong & Olatunji, 2012, for a review).

Ratings of photograph valence and arousal. All participants provided valence and arousal ratings for a randomly selected subset (50%) of the eye-tracking face stimuli. Participants rated each photograph's valence and arousal using a pictorial 9-point scale (0-8) ranging from "very bad/sad" to "very good/happy" for valence and from "calm" to "excited" for arousal.

2.3 - Apparatus and Stimuli

Eye-tracking was completed using a Tobii T60 binocular eye-tracker with a 38 cm thin film transistor (TFT) monitor and Studio 3.2 software. Tobii technology relies on the pupil center corneal reflection technique of eye-tracking (Tobii Technology, 2010). The eye-tracker collected raw eye movement data points every 16.7 ms (i.e., with a stable data accrual rate of 60 Hz) and sent them to the analysis application database on the connected computer. Studio software works well for fixed-duration trial presentations (Morgante, Zolfaghari, & Johnson, 2012), consistent with the current study's eye-tracking paradigm. Two display screens were used during the eye-tracking task. Participants viewed the stimulus displays on the TFT monitor, while the experimenter received real-time feedback about eye gaze location on a second monitor, as a way to evaluate system accuracy throughout the experiment. The TFT monitor was arm-mounted to allow for repositioning to maximize the quality of tracking for each participant. All participants were seated approximately 70 cm from the monitor screen in a darkened room.

Before data collection, the eye-tracking system was calibrated to each participant's eyes to accurately calculate gaze direction. The five-point calibration procedure involved tracking a

blue pulsating circle, which was accompanied by a sound, at five predefined locations across the screen (i.e., the four corners and the center of the screen). The study investigator advanced each step of the calibration once the participant fixated on the target circle. After all five circles appeared, the Tobii eye-tracker provided a pictorial representation of calibration quality, with small dots in the center of each circle representing high quality, and missing dots and/or lines extending from one or more dots representing lower quality. The study investigator visually inspected each display before advancing the participant to the eye-tracking task. Any missing calibration points or points with excessive error were recalibrated to achieve acceptable quality. The calibration procedure generally lasted for less than one minute, ranging from several seconds to a few minutes across participants. The degree of accuracy with this calibration system was 0.5 degrees, with less than 0.3 degrees of visual drift.

Upon completion of the calibration procedure, participants were instructed to simply look at the following faces on the screen (i.e., with no additional behavioral demands). Fifty-six face pairs were presented on a black background to each participant (one pair per trial). Face stimuli were color photographs taken from the NimStim Set of Facial Expressions (Tottenham et al., 2009). The faces represented an equal number of males and females, from different ethnic groups (European-American, African-American, and Asian-American). All face stimuli were selected to have at least 80% rater agreement on the depicted emotions of anger, disgust, and happiness (per Tottenham et al., 2009). The "calm" faces from the NimStim Set were used for the neutral facial stimuli because calm faces are thought to be perceived as less negative or less emotionally significant (Tottenham et al., 2009). According to the stimulus set developers, the calm faces are "essentially neutral faces with less overall muscle tension in the face" (Tottenham et al., 2009, p. 243).

For the first 48 trials, 24 distinct face pairs (8 angry-calm, 8 disgust-calm, 8 happy-calm) were each presented twice in a random order prepared manually by the study investigator, as Tobii technology did not allow an automatic randomization of all experimental stimuli. Each trial contained a pair of photographs of the same actor or actress, with one photo depicting an emotional expression and the other depicting a non-emotional expression, consistent with previous social anxiety eye-tracking research (e.g., Garner et al., 2006; Mogg et al., 2004; Wieser et al., 2009). Each face pair was shown for 4 s, based on other eye-tracking paradigms investigating the vigilance-avoidance hypothesis (e.g., In-Albon et al., 2010). The position of the

emotional face (left- or right-side of screen) was counterbalanced across the trials. Because each face pair depicted the same person, the main difference between the two faces was the emotional valence and not extraneous stimulus variables. Two faces were displayed instead of a single face because research suggests that attentional biases are more likely when more than one presented stimulus competes for attention (In-Albon et al., 2010).

For the last eight trials, participants viewed calm-calm face pairs of eight actors and actresses, with each photograph paired with an identical photograph. These calm-calm face pairings were included to assess participants' visual exploration of non-emotional faces. Instead of distributing these calm-calm presentations throughout the viewing period, they appeared at the end of the experiment because the current study aimed to replicate previous SAD studies with vigilance-avoidance eye-tracking paradigms, and no prior studies have interspersed calm-calm pairs in the stimuli, to the research team's knowledge.

Each face photograph was 18.5 cm long X 14 cm wide, with 3 cm of black screen between the two faces (all subtending 27° visual angle). Prior to each stimulus display, a centered "X" (17 cm long x 14 cm wide; 24° visual angle) appeared on screen for 1 s in order to centralize the participants' attention. Following each photograph pair, a black screen was presented as an inter-trial stimulus. Three different tests of the same stimuli were created, with face stimuli appearing in different orders (pre-selected in a random fashion) following the sequence described above (i.e., "X" – face-pair – black screen, with the eight calm-calm face pairs appearing last).

2.4 - Procedures

All procedures were approved by the university's Institutional Review Board (IRB) prior to beginning data collection (Appendix L). Participants were recruited and compensated using the methods described in the Participants section above. Data collection spanned a 7-month period.

Training of ADIS-IV clinicians. The study's supervising licensed clinical psychologist and four advanced doctoral student clinicians completed a training about administering and scoring the Social Phobia module of the ADIS-IV. The training was conducted by the study investigator and an advanced doctoral student clinician with established research reliability for the ADIS-IV. Training attendees read selected articles about the distinctions between ASD characteristics and SAD symptoms. This information was also presented and discussed during

two group training sessions prior to data collection. The importance of asking the participant follow-up questions to determine whether avoidance was related to evaluative fears or a lack of social interest/motivation was emphasized. During the training sessions, the clinicians independently coded two videotaped ADIS-IV Social Phobia module administrations (one case with ASD and one case without ASD), and then discussed their assigned CSRs as a group.

All clinicians met the reliability standard for the two videotaped cases, providing CSRs within 1 point of the gold-standard CSR, with diagnostic agreement (i.e., a CSR of 3 is not reliable with a CSR of 4 because 3 represents subthreshold symptoms and 4 represents a clinical diagnosis). Each clinician's first ADIS-IV Social Phobia module administration with a participant was observed by the study's supervising licensed clinical psychologist, who provided clinical supervision as needed. Although multiple trained clinicians were available, the study investigator completed the ADIS-IV Social Phobia module with 73 of the 75 participants to maintain consistency across sessions.

In-lab session. All individuals who expressed interest in the study were screened by the study investigator, via a brief telephone interview (Appendix M). For participants under the age of 18, a parent was allowed to complete the telephone screen on his or her child's behalf. The screening questions included five items from the MINI Social Phobia module and a question about having current diagnoses of ASD and/or intellectual disability. Individuals with a reported ASD diagnosis were invited to the in-lab session as part of the ASD group. Individuals without ASD who met criteria for SAD on the MINI were invited to the in-lab session as part of the SAD group. Individuals without ASD who did not meet criteria for SAD on the MINI were invited to the in-lab session as part of the NC group.

The study session was conducted in the psychology department building of a large public university in the Southeastern United States. The session lasted for approximately 2.0 to 2.5 hours for participants in the ASD group and 1.5 hours for participants in the two non-ASD groups. All participants provided informed written consent (or assent, if under age 18) at the start of the study session (Appendices N and O, respectively). Any participant under the age of 18 was accompanied by a parent or legal guardian to provide informed written parental permission (Appendix P). Following consent or assent, participants completed the eye-tracking paradigm. The study investigator, who had over two years of previous experience with running eye-tracking experiments on the Tobii system, oversaw all sessions. Following calibration, participants were

instructed to look at the "X" in the center of the screen until two pictures appeared, and they were told to look at the pictures in any way they wished. The total duration of the eye-tracking procedure was approximately 10 minutes. Any participant interested in seeing the replay of his or her eye-tracking data was given the opportunity to do so immediately after the study session.

Following the eye-tracking paradigm, participants rated a randomly selected subset (50%) of the face stimuli on scales of valence and arousal using E-Prime 2.0 Professional software (Psychology Software Tools, Inc.). They then completed the questionnaires (demographics, SRS-2-A, AQ, BFNE, SASPA, SIAS, and DASS) and cognitive testing (WASI) in a quiet room. After the WASI, participants completed a brief clinical intake and the SAD module of the ADIS-IV. Prior to beginning the interview, the study investigator informed participants that they would be asked specific questions regarding anxiety. Participants were reminded that they could discontinue the study or refuse to answer certain questions if they became uncomfortable.

After the ADIS-IV, participants in the ASD group completed the ADOS-2 to confirm ASD diagnosis. The ADOS-2 administrations were videotaped for later coding by a second rater. All participants received a list of local counseling resources (Appendix Q) at the end of the session, with a statement encouraging them to contact one of the agencies if they would like to talk to someone about personal problems or mental health services.

2.5 - Data Analyses

Data were analyzed with IBM SPSS Statistics Version 21. All variables were assessed for normality and outliers. Descriptive statistics were computed for all demographic variables, IQ scores, and questionnaire data to characterize the sample. The rate of SAD within the ASD group was determined by the ADIS-IV assessment (Hypothesis 1).

Preliminary eye-tracking data analyses. Preliminary analyses focused on the percentage of total viewing time that each participant was on-task, meaning that the participant was gazing at the screen and the Tobii eye-tracker was able to capture the participant's gaze for that time sample. These preliminary analyses aimed to quantify the quality of the collected eye-tracking data and evaluate whether missing eye-tracking data systematically biased our findings. To investigate whether the percentage of on-task time was related to participant group or gender, we conducted an analysis of variance (ANOVA) with on-task time as the outcome. To investigate whether the percentage of on-task time was related to other participant characteristics

(i.e., age, IQ, self-reported social anxiety or depression, ASD characteristics), we computed Pearson bivariate correlations.

Consistent with previous eye-tracking studies using paired stimuli (e.g., Garner et al., 2006), trials during which participants did not fixate on the centered "X" before stimulus onset were excluded from the first fixation analyses. Additional preliminary analyses were conducted to examine if eye gaze patterns differed as a function of participant gender, age, IQ, self-reported depression symptoms, or stimulus face gender, as potential covariates. Given that no specific hypotheses were made regarding gaze toward the eight calm-calm face pairs, these stimuli were included only in preliminary analyses to explore any group differences in FD toward non-emotional, identical paired faces.

Primary eye-tracking data analyses. To investigate group differences in eye gaze patterns, we analyzed several different indicators of visual attention, vigilance, and/or avoidance (Hypothesis 2). These variables are described in more detail in the Measures section above (see Appendix R for a summary of definitions and calculations). For all analyses, the Greenhouse-Geisser correction was used to adjust for sphericity assumption violations when necessary. The uncorrected degrees of freedom and the probability value after correction are reported. Partial eta-squared (η^2_p) and Cohen's *d* values are reported as a measure of effect size for *F* statistics and *t*-tests, respectively. Between-group analyses were conducted with the following eye-tracking dependent variables.

Proportion of FD. We calculated the proportion of total FD to each emotional face region by dividing the time spent fixating on each emotional face region by the total amount of time fixating on the screen during the corresponding trial. Higher proportions indicate greater attention towards the emotional images. We conducted a split-plot ANOVA to examine differences in proportion of FD to the face AOI, with group (3: ASD vs. SAD vs. NC) as a between-subject variable and stimulus emotion (angry vs. disgust vs. happy) as a within-subject variable. To examine the time-course of eye movements, the 4 s of stimulus presentation were subdivided into eight 500 ms intervals (consistent with previous SAD eye-tracking studies; e.g., Buckner, Maner, et al., 2010; Schofield et al., 2012). The proportion of FD on each emotional face was the dependent variable in separate repeated-measures ANOVAs, with group as the between-subjects factor (3: ASD vs. SAD vs. NC) and time (8: 0-500 ms vs. 500-1000 ms vs.

1000-1500 ms vs. 1500-2000 ms vs. 2000-2500 ms vs. 2500-3000 ms vs. 3000-3500 ms vs. 3500 vs. 4000 ms) as the within-subjects factor.

First fixation direction. The proportions of first fixations to each emotional face AOI (i.e., angry, disgust, happy) were averaged across the respective trials. An ANOVA was completed to compare groups (3: ASD vs. SAD vs. NC) on first fixations toward the face regions, with emotion (3: angry vs. disgust vs. happy) as the within-subject factor.

Latency. An ANOVA of the latency data (i.e., time to first fixation on an emotional face region), with group as the between-subject factor (3: ASD vs. SAD vs. NC) and emotion (3: angry vs. disgust vs. happy) as the within-subject factor, was completed.

First fixation duration. An ANOVA of the duration of the first fixation, with group as the between-subject factor (3: ASD vs. SAD vs. NC) and emotion (3: angry vs. disgust vs. happy) as the within-subject factor, was completed.

Fixation count. An ANOVA of the number of fixations to each face region, with group as the between-subject factor (3: ASD vs. SAD vs. NC) and emotion (4: angry vs. disgust vs. happy vs. calm) as the within-subject factor, was completed. To control for individual variations in overall on-screen fixation time, we calculated the proportion of total fixation count by dividing the number of fixations to each AOI by the total number of fixations to the screen during the corresponding trial.

To investigate the relation between fear of negative evaluation and eye gaze patterns within the ASD group only (Hypothesis 3), bivariate and partial (controlling for ASD symptoms as measured by the SRS-2-A) correlations were computed between BFNE score, average FD, and average number of fixations for each facial expression. In a similar manner, bivariate and partial correlations were computed between BFNE scores and FD for the subdivided 500 ms interval eye-tracking data, to explore how social anxiety influences gaze behaviors over time.

Exploratory eye-tracking data analyses. Although the BFNE was the primary self-report measure of social anxiety due to its frequent use in previous SAD eye-tracking studies of the vigilance-avoidance pattern (e.g., Garner et al., 2006; Wieser et al., 2009), the SASPA and SIAS were included in some exploratory eye-tracking analyses. They were substituted for the BFNE in the above analyses as secondary measures of social anxiety, defined more broadly (i.e., not only fear of negative evaluation).

Although the primary analyses were based on the three-group design of ASD vs. SAD vs. NC, we also completed exploratory analyses of the above dependent variables with four groups: ASD with SAD (i.e., ASD group participants who met diagnostic criteria for SAD on the ADIS-IV) vs. ASD without SAD (i.e., ASD group participants who did not meet diagnostic criteria for SAD on the ADIS-IV) vs. SAD vs. NC. Lastly, adopting a dimensional approach, we explored ASD and SAD symptoms continuously using regression analyses with the above eye gaze variables as the dependent variables.

Data analyses with behavioral data. Average valence and arousal ratings of the face stimuli were analyzed with separate ANOVAs, with group as the between-subject factor (3: ASD vs. SAD vs. NC) and emotion (4: angry vs. disgust vs. happy vs. calm) as the within-subject factor (Hypothesis 4). In order to investigate the exploratory aim related to the phenomenology of SAD within ASD, we completed analyses within the ASD group, comparing those with and without SAD on selected participant characteristics. For continuous variables, such as age, IQ, and self-reported social motivation, independent samples *t*-tests were conducted. For categorical variables, such as gender, Pearson's chi-square tests were used when expected cell counts were greater than five, and Fisher's exact tests were used when expected cell counts were less than five. To investigate whether differences exist between individuals with SAD in the ASD group and the non-ASD, SAD group on the social anxiety self-report measures, a multivariate analysis of variance (MANOVA) was completed with group (2: ASD+SAD vs. SAD only) as the predictor and total scores from the BFNE, SASPA, and SIAS as the dependent variables. To illuminate the development or life course of social anxiety, we examined participants' ADIS-IV responses about (1) when their social anxiety symptoms first became impairing, and (2) when their social anxiety peaked in intensity.

Chapter 3 - Results

3.1 - Descriptive Statistics and Preliminary Results

Skewness and kurtosis for all primary variables were within acceptable ranges, and visual inspection of the distribution of all variables indicated no concerns with non-normality or problematic outliers. For the multivariate analyses, the Box's M test of equality of covariance matrices was non-significant, demonstrating that the model assumption of homogeneity of covariances was not violated. Descriptive statistics were computed for all demographic variables to characterize the sample (Table 1). The three groups did not differ in age, $F(2, 72) = 1.81$, $p = .172$ (ASD: *M*age = 22.19 years, *SD* = 7.24; SAD: *M*age = 26.02 years, *SD* = 7.26; NC: *M*age = 24.78 years, *SD* = 7.31). In addition, the ASD group (14 males), SAD group (13 males), and NC group (12 males) did not differ on gender, $\chi^2(2) = .32$, $p = .852$.

Descriptive statistics for the primary eye-tracking variables (by group and emotion) are presented in Table 2. Group descriptive statistics were also computed for all questionnaire, WASI, and ADOS-2 data (see Table 3 for descriptive statistics and significant group differences on the self-report measures). Groups did not differ on full-scale IQ scores, $F(2, 72) = 1.82$, $p = .169$. No participants in the SAD and NC groups exceeded the cutoff on the AQ. All participants in the ASD group exceeded the threshold on the ADOS-2, according to the evaluator's coding. A second research reliable rater agreed with the diagnostic status for 6 of the 7 (86%) randomly selected ADOS-2 videotaped administrations. For the one participant with discrepant ADOS-2 classifications, the project's supervising licensed clinical psychologist recommended his inclusion in the ASD group based on all available data and first-hand clinical experience with the participant.

All participants were successfully calibrated for the eye-tracking task, meaning that their calibration pictorial representation showed detection of gaze within all five predefined areas. All participants also showed on-task percentage scores above 50%, which is a common benchmark within ASD eye-tracking studies for including participants in analyses (e.g., Fischer et al., 2014; Swanson, Serlin, & Siller, 2013). There was a significant difference in on-task percentage scores between groups, $F(2, 72) = 9.80$, $p < .001$, $\eta^2_p = .086$. Participants with ASD demonstrated significantly less on-task time ($M = 76.96\%$, $SD = 16.77$) than participants with SAD ($M = 87.36\%$, $SD = 8.24$), $t(48) = -2.74$, $p = .01$, $d = -.787$, and NC participants ($M = 90.84\%$, $SD =$

6.79), $t(48) = -3.77$, $p = .001$, $d = -1.085$. The SAD and NC groups did not differ on on-task percentage scores, $t(48) = -1.63$, $p = .110$. Across groups, males and females did not differ on on-task percentage scores, $t(73) = 1.17$, $p = .245$. To investigate whether the percentage of on-task time was related to other participant characteristics, we computed Pearson bivariate correlations (Table 4).

Additionally, there was a significant between-group difference in number of trials during which participants did not fixate on the centered "X" before stimulus onset, $F(2, 72) = 10.02$, $p < .001$, $\eta^2_p = .218$. The number of trials excluded because of this criterion was significantly higher for the ASD group (an average of 18.1% of trials per participant), compared to the SAD group (an average of 6.6% of trials per participant), $t(41.44) = 2.44$, $p = .019$, $d = .691$, and the NC group (an average of 1.2% of trials per participant), $t(24.65) = 4.27$, $p < .001$, $d = 1.209$. The number of excluded trials was also higher for the SAD group, compared to the NC group, $t(48) = 2.07$, $p = .044$, $d = .585$.

Additional preliminary analyses were conducted to examine if eye gaze patterns differed as a function of participant gender, age, IQ, self-reported depression symptoms, or stimulus face gender, as potential covariates. No significant differences were found, so the subsequent analyses were conducted without covariates. Similarly, a one-way ANOVA revealed no significant group differences in proportion of FD toward the calm-calm face AOIs, $F(2, 72) = 1.53$, $p = .223$.

3.2 - Rate of SAD within the ASD Group (Hypothesis 1)

Consistent with our stated hypothesis that at least one third of the participants with ASD would present with clinically significant social anxiety, a large proportion (44%) of the participants with ASD met diagnostic criteria for SAD. Table 5 shows the percentage of participants meeting diagnostic criteria for SAD on the ADIS-IV, along with the distribution of assigned CSRs.

3.3 - Group and Emotion Comparisons of Gaze Patterns (Hypothesis 2)

A split-plot ANOVA revealed no interaction effect for the average proportion of FD to the face AOI, $F(4, 144) = .39$, $p = .719$, or main effect of group, $F(2, 72) = 2.64$, $p = .078$. There was, however, a significant main effect of emotion, $F(2, 144) = 6.80$, $p = .007$, $\eta^2_p = .086$ (Figure 1). Pairwise comparisons with Bonferroni correction revealed that the average proportion of FD was significantly less toward disgust face regions ($M = .46$, $SD = .13$), relative to happy face regions ($M = .51$, $SD = .10$), $p = .014$, $d = -.431$. The proportion of FD toward angry face regions

(M = .47, SD = .11) was not significantly different from disgust (p = .287) or happy (p = .062) face regions.

To examine the time-course of possible vigilance and disengagement toward emotional faces, proportion of FD on the emotional face across each of the eight 500 ms epochs was examined. A repeated-measures ANOVA on the proportion of FD toward disgust face regions, with group as the between-subjects factor (3: ASD, SAD, NC) and time (8 epochs) as the within-subjects factor, revealed a non-significant interaction, $F(14, 504) = .68$, $p = .713$, and no significant main effect of group, $F(2, 72) = .86$, $p = .429$. Only the main effect of time was statistically significant, $F(7, 504) = 40.43$, $p < .001$, $\eta^2_p = .360$. The same analysis was conducted for the time-course of FD proportion toward anger face regions and happy face regions. The same pattern of results was found for FD proportion toward anger face regions, with only the main effect of time as significant, $F(7, 504) = 38.84$, $p < .001$, $\eta^2_p = .350$. As displayed in Figures 2 and 3, respectively, all three groups spiked in proportion of FD to disgust and anger face regions during the second epoch (500-1,000 ms) and then progressively disengaged their attention throughout the rest of the trial. Figure 4 displays the time-course of FD proportion toward happy face regions, which did not show the same clear pattern of progressive disengagement, compared to the disgust and anger face regions. The repeated-measures ANOVA with FD proportion toward happy face regions also revealed a different pattern of results. Although the interaction of groupXtime was still non-significant for happy face regions, the main effect of group was significant, $F(2, 72) = 5.57$, $p = .006$, $\eta^2_p = .134$, along with the significant main effect of time, $F(7, 504) = 49.82$, $p < .001$, $\eta^2_p = .409$. Pairwise comparisons with Bonferroni correction revealed that participants with ASD had significantly reduced FD proportion toward happy face regions across time (M = .46, SD = .11), relative to SAD participants (M = .53, SD = .07), p = .020, d = -.759 and NC participants (M = .53, SD = .08), p = .012, d = -.728.

Separate analyses of the first fixation direction (i.e., proportion of first fixations on emotional face regions) and first FD (i.e., duration of initial fixation) revealed no significant group, emotion, or interaction effects. Analysis of the latency data (i.e., time to first fixation on an emotional face region) revealed no interaction effect, $F(4, 144) = .44$, $p = .778$, or main effect of emotion, $F(2, 144) = .45$, $p = .641$. There was, however, a significant main effect of group, $F(2, 72) = 3.43$, $p = .038$, $\eta^2_p = .087$ (Figure 5). According to pairwise comparisons with

Bonferroni correction, participants with ASD demonstrated significantly longer latency to fixate on emotional face regions across emotions (M = .77 s, SD = .22), compared to NC participants (M = .63 s, SD = .15), p = .029, d = .744. Latency to fixate on emotional face regions for participants with SAD (M = .70 s, SD = .20) was not significantly different compared to participants with ASD (p = .359) or NC participants (p = .432).

Lastly, we examined the percentage of fixations to face regions, given that fixation count may be a proxy for alternating fixations or switching between two AOIs. ANOVA revealed no significant interaction between group (3: ASD vs. SAD vs. NC) and emotion (4: angry vs. disgust vs. happy vs. calm), $F(6, 216) = .99$, p = .408. However, the main effect of group was significant, $F(2, 72) = 3.86$, p = .026, η^2_p = .097 (Figure 6). Planned pairwise comparisons with Bonferroni correction indicated that participants with ASD made significantly fewer fixations to face regions (relative to total number of captured fixations during corresponding trials) across all emotions (M = .43, SD = .05), compared to SAD participants (M = .46, SD = .03), p = .046, d = -.728. Fixation count to face regions for NC participants (M = .45, SD = .03) was not significantly different compared to participants with ASD (p = .070) or SAD participants (p = .999). In addition, the main effect of emotion was significant, $F(3, 216) = 9.00$, $p < .001$, η^2_p = .111. Across groups, participants made significantly fewer fixations to calm face regions (M = .41, SD = .06), compared to happy face regions (M = .48, SD = .08), $p < .001$, d = -.990, and anger face regions (M = .46, SD = .09), p = .032, d = -.654. Participants also made significantly fewer fixations to disgust face regions (M = .45, SD = .09), compared to happy face regions, p = .042, d = -.352.

3.4 - Fear of Negative Evaluation and FD within ASD (Hypothesis 3)

As shown in Table 6, ASD symptom severity (as measured by the SRS-2-A) was significantly related to self-reported fear of negative evaluation (as measured by the BFNE) for participants with ASD. Self-reported fear of negative evaluation (BFNE) was not correlated with average FD or number of fixations for any face regions (happy, anger, disgust, or calm) within the ASD group. Controlling for ASD severity did not significantly change the strength of these correlations (Table 6). BFNE scores were also not significantly related to average face region FD within the individual 500 ms epochs, with or without controlling for ASD severity.

3.5 - Valence and Arousal Ratings (Hypothesis 4)

An ANOVA revealed no significant groupXemotion interaction for average valence ratings of the face stimuli, $F(6, 216) = 1.09$, $p = .365$, or main effect of group, $F(2, 72) = 1.91$, $p = .155$. There was, however, a significant main effect of emotion, $F(3, 216) = 18.36$, $p < .001$, $\eta^2_p = .718$ (Figure 7). Pairwise comparisons with Bonferroni correction revealed that participants rated the valence of happy faces ($M = 6.03$, $SD = 1.24$) significantly higher (i.e., more positively) than the valence of anger faces ($M = 2.54$, $SD = 1.32$), $p < .001$, $d = 2.725$, disgust faces ($M = 2.63$, $SD = 1.37$), $p < .001$, $d = 2.602$, and calm faces ($M = 3.66$, $SD = .84$), $p < .001$, $d = 2.238$. Participants also rated the valence of calm faces more positively than anger faces, $p < .001$, $d = 1.012$, and disgust faces, $p < .001$, $d = .906$. Average valence ratings of anger and disgust faces were not significantly different from each other, $p = .999$.

The analysis of average arousal ratings of the face stimuli also found no significant groupXemotion interaction, $F(6, 216) = 1.55$, $p = .335$, or main effect of group, $F(2, 72) = 2.63$, $p = .079$. There was a significant main effect of emotion, $F(3, 216) = 17.54$, $p < .001$, $\eta^2_p = .277$ (Figure 8). Pairwise comparisons with Bonferroni correction revealed that participants rated happy faces significantly less arousing ($M = 3.96$, $SD = 1.80$) than both anger faces ($M = 4.96$, $SD = 1.46$), $p < .001$, $d = -.610$, and disgust faces ($M = 4.79$, $SD = 1.57$), $p = .007$, $d = -.491$. Participants also rated calm faces significantly less arousing ($M = 3.35$, $SD = 1.22$) than both anger faces, $p < .001$, $d = -1.196$, and disgust faces, $p < .001$, $d = -1.024$. Participants' arousal ratings did not significantly differ between anger and disgust faces, $p = .338$, or between happy and calm faces, $p = .059$.

3.6 - Exploratory Eye-Tracking Results

Secondary measures of social anxiety. The SASPA and SIAS were substituted for the BFNE in the previously described within-ASD analyses as secondary, broader-based measures of social anxiety. Similar to the BFNE results, there were no significant correlations between the SASPA or SIAS and average FD or number of fixations for any face regions (happy, anger, disgust, or calm) within the ASD group (Table 6). Controlling for ASD severity did not significantly change the strength of these correlations. SASPA and SIAS scores were also not significantly related to average face region FD within the individual 500 ms epochs, with or without controlling for ASD severity.

Four-group comparisons. We completed exploratory analyses of the above primary eye-tracking variables with four groups: ASD with SAD (i.e., ASD group participants who met

diagnostic criteria for SAD on the ADIS-IV; $n = 11$) vs. ASD without SAD (i.e., ASD group participants who did not meet diagnostic criteria for SAD on the ADIS-IV; $n = 14$) vs. SAD ($n = 25$) vs. NC ($n = 25$). A split-plot ANOVA revealed no interaction effect for the average proportion of FD to the face AOI, $F(6, 142) = .26$, $p = .888$, or main effect of group, $F(3, 71) = 2.39$, $p = .076$. There was, however, a significant main effect of emotion, $F(2, 142) = 4.62$ $p = .027$, $\eta^2_p = .061$ (Figure 9). Pairwise comparisons with Bonferroni correction revealed that average proportion of FD was significantly reduced toward disgust face regions ($M = .46$, $SD = .13$), relative to happy face regions ($M = .51$, $SD = .10$), $p = .046$, $d = -.431$. The proportion of FD toward angry face regions ($M = .47$, $SD = .11$) was not significantly different from disgust ($p = .403$) or happy ($p = .178$) face regions.

A repeated-measures ANOVA of the proportion of FD toward the disgust face AOI, with the four groups and eight epochs of time, revealed a non-significant interaction, $F(21, 497) = .50$, $p = .920$, and no significant main effect of group, $F(3, 71) = 1.01$, $p = .394$. Only the main effect of time was statistically significant, $F(7, 497) = 36.40$, $p < .001$, $\eta^2_p = .339$. The same pattern of results was found for FD proportion toward anger face regions, with only the main effect of time as significant, $F(7, 497) = 33.33$, $p < .001$, $\eta^2_p = .319$. As displayed in Figures 10 and 11, respectively, all four groups spiked in proportion of FD to disgust and anger face regions during the second epoch (500-1,000 ms) and then progressively disengaged their attention throughout the rest of the trial. Figure 12 displays the time-course of FD proportion toward happy face regions for the four groups, which did not show the same clear pattern of progressive disengagement, compared to the disgust and anger face regions. Although the interaction of groupXtime was still non-significant for happy face regions, the main effect of group was significant $F(3, 71) = 4.29$, $p = .008$, $\eta^2_p = .153$, along with the significant main effect of time, $F(7, 497) = 40.73$, $p < .001$, $\eta^2_p = .365$. Pairwise comparisons with Bonferroni correction revealed that participants with ASD+SAD had significantly reduced FD proportion toward happy face regions across time ($M = .43$, $SD = .13$), relative to SAD participants ($M = .53$, $SD = .07$), $p = .020$, $d = -.958$, and NC participants ($M = .53$, $SD = .08$), $p = .013$, $d = -.926$. No other group differences were found.

Consistent with the three-group analyses, the four-group analyses revealed no significant group, emotion, or interaction effects for first fixation direction or first FD. Analysis of the latency data also did not reveal significant effects, although the trend of the group effect was

similar to the significant group effect from the three-group analyses, $F(3, 71) = 2.32$, $p = .083$, $\eta^2_p = .089$ (Figure 13).

The four-group analysis of fixation count data revealed no significant groupXemotion interaction, $F(9, 213) = 1.17$, $p = .329$. However, the main effect of group was significant, $F(3, 71) = 3.23$, $p = .028$, $\eta^2_p = .120$ (Figure 14). According to pairwise comparisons with Bonferroni correction, participants with ASD+SAD made significantly fewer fixations to face regions across all emotions ($M = .42$, $SD = .07$), compared to SAD participants ($M = .46$, $SD = .03$), $p = .039$, $d = -.743$. No other group comparisons were significant. In addition, the main effect of emotion was significant, $F(3, 213) = 5.33$, $p = .009$, $\eta^2_p = .07$. Across groups, participants made significantly fewer fixations to calm face regions ($M = .41$, $SD = .06$), compared to happy face regions ($M = .48$, $SD = .08$), $p < .001$, $d = -.990$. No other significant differences between emotions were found.

Dimensional approach with ASD and SAD symptoms. Adopting a dimensional approach, we explored ASD symptoms (as measured by the SRS-2-A) and SAD symptoms (as measured by the BFNE) continuously within the full sample ($n = 75$), using a series of multiple linear regression analyses with the above eye gaze variables as the dependent variables. Only two significant relationships were found: greater ASD symptoms significantly predicted (1) reduced FD toward the happy face region (relative to total FD toward screen), $\beta = -.41$, $t(73) = -3.34$, $p = .001$, $d = -.782$, and (2) reduced count toward the happy face region (relative to total number of captured fixations during corresponding trials), $\beta = -.44$, $t(73) = -3.60$, $p = .001$, $d = -.843$.

3.7 - Phenomenology of SAD within ASD (Exploratory Aim)

Within the ASD group, we compared those with and without SAD to better understand the phenomenology of SAD in the context of ASD (Table 7). Qualitatively, of the 14 participants without SAD (i.e., ASD-SAD), many expressed a dislike of, or disinterest in, social situations, but they reported no explicit fear of negative evaluation by others. As expected, participants with ASD and co-occurring SAD (i.e., ASD+SAD) had significantly higher scores on the three self-report social anxiety measures, relative to participants without SAD. In addition, participants with SAD demonstrated significantly higher verbal IQ scores and DASS-Stress subscale scores than participants without SAD. On the SRS-2-A, participants with SAD reported higher (i.e.,

more severe) scores on the Social Communication, Social Motivation, and Total scales, relative to participants without SAD.

We also completed between-group analyses to investigate whether the ASD+SAD group differed from the non-ASD, SAD group (i.e., SAD only) in any meaningful ways related to social anxiety symptomatology. The MANOVA of total scores from the BFNE, SASPA, and SIAS was significant, $F(3, 32) = 3.96$, $p = .017$; Pillai's trace = .270, $\eta^2_p = .270$. The tests of between-subjects effects indicated that the effect of group was only significant for SIAS scores, $F(1, 34) = 8.15$, $p = .007$, $\eta^2_p = .193$. Participants in the ASD+SAD group had significantly higher SIAS scores ($M = 54.45$, $SD = 9.15$) relative to the SAD only group ($M = 44.56$, $SD = 9.76$). Group did not predict BFNE scores, $F(1, 34) = .42$, $p = .521$, or SASPA scores, $F(1, 34) = 1.40$, $p = .244$.

Additional between-group comparisons were conducted with the ADIS-IV data. As displayed in Figure 15, the greatest proportion of participants in the SAD only group first developed impairing social anxiety during elementary school. Participants in the ASD+SAD group reported the highest rates of initial social anxiety during elementary school and middle school. As displayed in Figure 16, social anxiety symptoms tended to maximally intensify during adolescence or later for both groups (i.e., during college for participants without ASD and during high school for participants with ASD). Participants' qualitative descriptions about the contributory factors underlying their social anxiety revealed common themes of peer victimization (reported in 27% of ASD+SAD group and 16% of SAD only group), limited friendships (reported in 18% of ASD+SAD group and 16% of SAD only group), and family pressures (reported in 9% of ASD+SAD group and 28% of SAD only group). Furthermore, 55% of the participants with ASD+SAD emphasized the role of social skill impairment in the development and maintenance of their social anxiety symptoms. For example, one male reported: "I don't know what to do at a party. I have no idea how to keep a conversation going. I might ramble, and then people will judge me and think I'm odd or stupid."

During the ADIS-IV, the participants with ASD+SAD endorsed the following as their most feared social situations, on average, ranked from the most highly endorsed: (1) attending parties, (2) formal speaking, and (3) being assertive to ask others to change their behavior. The participants with SAD only endorsed the following as their most feared social situations, on average, ranked from the most highly endorsed: (1) formal speaking, (2) being assertive to ask

others to change their behavior, and (3) speaking with unfamiliar people. The least feared situations for both groups included (1) using public restrooms, (2) writing in public, and (3) eating in public.

Chapter 4 - Discussion

This study sought to assess the influence of co-occurring social anxiety on gaze patterns in adults with ASD. In addition, this study marks one of the first thorough characterizations of social anxiety symptomatology in adults with diagnosed ASD, through reports from the participants and clinicians, as well as multiple methods (i.e., questionnaires, diagnostic interview, and eye-tracking) that collectively assess all three dimensions (i.e., physical, behavioral, and cognitive) of social anxiety (Mesa et al., 2011).

Consistent with our hypothesis that a greater proportion of adults with ASD would meet diagnostic criteria for SAD than what is typically seen in epidemiological studies (Hypothesis 1), a large subset (44%) of the participants with ASD met diagnostic criteria for SAD. This high rate of SAD is particularly striking given the non-treatment-seeking nature of the sample. Previous estimates of SAD in adults with ASD have come from clinically referred samples (e.g., Joshi et al., 2013). Participants with ASD in the current study were not recruited for reasons related to social anxiety; their recruitment information only specified an ASD diagnosis and age between 16-45 years as inclusionary criteria (Appendix A). Despite differences in participant ascertainment, the observed rate of 44% for SAD is similar to Joshi et al. (2013)'s finding that 40% of clinically referred adults with ASD met diagnostic criteria for SAD. Of the 14 participants without SAD in the current sample, many expressed a dislike of or disinterest in social situations, but they reported no explicit fear of negative evaluation by others. The DSM-5 (APA, 2013) places an increased emphasis, relative to prior versions of the manual, on the role of fear of negative evaluation by others in the diagnostic criteria for SAD (Heimberg et al., 2014). The participants with ASD and SAD in the current study explicitly expressed a desire for social interaction, along with a fear of negative evaluation by others, the hallmark feature of SAD. This finding provides support for SAD being a separable phenomenon in ASD, which has important clinical implications as clinicians working with people with ASD struggle to tease apart social disinterest or lack of social motivation from active avoidance of social interactions due to social anxiety (e.g., White, Schry, et al., 2014).

To investigate the effects of participant group and stimuli emotion on eye gaze patterns, we analyzed several different indicators of visual attention, vigilance, and/or avoidance. Contrary to our prediction (Hypothesis 2), eye-tracking results did not support the vigilance-avoidance

model of social anxiety. The majority of analyses found no significant relationships between social anxiety, either dichotomously (based on ADIS-IV diagnosis) or dimensionally (BFNE, SASPA, or SIAS total score) measured, and the various eye gaze metrics. There are numerous explanations for why we did not find support for the vigilance-avoidance model of social anxiety. Most notably, the empirical study of the vigilance-avoidance model with eye-tracking technology is relatively new, with only a few published reports confirming this pattern with socially anxious participants (i.e., Garner et al., 2006; Wieser et al., 2009). Since the start of the current study, there has been more research examining the relationship between social anxiety and eye gaze patterns, with little support for both vigilance and avoidance mechanisms (e.g., Armstrong & Olatunji, 2012; Schofield et al., 2013). In light of this growing body of eye-tracking results that do *not* support the vigilance-avoidance model of social anxiety, it is important to consider whether alternative experimental paradigms are needed to detect this pattern, or whether the seminal vigilance-avoidance eye-tracking studies are examples of a 'false positive' finding.

Previous eye-tracking studies have also varied in sample composition, experimental tasks, and analytic approaches. Although the current study aimed to maintain consistency with the methods of other adult social anxiety eye-tracking studies, certain confounds are still possible, making systematic comparisons difficult. For example, few studies report data on medication status of participants, as well as on additional affective disorders (e.g., other anxiety disorders, depression), which have been shown to affect eye gaze patterns (e.g., Sears, Thomas, LeHuquet, & Johnson, 2010; Shechner et al., 2013; Toh, Rossell, & Castle, 2011). Another key difference between the current study and one of the earliest eye-tracking studies showing vigilance-avoidance (Garner et al., 2006) is that Garner and colleagues included a social stress induction, telling participants that they would be giving a videotaped speech after the eye-tracking task. The current study did not include a manipulation of social-evaluative stress.

Recent research also suggests that individuals with SAD show significant within-group variation in attentional biases to social threat, meaning that some may show vigilance, some may show avoidance, some may show a combination of vigilance and avoidance, and some may show neither (e.g., Turkel, 2013). This within-group variability may mask meaningful differences and produce non-significant findings when investigating the relationship between social anxiety and

eye gaze patterns. Although the current study was underpowered to examine SAD subgroupings based on patterns of visual attention, this is a fascinating area for future research.

Lastly, there is a possibility that response bias affected eye-tracking results. More specifically, it has been suggested that participants' knowledge that their gaze patterns are recorded by the eye-tracker may influence their gaze behavior during the experiment (Weeks, Howell, & Goldin, 2013). Perhaps participants put forth effort to visually explore the entire screen and examine both presented faces during each trial. The potential for this bias has led some researchers to covertly use eye-tracking technology during their studies, claiming that this approach provides "enhanced ecological validity" (Weeks et al., 2013, p. 750). However, response bias was not accounted for in previous eye-tracking studies finding vigilance-avoidance patterns, so it is not a likely confound in the present study.

For all groups, there was an effect of stimulus emotion on proportion of FD to the face AOI, with participants demonstrating significantly shorter FD to disgust face regions, relative to happy face regions. Similarly, participants made significantly fewer fixations to disgust face regions, compared to happy face regions. One potential reason for this pattern of reduced fixations (both in terms of duration and frequency) toward disgust faces could be related to participants finding these facial expressions more aversive, or less pleasant, relative to happy facial expressions. Although this explanation is supported by the participants' valence and arousal ratings of the disgust and happy faces, we would expect anger faces to also reveal reduced fixations based on these subjective ratings, but this effect was specific to disgust faces.

The ASD group displayed several differences in gaze patterns, compared to the non-ASD groups. Relative to NC participants, participants with ASD demonstrated significantly longer time to fixate on face regions, regardless of the emotion expressed, which is consistent with previous eye-tracking research examining latency (e.g., Freeth, Chapman, Ropar, & Mitchell, 2010; Riby & Hancock, 2009a). A related finding is that participants with ASD made significantly fewer fixations to face regions (relative to the total number of captured fixations during corresponding trials) across all emotions, compared to SAD participants. This longer latency and reduced fixation count to facial stimuli within ASD could reflect impaired social orienting ability, reduced preference for faces, or slower processing of the presented scene.

Results also suggest that there may be something unique about happy faces when considering visual attention within ASD. For the time-series analysis, participants with ASD

showed significantly reduced FD toward happy face regions across time, compared to both non-ASD groups. Importantly, this difference may be driven by the presence of social anxiety within the context of ASD, as supported by the four-group analyses of eye gaze patterns. When the participants with ASD were dichotomized based on SAD diagnosis (ASD+SAD n = 11; ASD-SAD n = 14) and compared to the SAD and NC groups on the 500 ms epoch data, the only significant group difference for FD came from the ASD+SAD group, who had significantly reduced FD toward happy face regions, relative to both non-ASD groups. One possible explanation is that the participants with ASD+SAD found the smiling faces threatening and therefore avoided them, relative to the non-ASD groups. This pattern of visually avoiding happy faces could be related to the fear of *positive* evaluation, which has recently been related to the maintenance of social anxiety (Weeks, Heimberg, Rodebaugh, & Norton, 2008). According to the bivalent fear of evaluation model (Weeks & Howell, 2012), fear of positive evaluation is an important construct within SAD because information conveying social approval (e.g., a smiling facial expression) also conveys threat by making a socially anxious person feel conspicuous or self-conscious.

However, the current findings are not entirely consistent with the fear of positive evaluation hypothesis. That is, the current study did not replicate recent research finding that typically developing (i.e., non-ASD) participants with SAD disengage more readily from happy faces or attend less to happy faces, relative to non-anxious controls (e.g., Chen, Clarke, MacLeod, & Guastella, 2012; Schofield et al., 2013). The current results are, however, consistent with other studies showing no relationship between social anxiety and gaze patterns to positive stimuli in typically developing samples (e.g., Buckner, Maner, et al., 2010; Gamble & Rapee, 2010). Thus, these findings, although preliminary, suggest that social anxiety within the context of ASD may affect gaze patterns to happy faces in a different way than social anxiety in typically developing individuals.

A competing explanation is that participants with ASD are not specifically avoiding happy faces, but rather have reduced social orienting to all faces, relative to non-ASD participants, and their co-occurring social anxiety leads to increased attending to potentially threatening social stimuli (i.e., anger and disgust faces). In other words, participants with ASD in this study tended to orient less quickly toward faces on average (i.e., longer latency), relative to the NC participants, but the co-occurring social anxiety made them more attentive to anger and

disgust faces, disguising the ASD vs. non-ASD group difference to these negative stimuli and revealing the group difference to positive stimuli. Unfortunately, it is impossible to directly compare these preliminary results to other studies because the exploration of how gaze patterns relate to co-occurring SAD in adults with ASD is so novel.

Although not a specific hypothesis of the current study, it is important to note that we did not find support for one of the most frequently reported differences in ASD eye-tracking research – namely, that participants with ASD fixate significantly less on faces (i.e., shorter FD) than do typically developing control participants (e.g., Riby & Hancock, 2008; Rice et al., 2012). Instead, we found that participants with ASD did not differ in FD toward face regions, compared to the SAD and NC groups. This finding is consistent with recent research challenging the common assumption that individuals with ASD demonstrate decreased attention to social stimuli, relative to typically developing individuals (e.g., Fischer et al., 2014; Guillon et al., 2014; Parish-Morris et al., 2013). The composition of our ASD sample may explain the lack of a significant group effect. First, the ASD group included a larger proportion of females (44%) than previous eye-tracking studies, which tend to more closely match the expected male-to-female gender ratio of ASD (i.e., 5:1; CDC, 2014). The current university provided a unique recruitment source with its focus on enrolling female students into its strong engineering and computer science programs, academic areas that often attract individuals with ASD or high levels of ASD characteristics (Baron-Cohen et al., 2001; White et al., 2011). In addition, our ASD sample was high-functioning, both in terms of cognitive abilities (M = 107.60, SD = 16.44, range = 80-141) and educational achievement (32% were current college students, 32% had obtained a college degree, and 12% were current graduate students). Recent research has demonstrated that higher verbal IQ and better adaptive communication skills in participants with ASD predict eye gaze patterns similar to those of typically developing participants (Falck-Ytter, von Hofsten, Gillberg, & Fernell, 2013). Although some studies with high-functioning ASD samples have found the expected pattern of reduced FD toward social stimuli (e.g., Rice et al., 2012), it is possible that the samples considered ‘high functioning’ are not equivalently so. As such, likely explanations for the current study’s finding of no group effect on FD include (1) the composition of the sample, (2) the amount of missing data for participants with ASD, and (3) the nature of the experimental stimuli.

In the current study, we calculated and reported the percentage of total viewing time that each participant was on-task, meaning that the participant was gazing at the screen and the Tobii eye-tracker was able to capture the participant's gaze for that time sample. Participants with ASD demonstrated significantly less on-task time (M = 76.96%) than participants with SAD (M = 87.36%) and NC participants (M = 90.84%). Our analytic approach accounted for these varying amounts of missing data by calculating proportions of FD and fixation count, dividing total FD or fixation count by the total FD or total number of fixations, respectively, on the screen during the corresponding trial (Appendix R). If we had not controlled for these individual variations in overall on-screen fixation time, participants with ASD would have demonstrated significantly less FD toward the face stimuli, relative to the SAD and NC groups, because their overall on-screen FD was significantly less.[2] Inconsistencies in eye gaze metrics across studies (e.g., total FD to AOI vs. proportion of FD to AOI) interfere with the ability to compare results across similar eye-tracking paradigms.

The current findings related to on-task time raise an important question: why did the eye-tracker capture significantly fewer gaze points for the ASD group? Data quality is typically affected by one or more of three primary sources, including equipment error, experimental arrangement, and participant characteristics (Blignaut & Wium, 2014). We have no reason to suspect that the Tobii equipment functions differently with participants with ASD, relative to non-ASD participants, and the experimental setup was constant across all participants. In terms of participant characteristics, on-task time was positively related to IQ and chronological age, and negatively related to self-reported ASD characteristics (AQ and SRS-2-A) and self-reported social anxiety without confounding by core ASD symptoms (SASPA). Although not directly measured in the current study, it is interesting to consider whether the participants with ASD possess any characteristics that contribute to their lower on-task time, such as increased distractibility by stimuli not on the computer screen. It is unknown whether participants with ASD demonstrated less on-task time due to distractibility, reduced interest in the social stimuli, active avoidance of the facial stimuli due to heightened arousal, or a combination of these factors. Support for the hypothesis that heightened arousal contributed to less on-task time comes from a study by Noris, Nadel, Barker, Hadjikhani, and Billard (2012). Their participants with ASD exhibited an increased number of downward gaze movements when viewing social stimuli, relative to typically developing participants. According to Noris and colleagues, this higher

frequency of downward gaze, in addition to lateral gaze, is a result of the participants' sensory overload or hypersensitivity to sensory input, which is included in the revised diagnostic criteria for ASD (APA, 2013).

Static face pairs were chosen for the current study's eye-tracking stimuli to most closely match the methodology from previous social anxiety eye-tracking research (e.g., Garner et al., 2006; Wieser et al., 2009). However, many of the ASD eye-tracking studies that have demonstrated reduced FD to faces included dynamic stimuli, more complex social scenes, and/or social stimuli paired with non-social stimuli as a comparison (e.g., Hanley et al., 2013; Riby & Hancock, 2009b). A common criticism of static photographs in eye-tracking research is that they diminish resemblance to a natural, live social context with other people. However, it is interesting to note that several studies have investigated the effect of static vs. interactive dynamic facial stimuli on gaze patterns and found a high degree of stability across conditions with ASD samples (Falkmer, Bjällmark, Larsson, & Falkmer, 2011; Horlin et al., 2013) and typically developing samples (Falkmer et al., 2011). In other words, visual scanning patterns (as measured by average FD and number of fixations to specific AOIs) remained unchanged at the group level between static and dynamic facial stimuli. This research is highlighted here because it suggests that studies with static facial stimuli can provide important information on visual attention that may also apply to more real-world settings.

Contrary to our prediction (Hypothesis 3), self-reported fear of negative evaluation was not positively associated with average FD or average number of fixations to faces depicting disgust and anger within the ASD group. Correlations remained non-significant when controlling for ASD symptoms (as measured by the SRS-2-A). These findings are inconsistent with our research team's recent eye-tracking study with adolescents with ASD, which found that greater self-reported fear of negative evaluation was associated with longer gaze duration to disgust and anger face AOIs (White, Maddox, et al., 2014). The positive relationships were even stronger when controlling for ASD severity (as measured by the parent-report version of the SRS). These discrepant findings between an adolescent sample and an adult sample may reflect developmental differences or a developmental change pattern in gaze patterns.

Participants' valence and arousal ratings of the face stimuli supported our hypothesis (Hypothesis 4) that groups would not differ in these subjective ratings. Across groups, participants rated the valence of happy faces more positively than anger, disgust, and calm faces.

Calm faces were also rated more positively than anger and disgust faces. In addition, participants rated happy and calm faces as less arousing than anger and disgust faces. Anger and disgust faces did not differ in terms of valence and arousal. Overall, these ratings support our selection of disgust and anger faces as the socially threatening stimuli. They also confirm that group differences in eye gaze patterns are not better explained by varying perceptions of facial valence and arousal. Recent eye-tracking research (e.g., Schofield et al., 2013) has cautioned against making assumptions about which stimuli are perceived by participants as threatening, emphasizing the value of future work with participants' ratings, as highlighted in the current study's methodology. The valence and arousal findings are also important in light of researchers questioning whether neutral faces should be used as non-threatening comparison stimuli (e.g., Eack, Mazefsky, & Minshew, 2014; Tottenham et al., 2014; Yoon & Zinbarg, 2007). Although these studies have suggested the possibility that ambiguous, neutral faces may be perceived as threatening by participants with social anxiety or ASD, the current study's participants rated the valence of calm faces as more positive than anger and disgust faces, and the arousal level of calm faces did not differ from that of happy faces.

To better understand the phenomenology of SAD within ASD (exploratory aim), we explored the manifestation of SAD, both within the ASD group and between the ASD group vs. the SAD (without ASD) group. Within the ASD group, participants with SAD had significantly higher verbal IQ scores than participants without SAD, which may reflect an increased ability to articulate fear of negative evaluation. Concern for others' opinions of self and excessive concern about negative evaluation are key factors when distinguishing between a lack of social interest or motivation and the presence of social anxiety. ASD group participants with SAD also had significantly higher DASS-Stress subscale scores than participants without SAD, which is not surprising given that the DASS-Stress subscale assesses the cognitive, subjective symptoms of anxiety (e.g., difficulty relaxing, impatience; Lovibond & Lovibond, 1995). No statistically significant group differences were found for the depression and anxiety subscales of the DASS, although this is likely due to the small sample size.

On the SRS-2-A, participants with ASD+SAD reported higher scores (i.e., more impairment) on the Social Communication, Social Motivation, and Total scales, relative to participants with ASD-SAD. The Social Communication scale assesses impairment in communicating or interacting with others (e.g., talking in a monotone voice, not answering

questions directly, struggling to make friends), and the Total scale provides a summary score of ASD-related impairments. Therefore, the finding that these two scales were positively related to SAD within ASD is consistent with the bi-directional model of social impairment and social anxiety (White et al., 2013). The relationship between the Social Motivation scale and SAD within ASD requires more explanation because one might expect that individuals with less impaired social motivation (i.e., greater social motivation or a lower SRS-2-A Social Motivation scale score) would experience more social anxiety, but the opposite result was found. Unfortunately, the Social Motivation scale of the SRS-2-A greatly confounds the measurement of social motivation, with the majority of items overlapping with the measurement of social anxiety (e.g., I am much more tense in social settings than when I am by myself; I feel self-confident when interacting with others [reversed coded]; I do not join group activities or social events unless prompted or strongly urged to do so; I avoid starting social interactions with other adults). A high score on this Social Motivation scale appears to more accurately reflect discomfort or tension in social situations, frequent social avoidance, and poor self-confidence, aspects that are not surprisingly related to SAD within ASD.

Additionally, participants with ASD+SAD did not show improved social awareness (as measured by the SRS-2-A), relative to the participants with ASD-SAD, which seems inconsistent with previous theory and research suggesting a positive association between awareness into personal social difficulties and social anxiety (e.g., White, Schry, et al., 2014). However, the SRS-2-A Social Awareness scale appears to assess a fairly basic level of social awareness (e.g., I have good personal hygiene [reverse coded]; I get overly loud without realizing it; I sometimes make the mistake of walking between two people who are trying to talk to one another). This scale does not explicitly measure the awareness that other people may be forming judgments or impressions of oneself, which we would expect to be significantly related to the experience of social anxiety within ASD.

Individuals with SAD in the ASD group were also compared to individuals with SAD in the non-ASD group, which revealed that participants with ASD had significantly higher SIAS scores. No group differences were found for the BFNE and SASPA. The SIAS primarily assesses social interaction anxiety, including “fears of being inarticulate, boring, sounding stupid, not knowing what to say or how to respond within social interactions, and of being ignored” (Mattick & Clarke, 1998, p. 457). The BFNE more specifically targets the cognitive domain of

social anxiety (e.g., fear of negative evaluation by others), while the SASPA assesses a combination of social interaction anxiety and performance-based fears. One interpretation of this group SIAS difference is that individuals with ASD were more likely to endorse social interaction anxiety (e.g., anxiety about attending a party with peers), relative to individuals in the SAD-only group. This difference may be apparent because individuals with ASD have core social skill impairments, which are pervasive across situations and can significantly interfere with social interactions. Typically developing individuals with SAD, on the other hand, may or may not demonstrate clear social skill impairment; when present, these abnormalities (e.g., not speaking, avoiding eye contact) are specific to anxiety-producing social or performance situations (White & Schry, 2011).

The social interaction concerns assessed by the SIAS were echoed by the participants with ASD during the ADIS-IV. These participants rated attending parties as the most feared social situation, on average, unlike participants with SAD only. More than half of the individuals with ASD+SAD emphasized the role of social impairment in the development and maintenance of their social anxiety symptoms. These findings demonstrate that many adults with ASD are acutely aware of their social difficulties and experience impairing social anxiety as they face increasing social complexities during adolescence and adulthood. Their increased anxiety then leads to more avoidance of social encounters, resulting in fewer opportunities to learn and practice social skills during interpersonal interactions.

Participants with SAD, with and without ASD, revealed interesting similarities in their ADIS-IV responses as well, such as the most frequently cited time periods for when their social anxiety symptoms first developed (i.e., ranging from elementary to middle school) and peaked in intensity (i.e., ranging from high school to college). Qualitative descriptions about the contributory factors underlying their social anxiety highlighted common themes, particularly those of peer victimization and limited friendships. Although the research on bullying experiences among individuals with ASD is relatively extensive (e.g., Schroeder, Cappadocia, Bebko, Pepler, & Weiss, 2014; Zeedyk, Rodriguez, Tipton, Baker, & Blacher, 2014), few studies have specifically examined how peer victimization may directly or indirectly contribute to impairing social anxiety over time. Participants with and without ASD also rated the same three social situations as the least feared (i.e., using public restrooms, writing in public, and eating in public), and both groups gave high fear ratings for formal speaking and asking others to change

their behavior. These collective findings, although preliminary, may contribute to a better understanding of how to conceptualize social anxiety and its manifestation in the ASD population.

4.1 - Limitations

These findings should be considered in light of the limitations of this study. A primary limitation is the varying amounts of missing eye-tracking data across the three groups of participants. Although these variations were controlled for in the data analyses, we are limited in our ability to explain why the participants with ASD demonstrated significantly less on-task time, relative to the SAD and NC groups. Additionally, we had to exclude portions of the eye-tracking data because participants did not fixate on the centered "X" before stimulus onset. A limitation of the current study's eye-tracking paradigm was the lack of a pre-programmed method to ensure that all participants fixated on the centered "X" before proceeding to the subsequent trial. Such methods (e.g., software designed to initiate the presentation of each stimulus only when the participant fixates on the center of the screen for 1 s) have been used in previous eye-tracking studies to ensure that the initial direction of eye gaze was controlled in all participants at stimulus onset (e.g., Horley et al., 2004). The current sample was well-characterized in many ways, such as ADOS-2 (the current gold-standard tool for diagnosing ASD) data for all participants with ASD. However, one limitation in terms of clinical phenotyping was that only the SAD module of the ADIS-IV was completed. Although participants completed a brief self-report measure of depression symptoms, the assessment battery did not thoroughly assess for other anxiety disorders or depression, which likely have an influence on eye gaze patterns (e.g., Armstrong & Olatunji, 2012; Sears et al., 2010). Other co-occurring psychiatric conditions were also not formally evaluated in the current study.

Although the sample size of the current study exceeded that of many published eye-tracking studies of ASD and SAD or social anxiety (e.g., Garner et al., 2006; Hanley et al., 2013; Horley et al., 2004; Klin et al., 2002; Schofield et al., 2012), we were still limited by issues related to a small sample, particularly for the four-group analyses and the comparisons between the ASD+SAD group and SAD only group. For example, although the effect of group (4: ASD+SAD vs. ASD-SAD vs. SAD only vs. NC) on proportion of FD toward the face AOI did not reach statistical significance, the effect size was medium-to-large ($\eta^2_p = .092$), with participants in the ASD+SAD group showing reduced FD to faces, relative to the NC group.

Power to detect this group effect was limited by the small sample size in the two ASD groups. A fully-powered four-group design (i.e., ASD high and low in social anxiety, and typically developing high and low in social anxiety) would have strengthened our ability to make clear group comparisons.

In terms of participant characteristics, the sample was predominately Caucasian, and these results may not generalize to individuals of other races and ethnicities. Similarly, the sample primarily consisted of university students or college graduates, meaning these results may not generalize to individuals with different educational backgrounds. It is also unknown whether these results would generalize to individuals with IQ < 80.

4.2 - Future Directions

The exploration of gaze pattern data to assess psychiatric comorbidity in individuals with ASD is novel and will require more research in the future. Longitudinal research including adolescents and adults with ASD is particularly important, in order to better understand the relationship between social anxiety and social attention across the lifespan. It would also be interesting to consider the role of social motivation in this relationship, which highlights the need for a social motivation measure with sound psychometric properties and minimal confounding by social anxiety within ASD samples.

Future eye-tracking studies could investigate the effects of social anxiety on eye gaze with more complex stimuli or tasks. For example, Chen and Gaustella (2014) proposed an innovative eye-tracking paradigm where participants gave a brief speech in front of a mock "audience" (i.e., a computer screen playing a pre-recorded video of an audience), consisting of eight confederates assigned to either express positive gestures (e.g., a smile) or negative gestures (e.g., a sigh of boredom). In addition, novel technology now offers the opportunity to complete mobile eye-tracking in a real-world environment (e.g., Tobii Glasses 2, a wearable eye-tracking tool; Tobii Technology, 2013). Another key factor to consider in future studies is pupil size. Pupillometry, combined with eye-tracking, holds promise for detecting sensitive physiological and behavioral differences in people with ASD (Anderson, Colombo, & Shaddy, 2006; Wagner, Hirsch, Vogel-Farley, Redcay, & Nelson, 2013), and it is an unexplored method in people with SAD.

Although there has been an increased focus recently on psychiatric comorbidity in adults with ASD, this focus tends not to be specifically on SAD, but rather all anxiety disorders are

collapsed (e.g., Buck et al., 2014). Large-scale epidemiological studies are needed to examine the comorbidity between ASD and SAD. Future research could also investigate the processes or mechanisms that contribute to the high rates of social anxiety within cognitively unimpaired individuals with ASD, along with exploring potential moderators for the experience of social anxiety within ASD. Despite growing evidence that SAD is common within ASD, many researchers are not considering this comorbidity when discussing the social isolation experienced by individuals with ASD (e.g., Orsmond, Shattuck, Cooper, Sterzing, & Anderson, 2013) or when investigating effective treatments for adults with ASD (e.g., Bishop-Fitzpatrick, Minshew, & Eack, 2013). This is particularly concerning given emerging evidence for the efficacy of cognitive-behavioral treatment (CBT) for anxiety (including SAD) in youth with ASD (e.g., Reaven, Blakeley-Smith, Culhane-Shelburne, & Hepburn, 2012; Wood et al., 2009). In addition, CBT is well-investigated and widely regarded as the first-line psychological treatment for adults with SAD (Hofmann & Otto, 2008), but it has yet to be explored for adults with ASD and co-occurring social anxiety.

4.3 - Conclusions

To our knowledge, the current study is the first to investigate the vigilance-avoidance gaze pattern in a sample of adults with ASD and varying degrees of social anxiety. Failing to distinguish between ASD characteristics and social anxiety often leads to diagnostic overshadowing (Mason & Scior, 2004), meaning socially anxious behaviors are attributed to the diagnosis of ASD and not recognized as social anxiety symptoms. Diagnostic overshadowing has likely influenced the solitary focus on ASD categorically in most eye-tracking research, whereas the current eye-tracking study examined the effect of co-occurring social anxiety both dichotomously and dimensionally in the context of ASD. Similarly, the vast majority of eye-tracking studies in ASD have compared ASD samples to typically developing comparison samples, regardless of comorbidity in the participants with ASD (Hanley et al., 2014). No previous eye-tracking studies have directly compared individuals with ASD to individuals with SAD, despite the high degree of phenotypic overlap between these two disorders. The current study offered a first step in closing this gap by including two comparison groups: a clinical comparison group (adults with SAD and without ASD) and a non-clinical comparison group (non-socially anxious adults without ASD).

By integrating self-report questionnaires and clinician-administered diagnostic interviews, this study provides an important model of multimodal assessment of social anxiety in adults with ASD. In general, there is a paucity of research addressing psychiatric comorbidities in adults with ASD, with recently increasing scientific and clinical attention being drawn to this understudied age group (e.g., Damiano, Mazefsky, White, & Dichter, in press). Specific to social anxiety within ASD, extant research has primarily focused on the physiological symptoms and behavioral avoidance, largely ignoring the influence of socially anxious cognitions. This study highlighted the importance of assessing for fear of negative evaluation by others, which may help practitioners and researchers tease apart ASD-related social avoidance or discomfort from DSM-consistent SAD. Based on the results presented here, nearly 1 of 2 cognitively unimpaired adults with ASD would meet diagnostic criteria for co-occurring SAD. Thus, there is a dramatic need for more research on how to best conceptualize, assess, and treat problems with social anxiety in people who have ASD.

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Footnotes

[1] Although the face region was the AOI of primary interest, the eye-tracking analyses were re-run to examine the eye region (i.e., an ellipse enclosing both left and right eye areas, including the eyebrows and region between eyes) and the mouth region (i.e., the mouth area, excluding most of the chin). Overall, the pattern of eye-tracking results (as described for Hypotheses 2 and 3) was unchanged when examining the eye and mouth AOIs as dependent variables.

[2] We conducted a split-plot ANOVA to examine differences in *total FD* (i.e., without controlling for individual variations in overall on-screen fixation time) to the face AOI, with group (3: ASD vs. SAD vs. NC) as a between-subject variable and stimulus emotion (angry vs. disgust vs. happy) as a within-subject variable. Results revealed no interaction effect, $F(4, 144) = .25$, $p = .828$. There was, however, a significant main effect of group, $F(2, 72) = 10.15$, $p < .001$, $\eta^2_p = .220$, along with a main effect of emotion, $F(2, 144) = 6.94$, $p = .006$, $\eta^2_p = .088$. Pairwise comparisons with Bonferroni correction revealed that participants with ASD had significantly reduced total FD toward face regions ($M = 57.34$ s, $SD = 21.41$), relative to SAD participants ($M = 73.04$ s, $SD = 14.35$), $p = .005$, $d = -.861$, and NC participants ($M = 78.13$ s, $SD = 14.26$), $p < .001$, $d = -1.143$. The SAD and NC groups did not differ on total FD, $p = .880$. In addition, total FD for all groups was significantly greater for happy face regions ($M = 24.69$ s, $SD = 7.36$), relative to disgust face regions ($M = 22.01$ s, $SD = 7.55$), $p = .010$, $d = .359$. No other significant emotion differences were found.

Table 1

Participant Characteristics (n = 75)

	M	*SD*	Minimum	Maximum
Age (in years)	24.33	7.35	16.08	44.25
			n	% of sample
Gender				
Male			39	52.0
Female			36	48.0
Race/Ethnicity				
African American			3	4.0
Asian/Asian-American			8	10.7
Caucasian			55	73.3
Latino/Hispanic			3	4.0
Bi-/Multi-Racial			6	8.0
Current Educational Status				
High School Student			10	13.3
College Student			39	52.0
Graduate Student			11	14.7
Not in School			15	20.0
Highest Level of Education Completed				
Some High School			10	13.3
High School Diploma			1	1.3
Some College			39	52.0
College Diploma			19	25.3
Graduate School			6	8.0
Current Employment Status				
Employed Part-Time			31	41.3
Employed Full-Time			14	18.7
Unemployed			30	40.0

Table 2

Means and Standard Deviations for Eye-Tracking Variables With Face Stimuli, by Group and Emotion

	ASD group (n = 25), M (SD)			SAD group (n = 25), M (SD)			NC group (n = 25), M (SD)		
	Anger	Disgust	Happy	Anger	Disgust	Happy	Anger	Disgust	Happy
Proportion of FD	.44 (.14)	.44 (.16)	.46 (.11)	.48 (.09)	.47 (.11)	.53 (.07)	.49 (.09)	.48 (.09)	.53 (.08)
Direction of first fixation	.53 (.13)	.55 (.15)	.52 (.13)	.56 (.10)	.55 (.09)	.53 (.15)	.57 (.13)	.55 (.12)	.58 (.13)
Latency of first fixation (s)	.77 (.24)	.75 (.30)	.79 (.28)	.71 (.24)	.70 (.25)	.68 (.18)	.61 (.19)	.61 (.16)	.66 (.20)
Duration of first fixation (s)	.27 (.06)	.27 (.07)	.28 (.09)	.29 (.07)	.26 (.05)	.28 (.06)	.29 (.10)	.29 (.08)	.30 (.12)
Proportion of fixation count	.44 (.12)	.42 (.13)	.44 (.08)	.47 (.08)	.45 (.09)	.50 (.06)	.47 (.08)	.46 (.07)	.50 (.07)

Note. ASD = Autism Spectrum Disorder; SAD = Social Anxiety Disorder; NC = Non-Clinical Comparison.

Table 3

Group Descriptive Statistics (n = 75)

	Group									Group comparison *p*-values		
	ASD (*n* = 25)			SAD (*n* = 25)			NC (*n* = 25)					
	M	*SD*	Range	*M*	*SD*	Range	*M*	*SD*	Range	ASD vs. NC	ASD vs. SAD	NC vs. SAD
ADOS-2	9.00	2.20	7-16	-	-	-	-	-	-	-	-	-
AQ	30.04	7.03	14-49	22.56	6.01	7-31	14.40	4.76	6-25	<.001	<.001	<.001
BFNE	21.60	9.02	9-37	29.56	7.02	17-40	16.96	6.79	8-36	.046	.001	<.001
DASS-Dep	6.44	5.35	0-16	6.32	5.34	0-19	2.92	3.30	0-12	.008	.937	.01
SASPA	76.68	22.02	31-114	86.68	12.32	67-110	53.80	12.88	32-70	<.001	.055	<.001
SIAS	37.40	19.80	4-66	44.56	9.76	26-65	14.20	10.04	1-39	<.001	.114	<.001
SRS-2-A	68.36	10.23	47-84	60.32	9.38	47-84	47.84	7.65	36-70	<.001	.006	<.001
WASI	107.60	16.44	80-141	109.08	10.66	88-127	114.24	10.78	91-133	.099	.708	.095

Note. ASD = Autism Spectrum Disorder; SAD = Social Anxiety Disorder; NC = Non-Clinical Comparison; ADOS-2 = Autism Diagnostic Observation Schedule, Second Edition; AQ = Autism Spectrum Quotient; BFNE = Brief Fear of Negative Evaluation Scale; DASS-Dep = Depression Anxiety Stress Scales-Depression Scale; SASPA = Social Anxiety Scale for People with ASD; SIAS = Social Interaction Anxiety Scale; SRS-2-A = Social Responsiveness Scale, Second Edition, Adult Version; WASI = Wechsler Abbreviated Scale of Intelligence.

Table 4

Bivariate Correlations Between On-Task Time and Participant Characteristics

	On-Task Time	IQ	Age	AQ	BFNE	DASS-Dep	SASPA	SIAS
IQ	.403***							
Age	.332**	.330**						
AQ	-.352**	-.145	.007					
BFNE	-.229	-.079	-.067	.339**				
DASS-Dep	-.202	-.227	-.009	.372**	.369**			
SASPA	-.251*	-.132	.072	.573***	.756***	.394**		
SIAS	-.171	-.036	.129	.579***	.721***	.458***	.853***	
SRS-2-A	-.302**	-.224	-.126	.781***	.449***	.550***	.640***	.670***

Note. IQ = Full Scale IQ from the Wechsler Abbreviated Scale of Intelligence; AQ = Autism Spectrum Quotient; BFNE = Brief Fear of Negative Evaluation Scale; DASS-Dep = Depression Anxiety Stress Scales-Depression Scale; SASPA = Social Anxiety Scale for People with ASD; SIAS = Social Interaction Anxiety Scale; SRS-2-A = Social Responsiveness Scale, Second Edition, Adult Version. *$p < .05$. **$p < .01$. ***$p < .001$.

Table 5

ADIS-IV Diagnoses of Social Anxiety Disorder (SAD) and Clinical Severity Rating (CSR) Distributions by Group

	Group		
	ASD (*n* = 25)	SAD (*n* = 25)	NC (*n* = 25)
	n (%)	*n (%)*	*n (%)*
SAD diagnosis?			
Yes	11 (44)	25 (100)	0 (0)
No	14 (56)	0 (0)	25 (100)
CSR:			
0	4 (16)	0 (0)	9 (36)
1	4 (16)	0 (0)	10 (40)
2	6 (24)	0 (0)	6 (24)
3	0 (0)	0 (0)	0 (0)
4	3 (12)	12 (48)	0 (0)
5	3 (12)	8 (32)	0 (0)
6	4 (16)	5 (20)	0 (0)
7	1 (4)	0 (0)	0 (0)
8	0 (0)	0 (0)	0 (0)

Note. ADIS-IV = Anxiety Disorders Interview Schedule for DSM-IV; ASD = Autism Spectrum Disorder; SAD = Social Anxiety Disorder; NC = Non-Clinical Comparison.

Table 6

Correlation Matrix (Bivariate/Partial) Within ASD Group (n = 25)

	Self-Report				FD				Count			
	SRS-2-A	BFNE	SASPA	SIAS	Anger	Disgust	Happy	Calm	Anger	Disgust	Happy	Calm
Self-Report												
BFNE	.561**	--	.676***	.606**	.112	.021	-.271	-.132	-.003	-.125	-.179	-.123
SASPA	.707***	.792***	--	.659***	.241	.160	-.250	-.188	.119	.086	-.004	.001
SIAS	.584**	.735***	.791***	--	.033	-.025	-.293	-.005	.033	.027	-.004	.168
FD												
Anger	-.264	-.059	-.022	-.129	--	.945***	.447*	.166	.864***	.802***	.618**	.326
Disgust	-.285	-.144	-.094	-.186	.949***	--	.451*	.149	.840***	.877***	.586**	.298
Happy	.074	-.182	-.124	-.194	.411*	.410*	--	.675***	.430*	.414*	.739***	.511*
Calm	.307	.068	.091	.176	.071	.048	.663***	--	.157	.157	.560**	.781***
Count												
Anger	-.141	-.082	-.017	-.056	.862***	.838***	.414*	.104	--	.931***	.789***	.532**
Disgust	-.223	-.226	-.099	-.109	.813***	.883***	.386	.077	.930***	--	.739***	.504*
Happy	.108	-.087	.074	.060	.564**	.527**	.741***	.563**	.761***	.692***	--	.803***
Calm	.254	.044	.180	.280	.237	.203	.511**	.797***	.473*	.419*	.800***	--

Note. Bivariate (in unshaded cells): zero-order correlations; Partial (in shaded cells): controlling for ASD symptoms (SRS-2-A Total score). SRS-2-A = Social Responsiveness Scale, Second Edition, Adult Version; BFNE = Brief Fear of Negative Evaluation Scale; SASPA = Social Anxiety Scale for People with ASD; SIAS = Social Interaction Anxiety Scale; FD = average fixation duration toward face stimuli; Count = average number of fixations toward face stimuli.
*$p < .05$. **$p < .01$. ***$p < .001$.

Table 7

Group Comparisons Between Participants With ASD+SAD vs. ASD-SAD

	ASD+SAD (n = 11)		ASD-SAD (n = 14)			
	M	*SD*	*M*	*SD*	*t*	*d*
Age (years)	22.95	7.67	21.59	7.12	.46	.184
Full scale IQ	112.36	15.85	103.86	16.47	1.30	.526
Verbal IQ	113.91	12.93	101.79	15.26	2.11*	.857
Performance IQ	107.55	16.86	105.36	17.50	.32	.127
AQ	32.00	8.11	28.50	5.92	1.25	.493
SRS-2-A Total	73.09	7.94	64.64	10.54	2.21*	.906
SRS-2-A Motivation	72.00	7.44	60.21	10.99	3.04**	1.256
SRS-2-A Soc. Awareness	63.73	10.94	63.43	10.98	.07	.027
SRS-2-A Soc. Cognition	68.45	8.08	61.93	9.13	1.87	.756
SRS-2-A Communication	71.73	8.20	62.43	10.28	2.45*	1.000
SRS-2-A RRB	75.36	9.26	69.50	11.16	1.40	.571
DASS Total	25.36	12.20	16.50	11.17	1.89	.758
DASS Depression	8.09	5.70	5.14	4.87	1.40	.556
DASS Anxiety	5.73	4.78	3.64	3.50	1.26	.498
DASS Stress	11.55	4.44	7.71	4.65	2.09*	.845
BFNE	28.00	5.68	16.57	7.97	4.02***	1.652
SASPA	91.91	11.90	64.71	20.87	3.85***	1.601
SIAS	54.45	9.15	24.00	14.82	5.97***	2.462
	n (% of group)		*n* (% of group)		Fisher's exact test *p*-value	
Female	7 (63.6%)		4 (28.6%)		0.116	

Note. ASD+SAD = Autism Spectrum Disorder and co-occurring Social Anxiety Disorder; ASD-SAD = Autism Spectrum Disorder without Social Anxiety Disorder; AQ = Autism Spectrum Quotient; SRS-2-A = Social Responsiveness Scale, Second Edition, Adult

Version (Total, Social Motivation, Social Awareness, Social Cognition, Social Communication, and Restricted Interests/Repetitive Behaviors scales); DASS = Depression Anxiety Stress Scales (Total, Depression, Anxiety, and Stress scales); BFNE = Brief Fear of Negative Evaluation Scale; SASPA = Social Anxiety Scale for People with ASD; SIAS = Social Interaction Anxiety Scale.
*$p < .05$. **$p < .01$. ***$p < .001$.

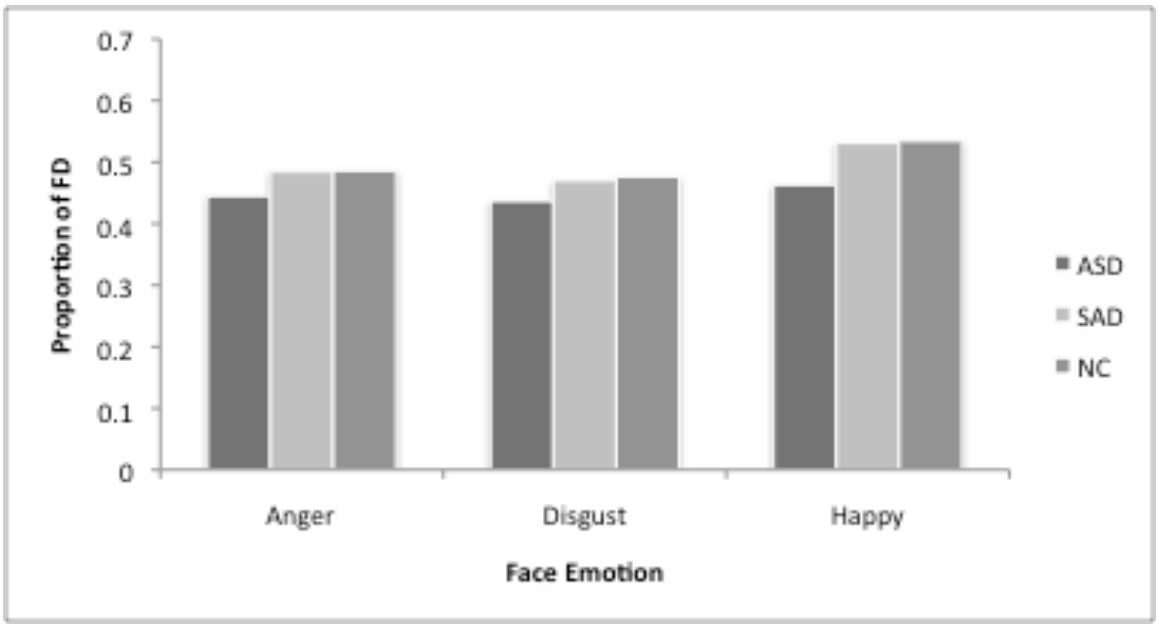


Figure 1. Proportion of fixation duration (FD) to the face AOI (by emotion).
ASD = Autism Spectrum Disorder; SAD = Social Anxiety Disorder; NC = Non-Clinical Comparison.

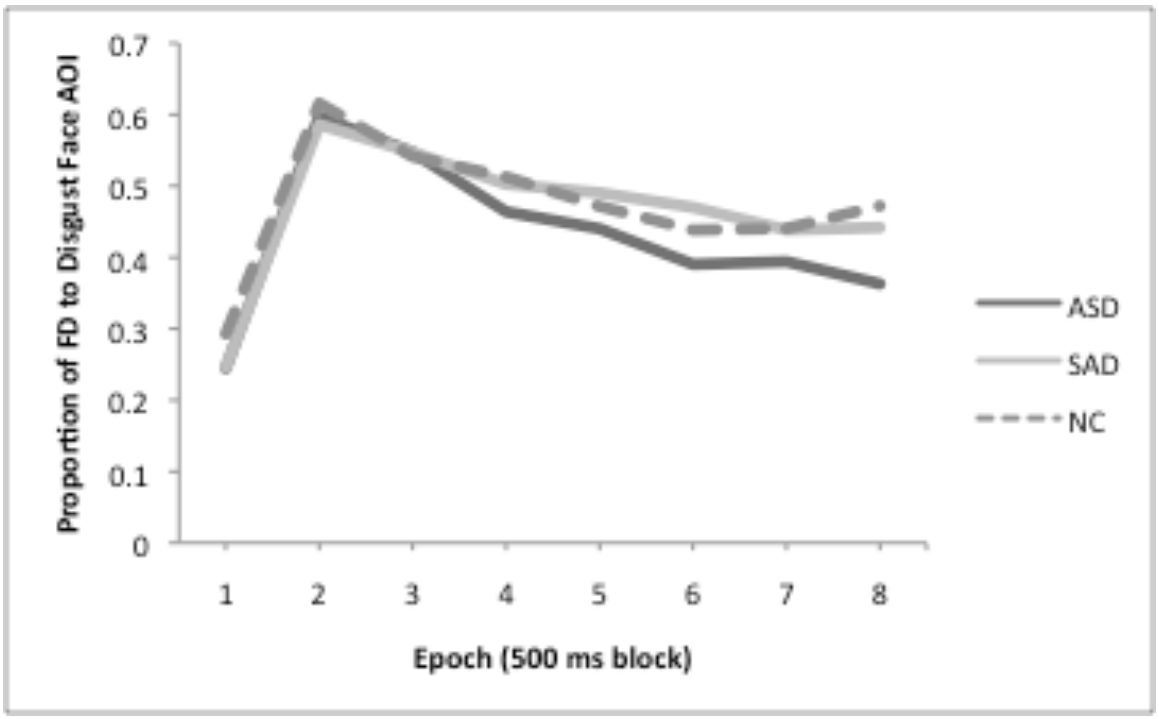


Figure 2. Proportion of fixation duration (FD) to the disgust face AOI for each 500 ms epoch. ASD = Autism Spectrum Disorder; SAD = Social Anxiety Disorder; NC = Non-Clinical Comparison.

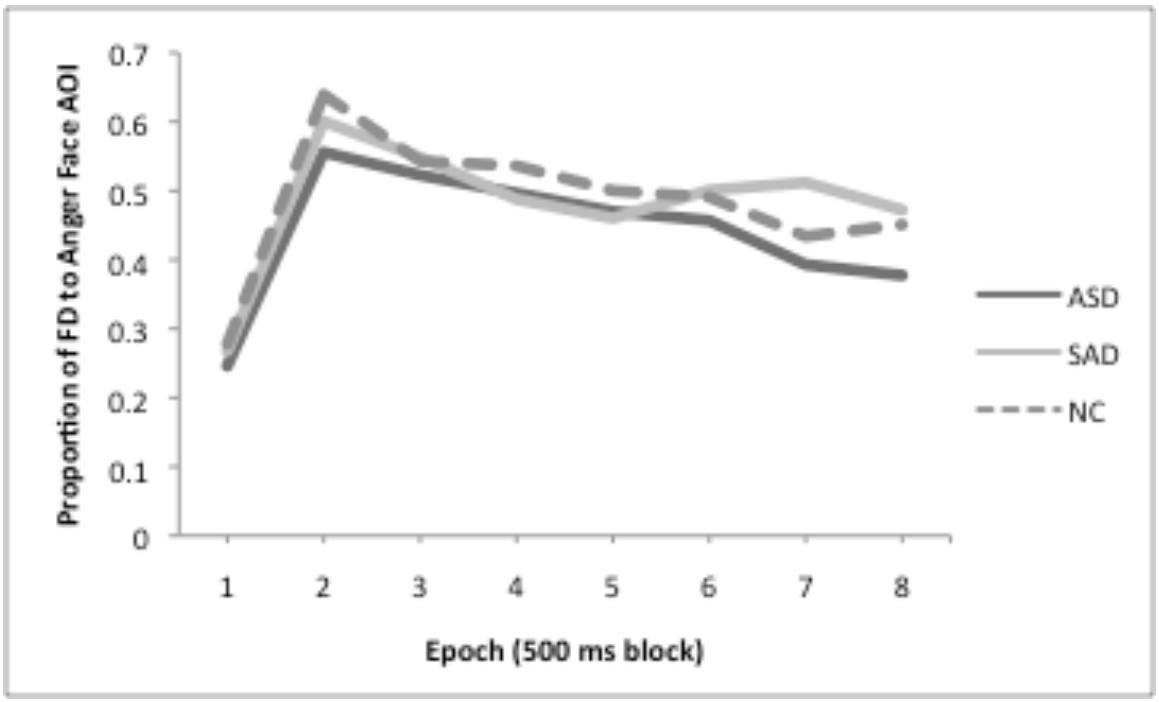


Figure 3. Proportion of fixation duration (FD) to the anger face AOI for each 500 ms epoch. ASD = Autism Spectrum Disorder; SAD = Social Anxiety Disorder; NC = Non-Clinical Comparison.

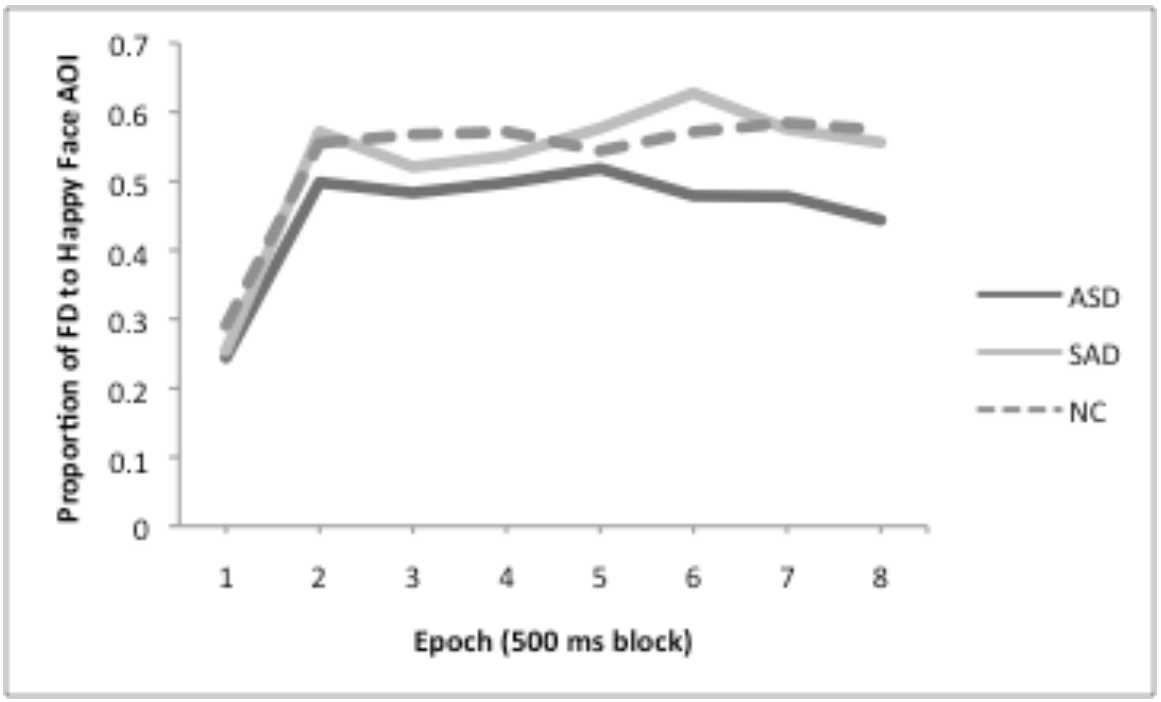


Figure 4. Proportion of fixation duration (FD) to the happy face AOI for each 500 ms epoch. ASD = Autism Spectrum Disorder; SAD = Social Anxiety Disorder; NC = Non-Clinical Comparison.

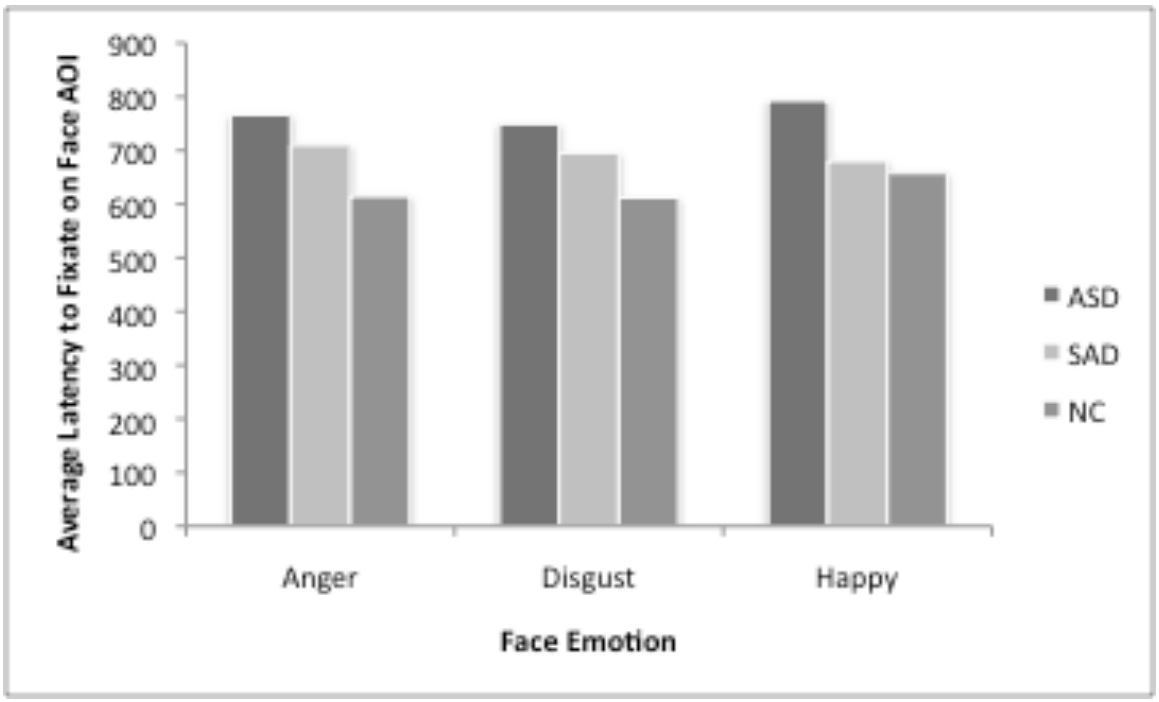


Figure 5. Average latency (ms) to fixate on the face AOI (by emotion).
ASD = Autism Spectrum Disorder; SAD = Social Anxiety Disorder; NC = Non-Clinical Comparison.

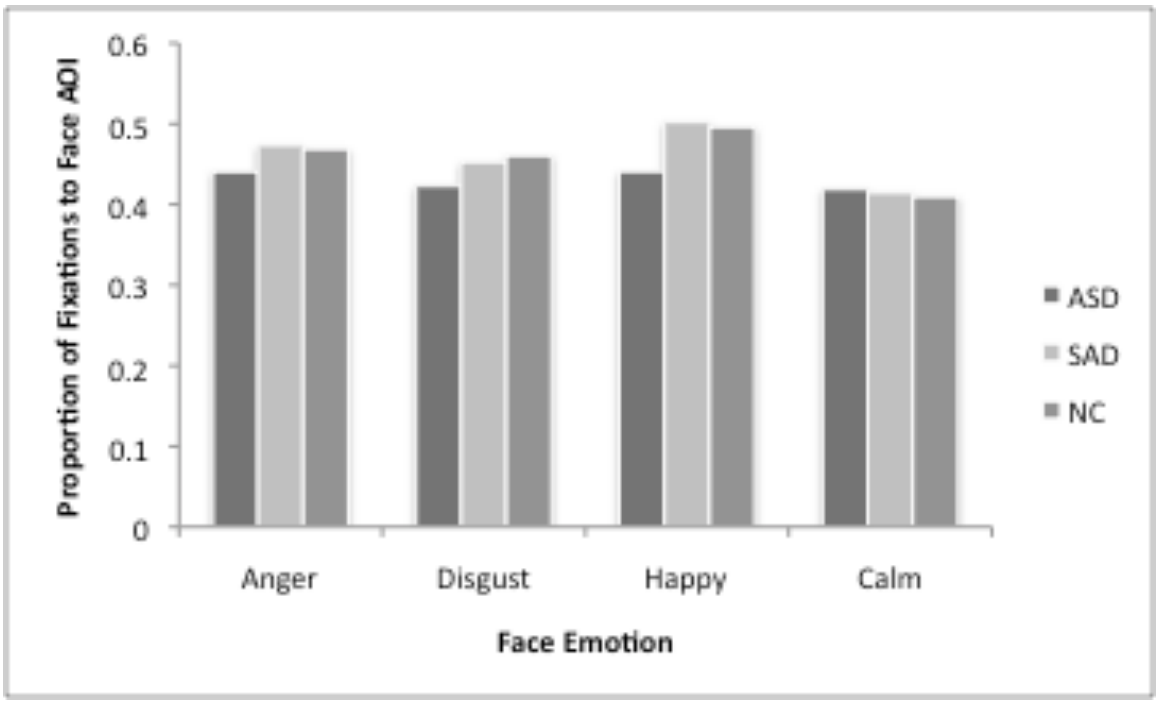


Figure 6. Proportion of fixations to the face AOI (by emotion).
ASD = Autism Spectrum Disorder; SAD = Social Anxiety Disorder; NC = Non-Clinical Comparison.

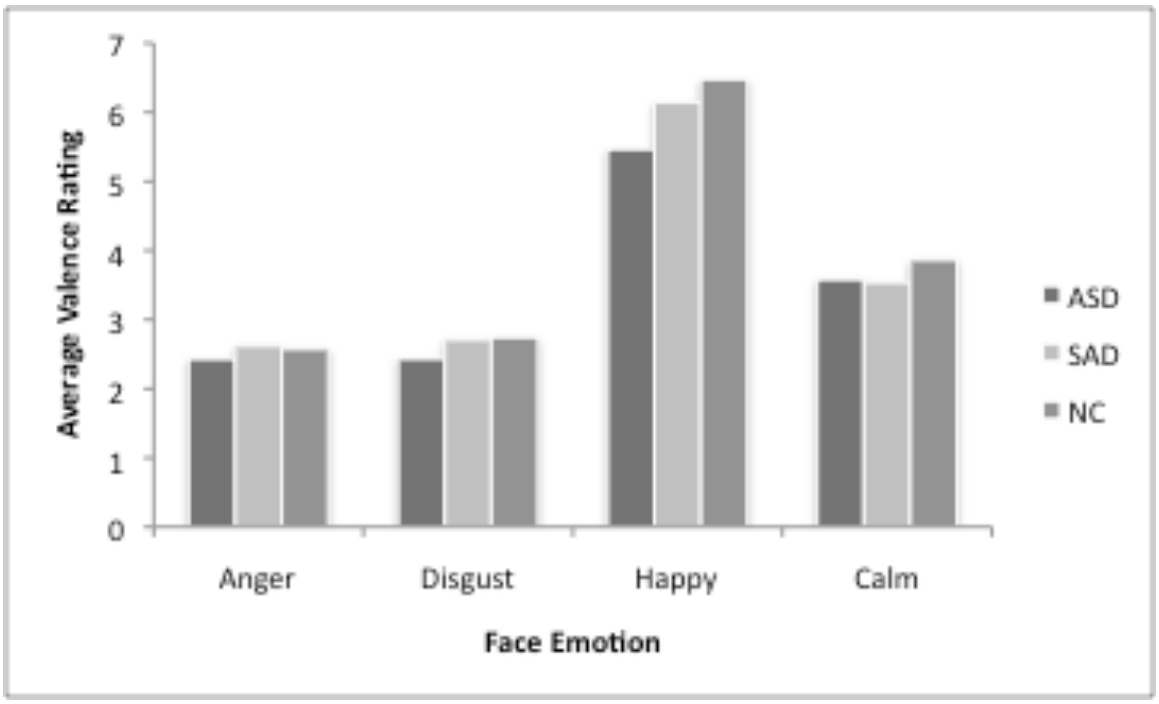


Figure 7. Average valence ratings of face stimuli (by emotion).
ASD = Autism Spectrum Disorder; SAD = Social Anxiety Disorder; NC = Non-Clinical Comparison.

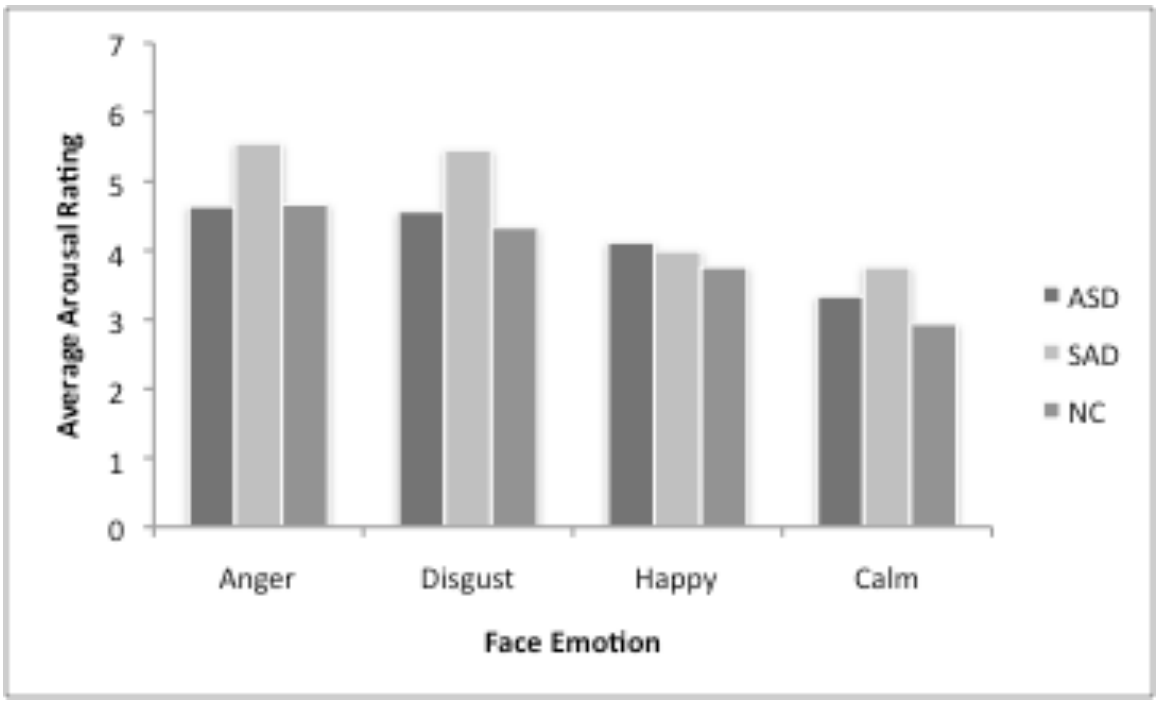


Figure 8. Average arousal ratings of face stimuli (by emotion).
ASD = Autism Spectrum Disorder; SAD = Social Anxiety Disorder; NC = Non-Clinical Comparison.

Figure 9. Proportion of fixation duration (FD) to the face AOI (by emotion) for four groups. ASD-SAD = Autism Spectrum Disorder without Social Anxiety Disorder; ASD+SAD = Autism Spectrum Disorder with co-occurring Social Anxiety Disorder; SAD = Social Anxiety Disorder; NC = Non-Clinical Comparison.

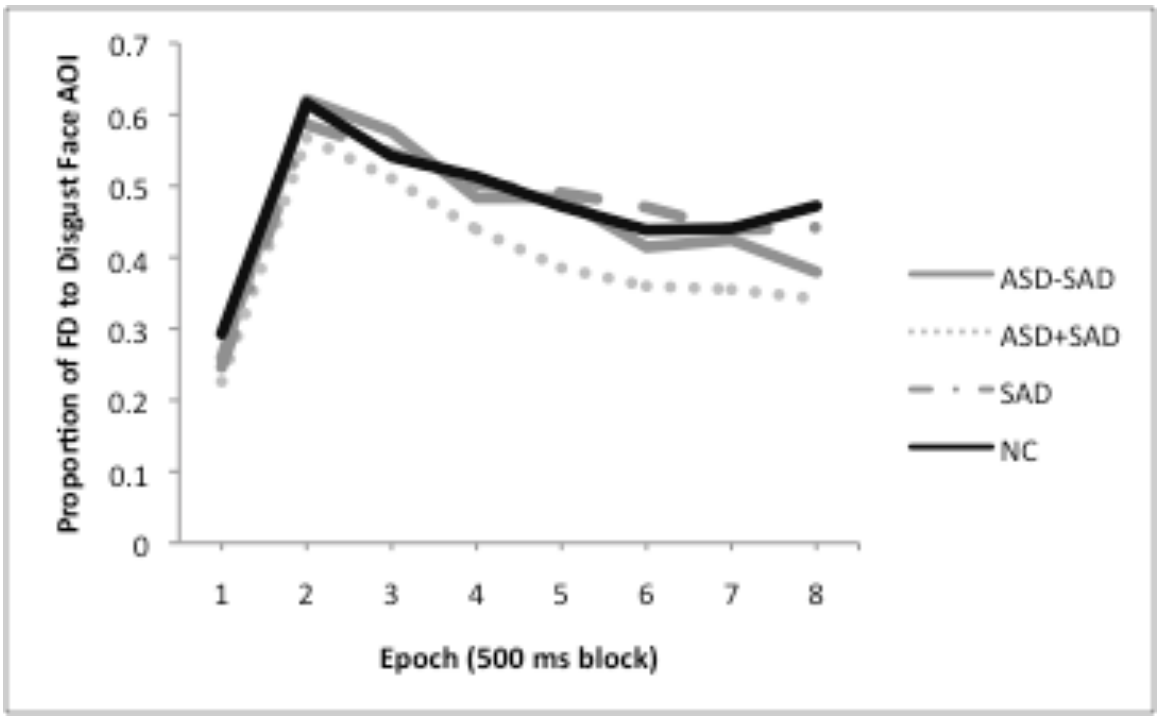


Figure 10. Proportion of fixation duration (FD) to the disgust face AOI for each 500 ms epoch (four groups).
ASD-SAD = Autism Spectrum Disorder without Social Anxiety Disorder; ASD+SAD = Autism Spectrum Disorder with co-occurring Social Anxiety Disorder; SAD = Social Anxiety Disorder; NC = Non-Clinical Comparison.

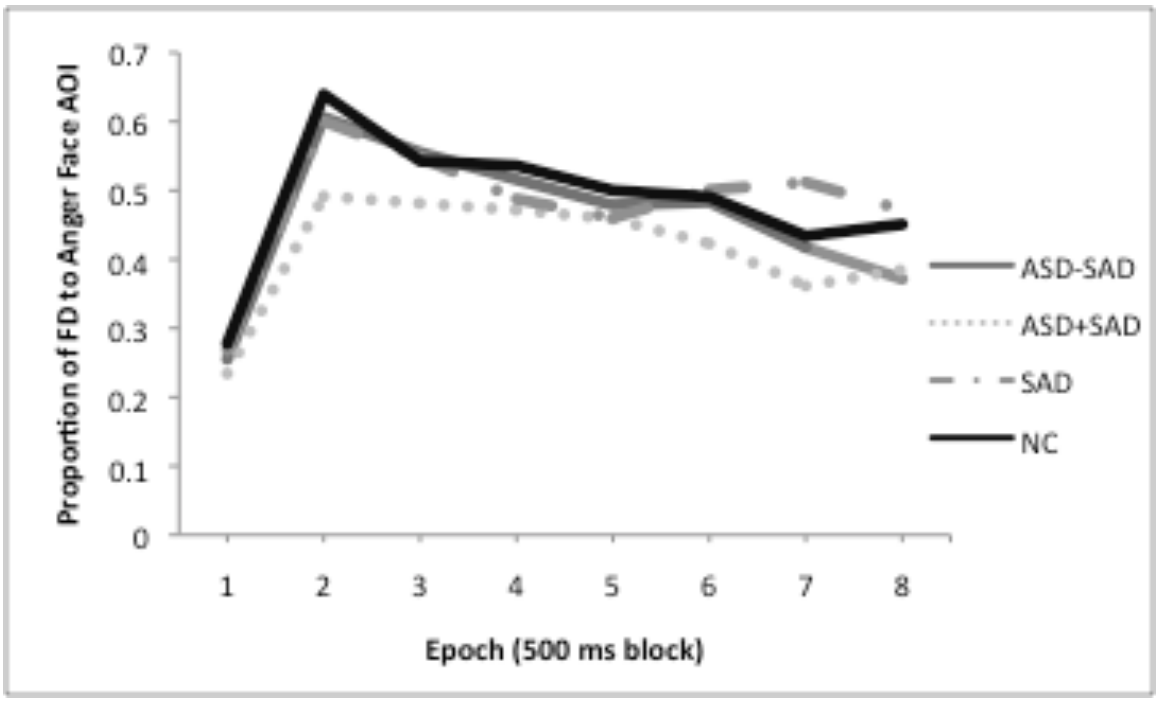


Figure 11. Proportion of fixation duration (FD) to the anger face AOI for each 500 ms epoch (four groups).
ASD-SAD = Autism Spectrum Disorder without Social Anxiety Disorder; ASD+SAD = Autism Spectrum Disorder with co-occurring Social Anxiety Disorder; SAD = Social Anxiety Disorder; NC = Non-Clinical Comparison.

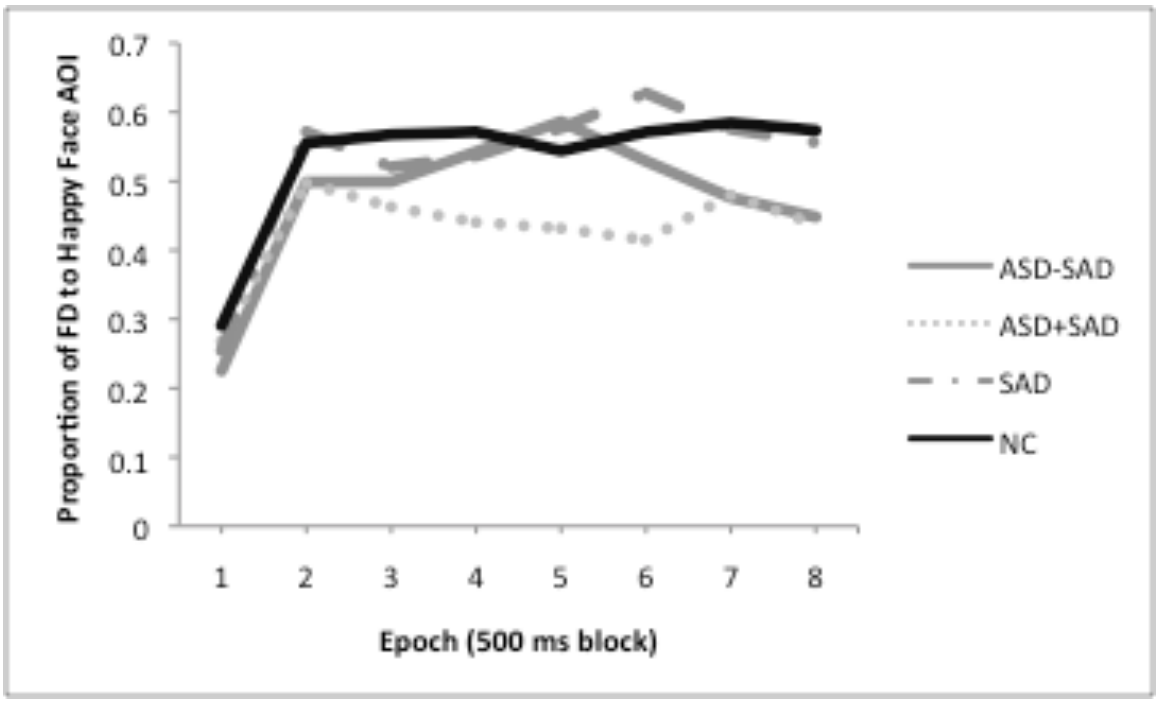


Figure 12. Proportion of fixation duration (FD) to the happy face AOI for each 500 ms epoch (four groups).
ASD-SAD = Autism Spectrum Disorder without Social Anxiety Disorder; ASD+SAD = Autism Spectrum Disorder with co-occurring Social Anxiety Disorder; SAD = Social Anxiety Disorder; NC = Non-Clinical Comparison.

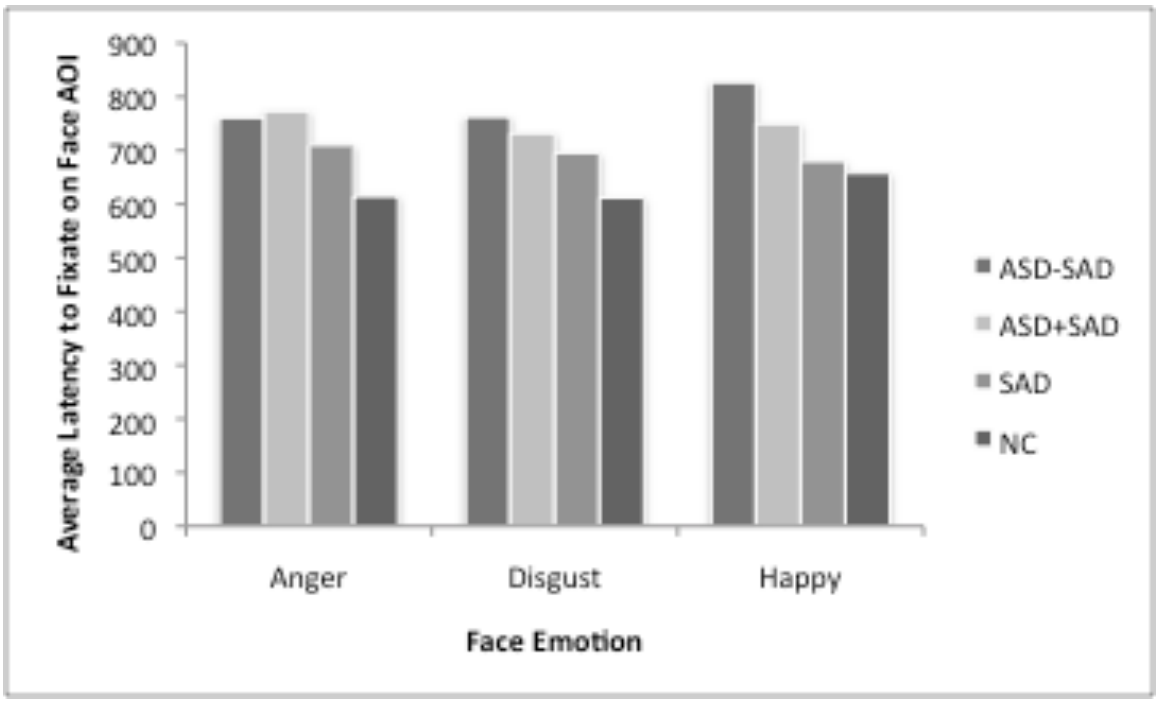


Figure 13. Average latency (ms) to fixate on the face AOI (by emotion) for four groups. ASD-SAD = Autism Spectrum Disorder without Social Anxiety Disorder; ASD+SAD = Autism Spectrum Disorder with co-occurring Social Anxiety Disorder; SAD = Social Anxiety Disorder; NC = Non-Clinical Comparison.

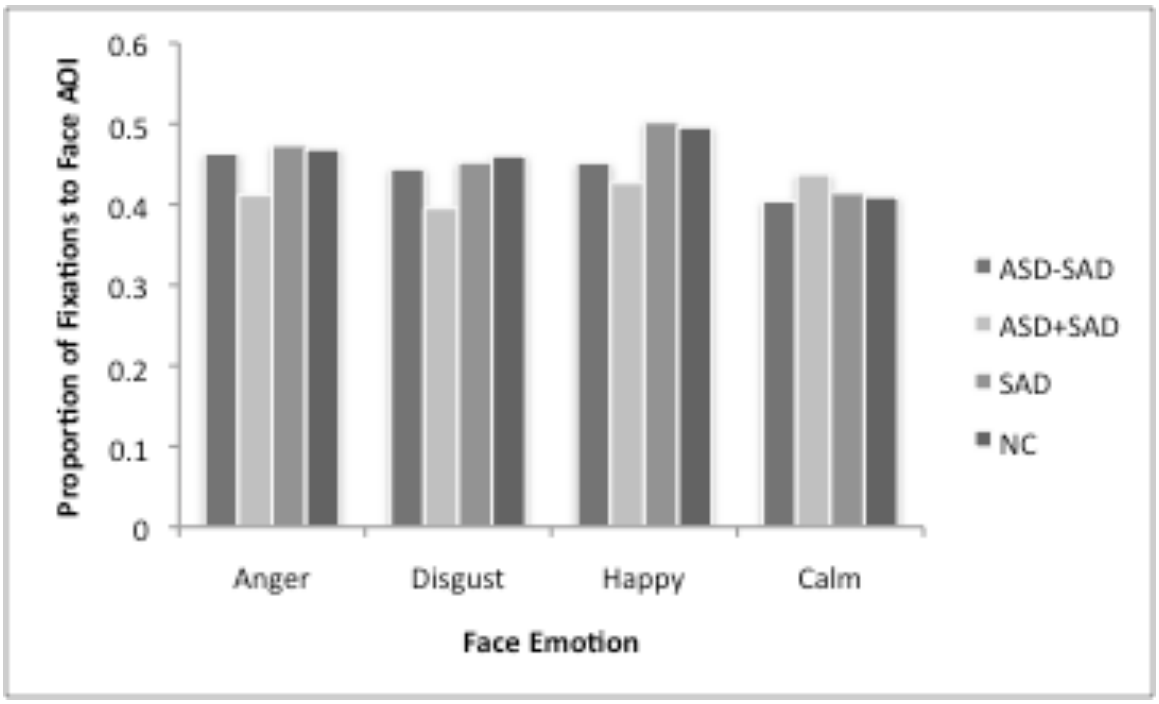


Figure 14. Proportion of fixations to the face AOI (by emotion) for four groups.
ASD-SAD = Autism Spectrum Disorder without Social Anxiety Disorder; ASD+SAD = Autism Spectrum Disorder with co-occurring Social Anxiety Disorder; SAD = Social Anxiety Disorder; NC = Non-Clinical Comparison.

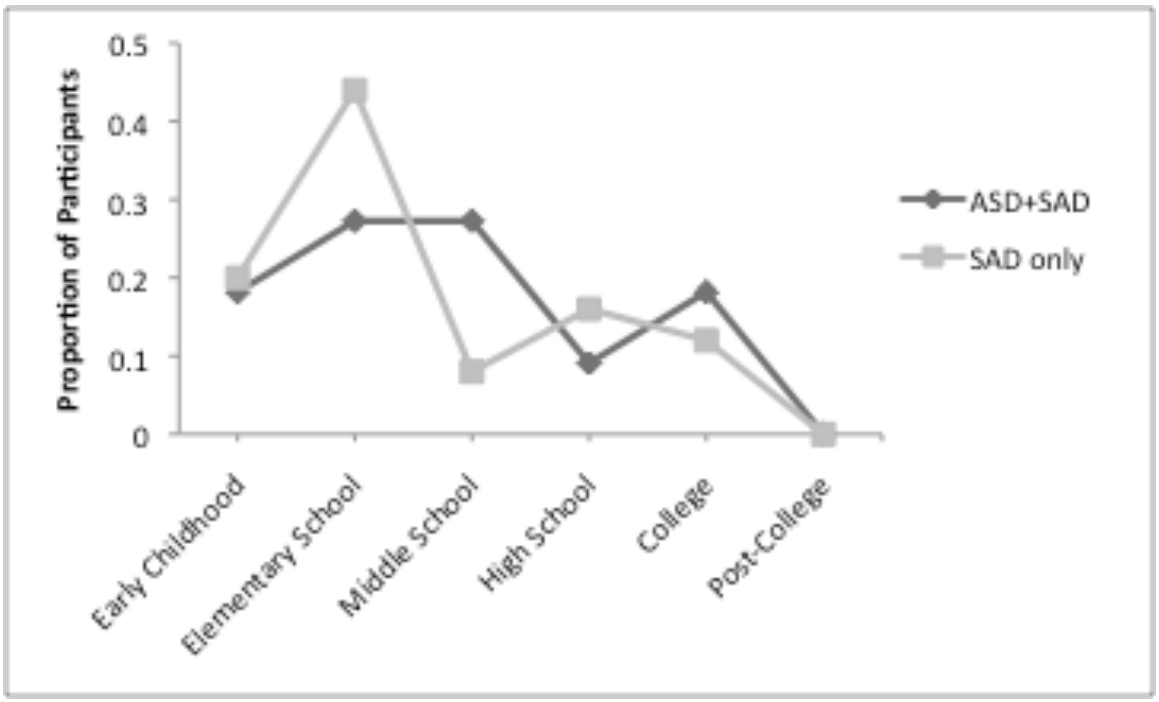


Figure 15. Time of initial impairment of social anxiety for participants with ASD and SAD (*n* = 11) and participants with SAD only (*n* = 25).
ASD = Autism Spectrum Disorder; SAD = Social Anxiety Disorder; Early Childhood = kindergarten or earlier.

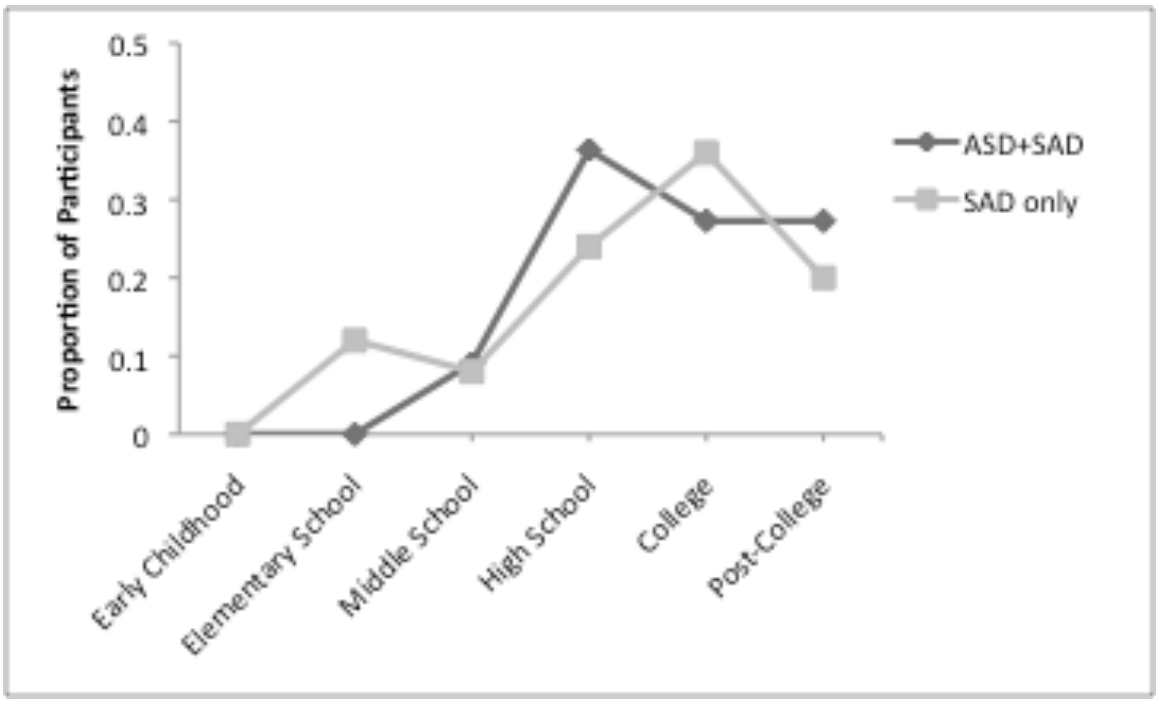


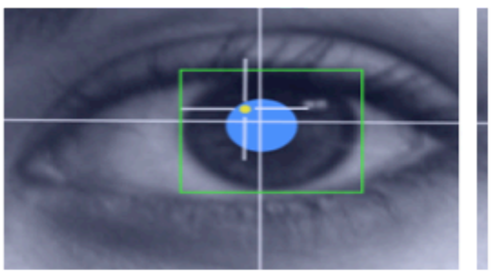
Figure 16. Time of most severe period of social anxiety for participants with ASD and SAD (*n* = 11) and participants with SAD only (*n* = 25).
ASD = Autism Spectrum Disorder; SAD = Social Anxiety Disorder; Early Childhood = kindergarten or earlier.

Appendix A

Recruitment Flyers

Eye-tracking Study Opportunity

If you are between the ages of 16 and 45, you may be eligible to participate in a one-session research study investigating gaze patterns with eye-tracking technology at Virginia Tech. If you are interested, please visit the website or call the phone number provided below for more information and to sign up for the study.
Eligible for Sona extra credit? You will earn two extra credit hours!
Students not eligible for Sona credit will receive $20 for study participation.



Eye-tracking Study
https://survey.vt.edu/survey/entry.jsp?id=1364152698284
540-231-6744
bmaddox7@vt.edu

Eye-tracking Study
https://survey.vt.edu/survey/entry.jsp?id=1364152698284
540-231-6744
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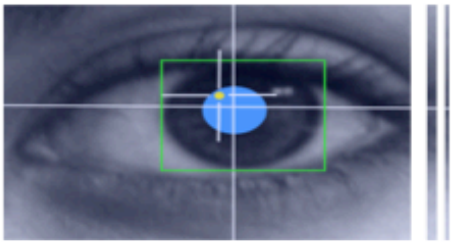
bmaddox7@vt.edu

Eye-tracking Study
https://survey.vt.edu/survey/entry.jsp?id=1364152698284
540-231-6744
bmaddox7@vt.edu

Eye-tracking Study Opportunity

Do you have an Autism Spectrum Disorder
(such as Asperger's)?

Are you between 16 - 45 years of age?
If so, you may be eligible to participate in our research study, investigating gaze patterns with eye-tracking technology at Virginia Tech.



If you are interested, please visit the website or call the phone number provided below for more information and to sign up for the study.

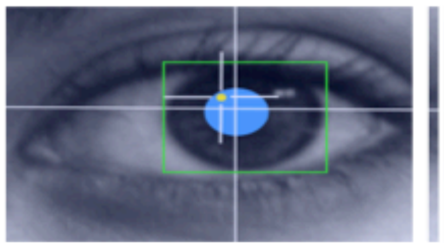
Eligible for Sona extra credit? You will earn two extra credit hours!
Students not eligible for Sona credit will receive $20 for study participation.

Autism/Asperger's Eye-tracking Study
https://survey.vt.edu/survey/entry.jsp?id=1364152698284
540-231-6744
bmaddox7@vt.edu

Eye-tracking Study Opportunity

Do you struggle with <u>social anxiety</u>?
Do social situations make you <u>nervous or uneasy</u>?

Are you between 16 - 45 years of age?
If so, you may be eligible to participate in our research study, investigating gaze patterns with eye-tracking technology at Virginia Tech.



If you are interested, please visit the website or call the phone number provided below for more information and to sign up for the study.

Eligible for Sona extra credit? You will earn two extra credit hours!
Students not eligible for Sona credit will receive $20 for study participation.

Social Anxiety Eye-tracking Study
https://survey.vt.edu/survey/entry.jsp?id=1364152698284
540-231-6744
bmaddox7@vt.edu

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540-231-6744
bmaddox7@vt.edu

Appendix B

E-mail to Request Student or Client Participation

Subject Line: Research Project with Individuals with an Autism Spectrum Disorder or Social Anxiety

Dear [FILL IN OFFICE OR CLINIC NAME] Staff,

I am a doctoral student in the Virginia Tech's Clinical Psychology program, and I am seeking adolescents and adults (ages 16-45) with an Autism Spectrum Disorder (such as Asperger's) or Social Anxiety Disorder to participate in my dissertation research study, investigating gaze patterns with eye-tracking technology. This project, supervised by Susan White, Ph.D., has been approved for data collection by Virginia Tech's institutional review board.

I am requesting your help in sharing this information with your students or clients with an Autism Spectrum Disorder (such as Asperger's) or with Social Anxiety Disorder. Interested individuals can visit the website or call the phone number provided below for more information and to sign up for the study:

https://survey.vt.edu/survey/entry.jsp?id=1364152698284

(540) 231-6744 (Psychosocial Interventions Lab)

Briefly, eligible participants will complete one eye-tracking session on campus. The study session will also include completing questionnaires and a brief interview. The total session length will vary between 1.5 to 2.5 hours.

All participating Virginia Tech students eligible for Sona extra credit will receive two extra credits. Participants not eligible for Sona extra credit will receive $20.00. Participants driving more than 30 miles to and from the study appointment will also receive mileage reimbursement ($0.50 per mile traveled, with a maximum mileage reimbursement of $50.00). Participants requesting mileage reimbursement will need to provide their home zip code in order to calculate the distance traveled.

I greatly appreciate your willingness to share information about this study with your students or clients. Please feel free to contact me with any questions or concerns at bmaddox7@vt.edu. Thank you very much for your time and consideration.

Sincerely,

Brenna Maddox, M.S.

Appendix C

Study Description on Sona Website

Study Name: Exploring Eye Gaze Patterns

Abstract: An eye-tracking study on campus to investigate gaze patterns.

Description: I am seeking students with an Autism Spectrum Disorder (such as Asperger's), students with Social Anxiety Disorder, and students without Autism Spectrum Disorder or Social Anxiety Disorder. Eligible participants will complete one eye-tracking session on campus. The study session will also include completing questionnaires and a brief interview. After signing up for this study, you will receive an e-mail to set up a brief telephone screening with the researcher, in order to confirm your eligibility.

Eligibility Requirements: Between the ages of 16-45 years

Duration: The session length will vary between 1.5 to 2.5 hours.

Credits: 2

Researcher: Brenna Maddox, M.S. E-mail: bmaddox7@vt.edu

Appendix D

Recruitment Information Posted on University Websites

Exploring Eye Gaze Patterns

We are enrolling teenagers and adults, between the ages of 16 and 45 years, to participate in a study on the influence of social anxiety on gaze patterns. We are seeking individuals with an Autism Spectrum Disorder (such as Asperger's), individuals with Social Anxiety Disorder, and individuals without Autism Spectrum Disorder or Social Anxiety Disorder. Involvement in the study will require one visit to the Virginia Tech campus, after completing a brief telephone screen to determine eligibility. Total time commitment is 1.5 to 2.5 hours. If you are not a Virginia Tech student who can receive Sona extra credit, you will be paid $20.00 for participating. Participants driving more than 30 miles to and from the study appointment will also receive mileage reimbursement ($0.50 per mile traveled, with a maximum mileage reimbursement of $50.00). Participants requesting mileage reimbursement will need to provide their home zip code in order to calculate the distance traveled. Please visit https://survey.vt.edu/survey/entry.jsp?id=1364152698284 or call 540-231-6744 if you would like more information about the study.

Appendix E

Demographic Questionnaire

1. **Your gender:** ☐ Male ☐ Female

2. **Your age in years and months:**
   _____ years
   _____ months

3. **Your racial background:**
   ☐ Caucasian
   ☐ Latino/Hispanic
   ☐ African American
   ☐ Asian
   ☐ Native American
   ☐ Middle-Eastern
   ☐ Other (specify): _____

4. **Are you currently in school?**
   ☐ Yes ☐ No
   If so, what year in school? _____

   If in college, what is your major? _____

5. **Your education:** Please check the highest level of education you have completed.

   ☐ Some High School
   ☐ High School Diploma
   ☐ Some College
   ☐ College Diploma
   ☐ Graduate School

6. **Are you currently employed?**
   ☐ Yes ☐ No

   What is your job position? _____

Appendix F

Brief Clinical Intake

1. **Have you ever received a formal diagnosis for an emotional or psychological problem?** (examples: Asperger's Disorder; Anxiety Disorder)

☐ Yes ☐ No

If yes, list any formal diagnoses:

2. **Have you ever struggled with an emotional or psychological problem, without receiving a formal diagnosis?** (example: Depression)

☐ Yes ☐ No

If yes, list any undiagnosed problems:

3. **Are you currently taking any prescription medication?**

☐ Yes ☐ No

If yes, list current medications:

4. Childhood and Current Behavior Ratings

Please answer the following questions to the best of your ability. Answer each question based on your current behavior and based on your own recollection of yourself as a child. We understand that you might not know the answers to all questions from your childhood – please just try your best, considering what others (e.g., your parents) have told you or what you remember.

For each question, give a rating from 1 to 7:
1 = behavior or symptom not present, no impairment
2 =
3 = behavior or symptom likely present, mild impairment
4 =
5 = behavior or symptom present, caused moderate impairment
6 =
7 = behavior or symptom present, caused severe impairment

	RATING (1-7)	
BEHAVIOR	**CURRENT**	**CHILDHOOD**
1. Marked impairment in use of nonverbal behaviors such as eye contact, facial expression, and gesture for social interactions		
2. Failure to develop peer relationships with same-age peers (examples: only relationships are organized around clubs, activities, or school; no identified 'best friend' of similar age/level)		
3. Lack of spontaneous seeking to share enjoyment, interests, or activities with other people (examples: did not show toys or point out objects of interest)		
4. Lack of social or emotional reciprocity (examples: not offering comfort when someone is hurt, unable to identify or interpret other people's feelings correctly)		
5. Delay in, or total lack of, the development of spoken language (examples: no words by 24 months, no phrase speech by 33 months)		
6. Impairment in the ability to initiate or sustain a conversation with others		
7. Stereotyped and repetitive use of language or idiosyncratic language (examples: saying the same thing over and over, unusual names/labels for objects or people)		
8. Lack of varied, spontaneous make-believe play or social imitative play appropriate to developmental level (examples: did not play with dolls or action figures, no pretend play/made-up games)		
9. Preoccupation with one or more stereotyped and restricted patterns of interest, that is abnormal either in intensity or focus (examples: extensive collection of pipe cleaners or printers; memorizing all facts about a particular TV show or team)		
10. Inflexible adherence to specific, nonfunctional routines or rituals (examples: must eat a certain type of cereal every morning before showering and can't have a different cereal or shower first, must organize toys by color before leaving the house)		
11. Stereotyped and repetitive motor mannerisms (examples: hand or finger flapping, twisting, whole-body rocking)		
12. Persistent preoccupation with parts of objects or toys (examples: only plays with wheels of toy car or eyes of a doll, repeatedly opens and closes doors)		

Appendix G

Autism Spectrum Quotient (AQ)

ID Number:..... Today's Date:.....

How to fill out the questionnaire

Below is a list of statements. Please read each statement very carefully and rate how strongly you agree or disagree with it by circling your answer.

Examples

E1. I am willing to take risks.	definitely agree	slightly agree	slightly disagree	definitely disagree
E2. I like playing board games.	definitely agree	slightly agree	slightly disagree	definitely disagree
E3. I find learning to play musical instruments easy.	definitely agree	slightly agree	slightly disagree	definitely disagree
E4. I am fascinated by other cultures.	definitely agree	slightly agree	slightly disagree	definitely disagree

1. I prefer to do things with others rather than on my own.	definitely agree	slightly agree	slightly disagree	definitely disagree
2. I prefer to do things the same way over and over again.	definitely agree	slightly agree	slightly disagree	definitely disagree
3. If I try to imagine something, I find it very easy to create a picture in my mind.	definitely agree	slightly agree	slightly disagree	definitely disagree
4. I frequently get so strongly absorbed in one thing that I lose sight of other things.	definitely agree	slightly agree	slightly disagree	definitely disagree
5. I often notice small sounds when others do not.	definitely agree	slightly agree	slightly disagree	definitely disagree
6. I usually notice car number plates or similar strings of information.	definitely agree	slightly agree	slightly disagree	definitely disagree

7. Other people frequently tell me that what I've said is impolite, even though I think it is polite.	definitely agree	slightly agree	slightly disagree	definitely disagree
8. When I'm reading a story, I can easily imagine what the characters might look like.	definitely agree	slightly agree	slightly disagree	definitely disagree
9. I am fascinated by dates.	definitely agree	slightly agree	slightly disagree	definitely disagree
10. In a social group, I can easily keep track of several different people's conversations.	definitely agree	slightly agree	slightly disagree	definitely disagree
11. I find social situations easy.	definitely agree	slightly agree	slightly disagree	definitely disagree
12. I tend to notice details that others do not.	definitely agree	slightly agree	slightly disagree	definitely disagree
13. I would rather go to a library than a party.	definitely agree	slightly agree	slightly disagree	definitely disagree
14. I find making up stories easy.	definitely agree	slightly agree	slightly disagree	definitely disagree
15. I find myself drawn more strongly to people than to things.	definitely agree	slightly agree	slightly disagree	definitely disagree
16. I tend to have very strong interests which I get upset about if I can't pursue.	definitely agree	slightly agree	slightly disagree	definitely disagree
17. I enjoy social chit-chat.	definitely agree	slightly agree	slightly disagree	definitely disagree
18. When I talk, it isn't always easy for others to get a word in edgeways.	definitely agree	slightly agree	slightly disagree	definitely disagree
19. I am fascinated by numbers.	definitely agree	slightly agree	slightly disagree	definitely disagree
20. When I'm reading a story, I find it difficult to work out the characters' intentions.	definitely agree	slightly agree	slightly disagree	definitely disagree
21. I don't particularly enjoy reading fiction.	definitely agree	slightly agree	slightly disagree	definitely disagree
22. I find it hard to make new friends.	definitely agree	slightly agree	slightly disagree	definitely disagree
23. I notice patterns in things all the time.	definitely agree	slightly agree	slightly disagree	definitely disagree

24. I would rather go to the theatre than a museum.	definitely agree slightly agree slightly disagree definitely disagree
25. It does not upset me if my daily routine is disturbed.	definitely agree slightly agree slightly disagree definitely disagree
26. I frequently find that I don't know how to keep a conversation going.	definitely agree slightly agree slightly disagree definitely disagree
27. I find it easy to "read between the lines" when someone is talking to me.	definitely agree slightly agree slightly disagree definitely disagree
28. I usually concentrate more on the whole picture, rather than the small details.	definitely agree slightly agree slightly disagree definitely disagree
29. I am not very good at remembering phone numbers.	definitely agree slightly agree slightly disagree definitely disagree
30. I don't usually notice small changes in a situation, or a person's appearance.	definitely agree slightly agree slightly disagree definitely disagree
31. I know how to tell if someone listening to me is getting bored.	definitely agree slightly agree slightly disagree definitely disagree
32. I find it easy to do more than one thing at once.	definitely agree slightly agree slightly disagree definitely disagree
33. When I talk on the phone, I'm not sure when it's my turn to speak.	definitely agree slightly agree slightly disagree definitely disagree
34. I enjoy doing things spontaneously.	definitely agree slightly agree slightly disagree definitely disagree
35. I am often the last to understand the point of a joke.	definitely agree slightly agree slightly disagree definitely disagree
36. I find it easy to work out what someone is thinking or feeling just by looking at their face.	definitely agree slightly agree slightly disagree definitely disagree
37. If there is an interruption, I can switch back to what I was doing very quickly.	definitely agree slightly agree slightly disagree definitely disagree
38. I am good at social chit-chat.	definitely agree slightly agree slightly disagree definitely disagree
39. People often tell me that I keep going on and on about the same thing.	definitely agree slightly agree slightly disagree definitely disagree

40. When I was young, I used to enjoy playing games involving pretending with other children.	definitely agree	slightly agree	slightly disagree	definitely disagree
41. I like to collect information about categories of things (e.g. types of car, types of bird, types of train, types of plant, etc.).	definitely agree	slightly agree	slightly disagree	definitely disagree
42. I find it difficult to imagine what it would be like to be someone else.	definitely agree	slightly agree	slightly disagree	definitely disagree
43. I like to plan any activities I participate in carefully.	definitely agree	slightly agree	slightly disagree	definitely disagree
44. I enjoy social occasions.	definitely agree	slightly agree	slightly disagree	definitely disagree
45. I find it difficult to work out people's intentions.	definitely agree	slightly agree	slightly disagree	definitely disagree
46. New situations make me anxious.	definitely agree	slightly agree	slightly disagree	definitely disagree
47. I enjoy meeting new people.	definitely agree	slightly agree	slightly disagree	definitely disagree
48. I am a good diplomat.	definitely agree	slightly agree	slightly disagree	definitely disagree
49. I am not very good at remembering people's date of birth.	definitely agree	slightly agree	slightly disagree	definitely disagree
50. I find it very easy to play games with children that involve pretending.	definitely agree	slightly agree	slightly disagree	definitely disagree

Developed by:
The Autism Research Centre
University of Cambridge

Appendix H

Brief Fear of Negative Evaluation Scale (BFNE)

Please read each of the following statements carefully and indicate how characteristic it is of you according to the following scale:
1= Not at all characteristic of me, 2= Slightly characteristic of me, 3= Moderately characteristic of me, 4= Very characteristic of me, 5= Extremely characteristic of me

	1 Not at all characteristic of me	2 Slightly characteristic of me	3 Moderately characteristic of me	4 Very characteristic of me	5 Extremely characteristic of me
1. I worry about what other people will think of me even when I know it doesn't make any difference.					
2. I am unconcerned even if I know people are forming an unfavorable impression of me.					
3. I am frequently afraid of other people noticing my shortcomings.					
4. I rarely worry about what kind of impression I am making on someone.					
5. I am afraid that others will not approve of me.					
6. I am afraid that people will find fault with me.					
7. Other people's opinions of me do not bother me.					
8. When I am talking to someone, I worry about what they may be thinking about me.					
9. I am usually worried about what kind of impression I make.					
10. If I know someone is judging me, it has little effect on me.					
11. Sometimes I think I am too concerned with what other people think of me.					
12. I often worry that I will say or do the wrong thing.					

Appendix I

Social Anxiety Scale for People with ASD (SASPA)

Client ID: _____ Age: _____ Sex: M F Date: ___/___/____

Please Read Carefully:

INSTRUCTIONS: On this page is a list of thoughts, emotions, feelings in your body, and behaviors that may or may not be relevant for you. Based on your experience, please rate each item on how well it describes you. Please circle one response for each item.

Please use the scale listed opposite and circle the number which best reflects how relevant each item is for you. →	Strongly Disagree	Disagree	Agree	Strongly Agree
1. I feel shy around people I don't know.	1	2	3	4
2. I get nervous when I meet new people.	1	2	3	4
3. I am more anxious/uncomfortable in social situations than most people.	1	2	3	4
4. I am too scared to ask other people questions.	1	2	3	4
5. Answering questions in front of others makes me feel sick in my stomach or nervous.	1	2	3	4
6. I feel comfortable around people I don't know.	1	2	3	4
7. When I speak to people I don't know, I feel sick in my stomach or nervous.	1	2	3	4
8. Being the center of attention makes me feel sick in my stomach or nervous.	1	2	3	4
9. I like getting called on in class/meetings.	1	2	3	4
10. I feel so scared at parties, social gatherings, school, or anyplace where there will be more than two other people that I go home early.	1	2	3	4
11. When I am addressed by another, I become so nervous I cannot speak more often than not.	1	2	3	4
12. I'm afraid of going to a party.	1	2	3	4
13. I fear acting, performing (e.g. choir, music, dance, sports performance, etc.), or speaking (e.g., giving a report, reading aloud, etc.) in front of an audience.	1	2	3	4
14. I fear participating in group activities.	1	2	3	4
15. I am more comfortable in social situations than most people.	1	2	3	4
16. I fear talking to persons I don't know well (e.g., strangers, new or unfamiliar people)	1	2	3	4
17. I worry about being teased, ignored, or made fun of by people.	1	2	3	4

Please use the scale listed opposite and circle the number which best reflects how relevant each item is for you.	Strongly Disagree	Disagree	Agree	Strongly Agree
18. I feel scared starting or joining in on a conversation.	1	2	3	4
19. I worry about what other people will think of me.	1	2	3	4
20. I worry about what others say about me.	1	2	3	4
21. I am comfortable asking other people questions.	1	2	3	4
22. I worry about people laughing at me.	1	2	3	4
23. I worry about getting called on in class/meetings.	1	2	3	4
24. I worry about doing something stupid or embarrassing.	1	2	3	4
25. I worry about meeting new people.	1	2	3	4
26. I worry about entering a room full of people.	1	2	3	4
27. I am afraid of calling someone I don't know very well.	1	2	3	4
28. I'm afraid of being the center of attention.	1	2	3	4
29. I'm afraid of speaking up at a meeting.	1	2	3	4
30. When I'm with other people sometimes I think whatever I say will sound stupid.	1	2	3	4
31. Before I go to a party or I go some place where others will be, I think about what might go wrong.	1	2	3	4
32. Before I go to a party or I go some place where others will be, I think, "Will I make a mistake and look stupid?"	1	2	3	4
33. Before I go to a party or I go some place where others will be, I think, "What if somebody talks to me and I can't think of what to say?"	1	2	3	4
34. I feel like I can't talk or move when I'm with other people.	1	2	3	4
35. I go out of my way to avoid seeing people I know in public.	1	2	3	4
36. I like being the center of attention.	1	2	3	4

Appendix J

Social Interaction Anxiety Scale (SIAS)

Instructions: For each item, please circle the number to indicate the degree to which you feel the statement is characteristic or true for you. The rating scale is as follows:

0 = **Not at all** characteristic or true of me.
1 = **Slightly** characteristic or true of me.
2 = **Moderately** characteristic or true of me.
3 = **Very** characteristic or true of me.
4 = **Extremely** characteristic or true of me.

CHARACTERISTIC	NOT AT ALL	SLIGHTLY	MODERATELY	VERY	EXTREMELY
1. I get nervous if I have to speak with someone in authority (teacher, boss, etc.).	0	1	2	3	4
2. I have difficulty making eye contact with others.	0	1	2	3	4
3. I become tense if I have to talk about myself or my feelings.	0	1	2	3	4
4. I find it difficult to mix comfortably with the people I work with.	0	1	2	3	4
5. I find it easy to make friends my own age.	0	1	2	3	4
6. I tense up if I meet an acquaintance in the street.	0	1	2	3	4
7. When mixing socially, I am uncomfortable.	0	1	2	3	4
8. I feel tense if I am alone with just one other person.	0	1	2	3	4
9. I am at ease meeting people at parties, etc.	0	1	2	3	4
10. I have difficulty talking with other people.	0	1	2	3	4
11. I find it easy to think of things to talk about.	0	1	2	3	4
12. I worry about expressing myself in case I appear awkward.	0	1	2	3	4
13. I find it difficult to disagree with another's point of view.	0	1	2	3	4
14. I have difficulty talking to attractive persons of the opposite sex.	0	1	2	3	4
15. I find myself worrying that I won't know what to say in social situations.	0	1	2	3	4
16. I am nervous mixing with people I don't know well.	0	1	2	3	4
17. I feel I'll say something embarrassing when talking.	0	1	2	3	4
18. When mixing in a group, I find myself worrying I will be ignored.	0	1	2	3	4
19. I am tense mixing in a group.	0	1	2	3	4
20. I am unsure whether to greet someone I know only slightly.	0	1	2	3	4

Appendix K

Depression Anxiety Stress Scales (DASS-21)

DASS21

ID #: *Date:*

Please read each statement and circle a number 0, 1, 2 or 3 that indicates how much the statement applied to you *over the past week*. There are no right or wrong answers. Do not spend too much time on any statement.

The rating scale is as follows:

0 Did not apply to me at all
1 Applied to me to some degree, or some of the time
2 Applied to me to a considerable degree, or a good part of time
3 Applied to me very much, or most of the time

1	I found it hard to wind down	0	1	2	3
2	I was aware of dryness of my mouth	0	1	2	3
3	I couldn't seem to experience any positive feeling at all	0	1	2	3
4	I experienced breathing difficulty (e.g., excessively rapid breathing, breathlessness in the absence of physical exertion)	0	1	2	3
5	I found it difficult to work up the initiative to do things	0	1	2	3
6	I tended to over-react to situations	0	1	2	3
7	I experienced trembling (e.g., in the hands)	0	1	2	3
8	I felt that I was using a lot of nervous energy	0	1	2	3
9	I was worried about situations in which I might panic and make a fool of myself	0	1	2	3
10	I felt that I had nothing to look forward to	0	1	2	3
11	I found myself getting agitated	0	1	2	3
12	I found it difficult to relax	0	1	2	3
13	I felt down-hearted and blue	0	1	2	3
14	I was intolerant of anything that kept me from getting on with what I was doing	0	1	2	3
15	I felt I was close to panic	0	1	2	3
16	I was unable to become enthusiastic about anything	0	1	2	3

17	I felt I wasn't worth much as a person	0	1	2	3
18	I felt that I was rather touchy	0	1	2	3
19	I was aware of the action of my heart in the absence of physical exertion (e.g., sense of heart rate increase, heart missing a beat)	0	1	2	3
20	I felt scared without any good reason	0	1	2	3
21	I felt that life was meaningless	0	1	2	3

Appendix L

IRB Approval Letter

VirginiaTech

Office of Research Compliance
Institutational Review Board
North End Center, Suite 4120, Virginia Tech
300 Turner Street NW
Blacksburg, Virginia 24061
540/231-4606 Fax 540/231-0959
email irb@vt.edu
website http://www.irb.vt.edu

MEMORANDUM

DATE: June 24, 2013

TO: Susan Williams White, Brenna Burns Maddox, Caitlin Mary Conner, Nicole L Kreiser, Amie R Schry, Katharine A Donlon

FROM: Virginia Tech Institutional Review Board (FWA00000572, expires April 25, 2018)

PROTOCOL TITLE: Eye-Gaze Pattern Analysis as a Key to Understanding Co-occurring Social Anxiety within Autism Spectrum Disorder

IRB NUMBER: **13-174**

Effective June 21, 2013, the Virginia Tech Institution Review Board (IRB) Chair, David M Moore, approved the Amendment request for the above-mentioned research protocol.

This approval provides permission to begin the human subject activities outlined in the IRB-approved protocol and supporting documents.

Plans to deviate from the approved protocol and/or supporting documents must be submitted to the IRB as an amendment request and approved by the IRB prior to the implementation of any changes, regardless of how minor, except where necessary to eliminate apparent immediate hazards to the subjects. Report within 5 business days to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.

All investigators (listed above) are required to comply with the researcher requirements outlined at:

http://www.irb.vt.edu/pages/responsibilities.htm

(Please review responsibilities before the commencement of your research.)

PROTOCOL INFORMATION:

Approved As:	**Full Review**
Protocol Approval Date:	**March 19, 2013**
Protocol Expiration Date:	**March 18, 2014**
Continuing Review Due Date*:	**February 24, 2014**

*Date a Continuing Review application is due to the IRB office if human subject activities covered under this protocol, including data analysis, are to continue beyond the Protocol Expiration Date.

FEDERALLY FUNDED RESEARCH REQUIREMENTS:

Per federal regulations, 45 CFR 46.103(f), the IRB is required to compare all federally funded grant proposals/work statements to the IRB protocol(s) which cover the human research activities included in the proposal / work statement before funds are released. Note that this requirement does not apply to Exempt and Interim IRB protocols, or grants for which VT is not the primary awardee.

The table on the following page indicates whether grant proposals are related to this IRB protocol, and which of the listed proposals, if any, have been compared to this IRB protocol, if required.

Date*	OSP Number	Sponsor	Grant Comparison Conducted?
03/22/2013	13193902	Organization for Autism Research	Not required (Not federally funded)

* Date this proposal number was compared, assessed as not requiring comparison, or comparison information was revised.

If this IRB protocol is to cover any other grant proposals, please contact the IRB office (irbadmin@vt.edu) immediately.

Appendix M

Telephone Interview Script

PHONE SCREEN SCRIPT FOR POTENTIAL PARTICIPANTS

Phone Screening Script
Date _____

ID #: _____

NOTE: This phone script will be used for either lab-initiated phone calls (e.g., when a potential participant has emailed our lab indicating an interest), as well as participant-initiated calls (when a participant telephones our lab directly, in response to a community or campus advertisement).

NOTE: If the parent of a potential participant initiates the call, please follow the script starting on page 4.

Lab initiated call:

Hello, my name is _____, and I am calling about the eye-tracking research study you recently indicated interested in.

Participant initiated call:

Thank you for your interest in our study. My name is _____.

Introduction to study:
What I would like to do is first tell you about our research study, and then later ask some questions to help us determine if you qualify to participate. These questions will involve some basic information about your age, current anxiety symptoms, and diagnoses. Answering these questions is voluntary. You are under no obligation to answer them. However, not answering the questions means that you will not be able to participate in this research study. You are also free to stop answering questions at any time.

The phone call today should take less than 10 minutes. Is this ok?

If yes: Continue
If no: Reschedule phone call if time is inconvenient, or if participant declines, thank participant for his/her time, indicate that if they change their mind they are free to re-contact us and politely hang up.

Dr. Susan White, a faculty member in the VT Department of Psychology, is the principal investigator of this study, and the purpose of this research study is to examine how social anxiety symptoms influence how adults with an Autism Spectrum Disorder (ASD) look at other people. We plan to compare gaze patterns across three groups of participants: (1) adults with ASD, (2) adults with social anxiety, and (3) adults without ASD or social anxiety. We hope to complete eye-tracking sessions with a total of 60 to 90 adults (20 to 30 per group), ages 16 to 45.

If you are interested in this study after our phone call and eligible to participate, then the next step will be for you to attend the study session, where you will complete the eye-tracking task, some questionnaires, and a brief interview with the researcher. During the eye-tracking task, participants watch a series of faces depicting different emotional expressions on a computer screen. The study session will take between 1.5 to 2.5 hours to complete.

Here is some information about the confidentiality of the information I collect today. If you do not qualify for the study or decide not to participate, we will not keep the information we collect today. If you do qualify for the study and decide to participate, we will ask you to sign a consent form at the study appointment. The personal information you give me today will become part of your research record and will be reviewed by Dr. White and the research staff. Your name will **not** appear on this screening information. We will assign a code number and the key to the code will be kept in a locked file separate from the other information I collect today. If you change your mind at any time and decide that you do not want to participate, you can call us and we will immediately destroy the private information that we collect today.

Would you like to continue to learn some more information about the study?

If yes: Continue
If no: Ask participant if they would like to reschedule the Phone Screen, or if participant declines, thank participant for his/her time, indicate that if they change their mind they are free to re-contact us and politely hang up.

Description of Study Session:
Before I ask you the screening questions, let me tell you some more information about the study session. If you choose to participate, you will be asked to come to our lab in Williams Hall (the psychology department building) on Virginia Tech's campus for one appointment. At the appointment, you will first meet with a study investigator to further discuss the consent form and address any questions you may have. Once you have all your questions answered, you will sign the consent form if you wish to continue with the research study. You will then accompany a study investigator to a separate room in Williams Hall for the eye-tracking task. You will be seated approximately 70 cm from a computer screen, on which a series of faces will appear showing different emotional expressions. The stimuli will appear quickly, and the computer technology will record the movements of your eyes as you look at the screen. We will also ask you to rate some of the facial expressions on how emotional they appear to you. We will be videotaping your face during the eye-tracking task, so we can record your own facial expressions. This eye-tracking task should take less than 20 minutes.

Following the eye-tracking task, you will be asked to complete a few questionnaires about your behaviors, interests, and experiences. Your time commitment to complete these questionnaires is under 30 minutes. After the questionnaires, you will complete a brief assessment of cognitive functioning (approximately 20 minutes), followed by an interview about your previous or current psychological diagnoses, current medication use, ASD symptoms, and social anxiety symptoms (approximately 30 minutes). Lastly, any participant with an ASD diagnosis will complete a videotaped assessment of ASD characteristics, which involves interacting with the investigator for approximately 30-45 minutes.

If you are a Virginia Tech student eligible for Sona extra credit, you will receive 2 Sona extra credits. If you are not eligible for Sona extra credit, you will receive $20.00. Participants driving

more than 30 miles to and from the study appointment will also receive mileage reimbursement ($0.50 per mile traveled, with a maximum mileage reimbursement of $50.00). Participants requesting mileage reimbursement will need to provide their home zip code in order to calculate the distance traveled.

If the participant is a Virginia Tech student:
Are you currently eligible for Sona extra credit? □ YES □ NO

If the participant has not yet indicated how they heard about the study:
May I also ask how you heard about our study? _____

Phone: _____ Email: _____

What is the best way to contact you? _____

Screening Questions:

Would you like to continue now with the screening questions?

If yes: Continue
If no: Ask participant if they would like to reschedule the Phone Screen, or if participant declines, thank participant for his/her time, indicate that if they change their mind they are free to re-contact us and politely hang up.

1. What is your age? _____
□ If not between 16-45 years old, say "We are currently only recruiting individuals 16-45 years old, so you are not eligible to participate in this study."

2. In the past month, were you fearful or embarrassed being watched, being the focus of attention, or fearful of being humiliated? This includes things like speaking in public, eating in public or with others, writing while someone watches, or being in social situations.
□ YES (if yes, continue)
□ NO (if no, skip to Question 7)

3. Is this social fear excessive or unreasonable?
□ YES (if yes, continue)
□ NO (if no, skip to Question 7)

4. Do you fear these social situations so much that you avoid them or suffer through them?
□ YES (if yes, continue)
□ NO (if no, skip to Question 7)

5. Do these social fears disrupt your normal work or social functioning or cause you significant distress?
□ YES (if yes, continue)
□ NO (if no, skip to Question 7)

6. Do you fear and avoid 4 or more social situations?
□ YES
□ NO

7. Do you currently have a diagnosis of Autism Spectrum Disorder, such as Asperger's?
□ YES
□ NO

8. Have you ever been diagnosed with an intellectual disability or mental retardation?
□ YES (if yes, the participant is not eligible for the study)
□ NO

Those are all the questions I have for you now. What questions do you have for me?

IF QUALIFIED:
□ Qualified for ASD group (if 'Yes' to question 7)
□ Qualified for Social Phobia group (if 'Yes' to questions 2 through 5 and 'No' to question 7)
□ Qualified for non-ASD, non-Social Phobia group (if 'No' to questions 2, 3, 4, or 5 and 'No' to question 7)

You are eligible for the study session. As a reminder, that appointment lasts between 1.5-2.5 hours. What days and times are convenient for you? [Schedule appointment.] When you come in for the study, you will review a consent document with further details of the study, which, if you decide to participate, you will sign. For your convenience, we will email you the consent document so you can review it prior to coming to our lab.

IF NOT QUALIFIED:
Thank you for providing this information. Based on this information, I find that you don't qualify to participate in this study. All the information I collected for this screening will be erased. Thank you for your time.

PHONE SCREEN SCRIPT FOR PARENTS OF POTENTIAL PARTICIPANTS

Phone Screening Script
Date _____

ID #: _____

NOTE: This phone script will be used for either lab-initiated phone calls (e.g., when a parent of a potential participant has emailed our lab indicating an interest), as well as participant-initiated calls (when a parent of a participant telephones our lab directly, in response to a community or campus advertisement).

NOTE: If a potential participant initiates the call, instead of his/her parent, please follow the script starting on page 1.

Lab initiated call:

Hello, my name is _____, and I am calling about the eye-tracking research study you recently indicated interested in.

Parent initiated call:

Thank you for your interest in our study. My name is _____.

Introduction to study:

What I would like to do is first tell you about our research study, and then later ask some questions to help us determine if your child qualifies to participate. These questions will involve some basic information about your child's age, current anxiety symptoms, and diagnoses. Answering these questions is voluntary. You are under no obligation to answer them. However, not answering the questions means that your will not be able to participate in this research study. You are also free to stop answering questions at any time.

The phone call today should take less than 10 minutes. Is this ok?

If yes: Continue

If no: Reschedule phone call if time is inconvenient, or if the parent declines, thank parent for his/her time, indicate that if they change their mind they are free to re-contact us and politely hang up.

Dr. Susan White, a faculty member in the VT Department of Psychology, is the principal investigator of this study, and the purpose of this research study is to examine how social anxiety symptoms influence how adults with an Autism Spectrum Disorder (ASD) look at other people. We plan to compare gaze patterns across three groups of participants: (1) adults with ASD, (2) adults with social anxiety, and (3) adults without ASD or social anxiety. We hope to complete eye-tracking sessions with a total of 60 to 90 adults (20 to 30 per group), ages 16 to 45.

If you are interested in this study after our phone call and eligible to participate, then the next step will be for you and your child to attend the study session, where your child will complete the eye-tracking task, some questionnaires, and a brief interview with the researcher. You will also complete a questionnaire about your child's behaviors and interests. During the eye-tracking task, participants watch a series of faces depicting different emotional expressions on a computer screen. The study session will take between 1.5 to 2.5 hours to complete.

Here is some information about the confidentiality of the information I collect today. If your child does not qualify for the study or decides not to participate, we will not keep the information we collect today. If your child does qualify for the study and decides to participate, we will ask you and your child to sign a consent and assent form at the study appointment. The personal information you give me today will become part of your research record and will be reviewed by Dr. White and the research staff. You and your child's names will **not** appear on this screening information. We will assign a code number and the key to the code will be kept in a locked file separate from the other information I collect today. If you change your mind at any time and decide that you do not want your child to participate, you can call us and we will immediately destroy the private information that we collect today.

Would you like to continue to learn some more information about the study?

If yes: Continue

If no: Ask participant if they would like to reschedule the Phone Screen, or if participant declines, thank participant for his/her time, indicate that if they change their mind they are free to re-contact us and politely hang up.

Description of Study Session:

Before I ask you the screening questions, let me tell you some more information about the study session. If you choose to participate, you and your child will be asked to come to our lab in Williams Hall (the psychology department building) on Virginia Tech's campus for one appointment. At the appointment, you and your child will first meet with a study investigator to further discuss the consent form and address any questions you may have. Once you have all your questions answered, you will sign the consent form and your child will sign the assent form if you wish to continue with the research study. Your child will then accompany a study investigator to a separate room in Williams Hall for the eye-tracking task. He/she will be seated approximately 70 cm from a computer screen, on which a series of faces will appear showing different emotional expressions. The stimuli will appear quickly, and the computer technology will record the movements of his/her eyes as he/she looks at the screen. We will also ask your child to rate some of the facial expressions on how emotional they appear to him/her. We will be videotaping your child's face during the eye-tracking task, so we can record his/her own facial expressions. This eye-tracking task should take less than 20 minutes. During this time, you will complete a questionnaire.

Following the eye-tracking task, your child will be asked to complete a few questionnaires about his or her behaviors, interests, and experiences. The time commitment to complete these questionnaires is under 30 minutes. After the questionnaires, your child will complete a brief assessment of cognitive functioning (approximately 20 minutes), followed by an interview about his or her previous or current psychological diagnoses, current medication use, ASD symptoms, and social anxiety symptoms (approximately 30 minutes). Lastly, any participant with an ASD diagnosis will complete a videotaped assessment of ASD characteristics, which involves interacting with the investigator for approximately 30-45 minutes.

If your child is a Virginia Tech student eligible for Sona extra credit, he or she will receive 2 Sona extra credits. If your child is not eligible for Sona extra credit, you will receive $20.00. Participants driving more than 30 miles to and from the study appointment will also receive mileage reimbursement ($0.50 per mile traveled, with a maximum mileage reimbursement of $50.00). Participants requesting mileage reimbursement will need to provide their home zip code in order to calculate the distance traveled.

If the participant is a Virginia Tech student:
Is your child currently eligible for Sona extra credit? □ YES □ NO

If the participant has not yet indicated how they heard about the study:
May I also ask how you heard about our study? _____

Phone: _____ Email: _____

What is the best way to contact you? _____

Screening Questions:

Would you like to continue now with the screening questions?

If yes: Continue

If no: Ask participant if they would like to reschedule the Phone Screen, or if participant declines, thank participant for his/her time, indicate that if they change their mind they are free to re-contact us and politely hang up.

1. What is your child's age? _____
□ If not between 16-45 years old, say "We are currently only recruiting individuals 16-45 years old, so your child is not eligible to participate in this study."

2. In the past month, has your child been fearful or embarrassed being watched, being the focus of attention, or fearful of being humiliated? This includes things like speaking in public, eating in public or with others, writing while someone watches, or being in social situations.
□ YES (if yes, continue)
□ NO (if no, skip to Question 7)

3. Is this social fear excessive or unreasonable?
□ YES (if yes, continue)
□ NO (if no, skip to Question 7)

4. Does your child fear these social situations so much that he or she avoids them or suffers through them?
□ YES (if yes, continue)
□ NO (if no, skip to Question 7)

5. Do these social fears disrupt your child's normal work or social functioning or cause him/her significant distress?
□ YES (if yes, continue)
□ NO (if no, skip to Question 7)

6. Does your child fear and avoid 4 or more social situations?
□ YES
□ NO

7. Does your child currently have a diagnosis of Autism Spectrum Disorder, such as Asperger's?
□ YES
□ NO

8. Has your child ever been diagnosed with an intellectual disability or mental retardation?
□ YES (if yes, the participant is not eligible for the study)
□ NO

Those are all the questions I have for you now. What questions do you have for me?

IF QUALIFIED:
□ Qualified for ASD group (if 'Yes' to question 7)
□ Qualified for Social Phobia group (if 'Yes' to questions 2 through 5 and 'No' to question 7)
□ Qualified for non-ASD, non-Social Phobia group (if 'No' to questions 2, 3, 4, or 5 and 'No' to question 7)

Your child is eligible for the study session. As a reminder, that appointment lasts between 1.5-2.5 hours. What days and times are convenient for you and your child? [Schedule appointment.]

When you come in for the study, you will review a consent document with further details of the study, which, if you decide to participate, you will sign. For your convenience, we will email you the consent document and your child's assent form so you both can review them prior to coming to our lab.

IF NOT QUALIFIED:
Thank you for providing this information. Based on this information, I find that your child doesn't qualify to participate in this study. All the information I collected for this screening will be erased. Thank you for your time.

Appendix N

Participant Consent Form

INFORMED CONSENT FOR RESEARCH PROJECT

Project Title: *Exploring Eye Gaze Patterns*

Investigators
Principal Investigator: Susan W. White, Ph.D., Assistant Professor
Co-Investigator: Brenna Maddox, M.S., Doctoral Graduate Student
Psychology Department, Virginia Tech

Purpose of the Study
The purpose of this research study is to examine how Social Phobia (SP) or social anxiety symptoms influence how adults with an Autism Spectrum Disorder (ASD) look at other people. We plan to compare gaze patterns across three groups of participants: (1) adults with ASD, (2) adults with SP, and (3) adults without ASD or SP. We hope to complete eye-tracking sessions with a total of 60 to 90 adults (20 to 30 per group), ages 16 to 45.

In order to decide whether or not you wish to be a part of this research study, you should know enough about its risks and benefits to make an informed decision. This consent form gives you detailed information about the research study, which a study investigator will also discuss with you.

Procedures
If you choose to participate in this research study, you will be asked to come to our lab at 252 Williams Hall (the psychology department building) on Virginia Tech's campus for one appointment. The session length will vary between 1.5 to 2.5 hours. It is important that you do not wear mascara to this appointment, as mascara can interfere with the eye-tracking technology. At the appointment, you will first meet with a study investigator to further discuss this consent form and address any questions you may have. Once you have all your questions answered, you will sign the consent form if you wish to continue with the research study. You will then accompany a study investigator to a separate room in Williams Hall for the eye-tracking task. You will be seated approximately 70 cm from a computer screen, on which a series of faces will appear showing different emotional expressions. The stimuli will appear quickly, and the computer technology will record the movements of your eyes as you look at the screen. We will also ask you to rate some of the facial expressions on how emotional they appear to you. We will be videotaping your face during the eye-tracking task, so we can record your own facial expressions. This eye-tracking task should take less than 20 minutes.

Following the eye-tracking task, you will be asked to complete a few questionnaires about your behaviors, interests, and experiences. Your time commitment to complete these questionnaires is under 30 minutes. After the questionnaires, you will complete a brief assessment of cognitive functioning (approximately 20 minutes), followed by an interview about your previous or current psychological diagnoses, current medication use, ASD symptoms, and social anxiety symptoms (approximately 30 minutes). Lastly, any participant with an ASD diagnosis will complete a videotaped assessment of ASD characteristics, which involves interacting with the investigator for approximately 30-45 minutes.

Risks and Benefits
One possible risk is experiencing anxiety during some of the tasks. During the eye-tracking task, faces depicting a range of both positive and negative emotional expressions (e.g., happy, disgust)

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Approved June 21, 2013 to March 18, 2014

will be presented. Although these expressions are no more unusual than what might be encountered during everyday social interactions, they could possibly be upsetting to some people. Also, you might experience anxiety or discomfort being videotaped or answering questions about situations that make you anxious. A second risk is related to confidentiality. We have procedures to ensure confidentiality and protection of your personal information (see below), but the risk of compromised confidentiality is still somewhat present.

There is no immediate, direct, or indirect benefit to you for participating in this study. No promises of benefits have been made to encourage you to participate. However, we hope that results of this project can help in designing future research and interventions to benefit students and adults in the greater community. In addition, if you would like to watch the replay of your eye-tracking patterns when you finish the task, please let us know. Some people are curious to see what their gaze looks like with eye-tracking technology, so we offer the replay immediately after the session for anyone interested.

Costs and Payment for Participation

There is no cost for participating in this study. If you are a current Virginia Tech student and in a class that uses the Sona system, you will be offered two hours of Sona credit for participating in this study. For information about how this extra credit will affect your grade and alternative ways to earn extra credit, please speak with your class instructor. Please refer to the Sona system to receive your extra credit: https://vt-psyc.sona-systems.com/. Even if you do not complete the whole session, you will still be entered in the Sona system to receive the credit.

If you are not enrolled in a Virginia Tech course that uses the Sona system, you will receive $20 at the completion of the consent process. Participants driving more than 30 miles to and from the study appointment will also receive mileage reimbursement ($0.50 per mile traveled, with a maximum mileage reimbursement of $50.00). Participants requesting mileage reimbursement will need to provide their home zip code in order to calculate the distance traveled. If you choose to not complete the whole appointment, you will still keep the money.

Confidentiality

Any identifiable information that is obtained in connection with this study will remain confidential and will be disclosed only with your permission or as required by U.S. or State law. Examples of information that we are legally required to disclose include suspected abuse of a child or elderly person, suicidality, and intention to harm identifiable others. Each person who participates in this study will be assigned a unique, identifying number. This number will be used to identify all research data within our database. The master list, which will contain your name and the unique identifying number, will be kept separate from all other data. Only the investigators of the study will have access to this master list. All video files of the eye-tracking sessions are password protected on a computer in the eye-tracking room, which is locked at all times. All video recordings of the interaction task will be kept separate from identifying information, in a secure locked filing cabinet. Only the investigators and trained lab personnel will have access to these recordings. All identifying information will be destroyed within five years of data collection. However, if you indicate on this consent form that you would like to be contacted about future studies, your contact information will be maintained in a secure, password-protected file that is kept separate from all

data related to this study, so that we are able to contact you about other studies unless you indicate to us in writing that you want to be removed from the contact list.

When the results of the research are published or discussed in conferences, no information will be included that would reveal your identity. It is possible that the Institutional Review Board (IRB) may view this study's collected data for auditing purposes. The IRB is responsible for the oversight of the protection of human subjects involved in research. These individuals are required to keep all information confidential.

Freedom to Withdraw

You do not have to participate in this study. If you do participate, you can stop at any time and without penalty, by telling the researchers that you want to stop the study. If you decide to not participate or to withdraw from the study, your involvement in any future study will not be jeopardized.

Questions

Please feel free to ask about anything you do not understand. In addition, consider this research and the consent form carefully – as long as you feel is necessary – before you make a decision. If you would like to speak with a member of the research team, please call Brenna Maddox or Dr. Susan White at the Psychosocial Interventions Lab at (540) 231-6744 or e-mail: bmaddox7@vt.edu.

If you should have any questions about the protection of human research participants regarding this study, you may contact: Dr. David Harrison, Chair of Departmental Human Subjects Committee, (540) 231-4422, e-mail: dwh@vt.edu, or Dr. David Moore, Chair Virginia Tech Institutional Review Board for the Protection of Human Subjects, telephone: (540) 231-4991; e-mail: moored@vt.edu; address: Office of Research Compliance, 2000 Kraft Drive, Suite 2000 (0497), Blacksburg, VA 24060.

Subject's Responsibility

As a participant in this study, you voluntarily agree to participate in this study. You have the following responsibilities:

1. Ask any questions you have about the study and the consent process.
2. Complete the tasks given to you to the best of your ability.

Subject's Permission

I have read the Consent Form and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent.

Subject signature Date	Subject name (printed)
Study Investigator Name	Investigator Signature Date

Virginia Tech Institutional Review Board Project No. 13-174
Approved June 21, 2013 to March 18, 2014

If I participate in other studies affiliated with the VT Autism Clinic (VTAC) or the VT Center for Autism Research (VTCAR), my data will be given a code and potentially combined with my other coded data. A master list will be maintained in order to match my current data with previously collected data. My name from this master list will only be available to VTAC or VTCAR staff and will not be shared with others. I may be contacted for future studies if I give separate permission below.

Yes, I would like to be contacted for possible participation in future studies through VTAC or VTCAR. I understand I would be under no obligation to participate in these studies if contacted. I can decide at that time if I would like to participate.

_____

Subject signature Date

Virginia Tech Institutional Review Board Project No. 13-174
Approved June 21, 2013 to March 18, 2014

Appendix O

Participant Assent Form

YOUTH ASSENT FORM

Project Title: *Exploring Eye Gaze Patterns*

This form may have some words that you do not know. Please ask someone to explain any words that you do not know. You may talk to your parents about this study before you decide if you want to be in this study.

What is this study about?

Researchers here at Virginia Tech are trying to understand how social anxiety symptoms affect how adults with Autism Spectrum Disorder (ASD) look at other people. Social anxiety is quite common, and refers to being fearful in social situations or afraid of what other people might think badly of you. We want to learn if social anxiety in people with ASD affects eye-gaze patterns similarly to people without ASD who have social anxiety. We are inviting people between the ages of 16 and 45 to this study.

What will happen to me if I choose to be in this study?

If you decide to participate in this research study, you will be asked to come to our research lab on Virginia Tech's campus for one appointment. The session will last between 1.5 to 2.5 hours. It is important that you do not wear mascara to this appointment, as it interferes with the eye-tracking technology. At the appointment, you will first meet with a researcher to talk about the study and address any questions you may have. Once you have all your questions answered, you will be asked to sign this permission form if you wish to continue with the research study. You will then go with the researcher to a separate room for the eye-tracking task, while your parent or guardian waits in the main waiting area down the hall. You will be seated in front of a computer screen. On the computer screen, several faces will appear showing different emotional expressions. You will be asked to just watch the screen. The faces will appear quickly and we will record the movements of your eyes as you look at the screen. We will also ask you to rate some of the facial expressions on how emotional they appear to you. We will be videotaping your face during the eye-tracking task as well, so we can record your own facial expressions. This eye-tracking task should take less than 20 minutes.

After the eye-tracking task, you will be asked to complete a few brief questionnaires about your behaviors, interests, and experiences. The questionnaires should take 30 minutes or less. After the questionnaires, you will complete a brief test of cognitive abilities (approximately 20 minutes), followed by an interview about your previous or current psychological diagnoses, current medication use, ASD symptoms, and social anxiety symptoms (approximately 30 minutes). Lastly, any participant with an ASD diagnosis will do some additional activities, such as creating a puzzle and reading a story, with the researcher for approximately 30-45 minutes. This part of the session will be videotaped.

What might happen if I am in this study?

Sometimes when people are asked questions about their feelings related to social interaction or fears about others judging them, they may feel anxious or nervous. Also, in the eye-tracking task, seeing facial expressions of both positive and negative emotions (such as happy, sad, disgust) could possibly be upsetting to some people. Some people may feel anxious or nervous about being videotaped for parts of the appointment.

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What do I get if I'm in this study?
There is no immediate or direct benefit to you for enrolling in this study. However, if you would like to watch the replay of your eye-tracking patterns when you finish the task, please let us know. Some people are curious to see what their gaze looks like with eye-tracking technology, so we offer the replay immediately after the session for anyone interested. In addition, your parent or caregiver will receive $20.00 to help with costs they might have because of the study. If you and your parent or caregiver are driving more than 30 miles to and from the study appointment, your parent or caregiver will receive additional money ($0.50 per mile traveled, with a maximum of $50.00) to help with travel costs. If you choose to not complete the whole appointment, your parent or caregiver will still keep the money.

Will you tell anyone what I say?
Only the researchers involved in this research study will see your eye-tracking patterns. We will not share your answers to the questionnaires with your teachers, your parents, or your friends.

If you were to tell us that someone is hurting you, or that you might hurt yourself or someone else, the law requires us to let people in authority know so they can help you.

If we talk about this study in speeches or in writing, we will never use your name.

Do I have to be in this study?
You do not have to be in this study. If you choose to be in this study, you can stop at any time. No one will blame you or criticize you if you drop out of the study. Adults at this facility will not treat you differently if you choose not to be in this study.

Questions
If you have any questions about being in this study, you can talk to the following people or you can have your parent or another adult call:

Brenna Maddox
Virginia Tech Graduate Student
(540) 231-6744
bmaddox7@vt.edu

Dr. Susan W. White
Virginia Tech Assistant Professor
(540) 231-6174
sww@vt.edu

Or if you or an adult have any questions about your rights in this study, you may contact:

Office for Research, Institutional Review Board
Virginia Tech
David M. Moore, IRB Chair
(540) 231-4991
moored@vt.edu

Do not sign this form if you have any questions. Be sure someone answers your questions.

Assent:
I have read this form. I understand the information about this study. I am willing to be in this study.

Youth Name (printed)	Youth Signature	Date

Person conducting Informed Consent (Print Name)	Signature	Date

Appendix P

Parental Permission Form

PARENT PERMISSION TO PARTICIPATE IN A RESEARCH PROJECT

Project Title: *Exploring Eye Gaze Patterns*

Investigators
Principal Investigator: Susan W. White, Ph.D., Assistant Professor
Co-Investigator: Brenna Maddox, M.S., Doctoral Graduate Student
Psychology Department, Virginia Tech

Purpose of the Study

The purpose of this research study is to examine how Social Phobia (SP) or social anxiety symptoms influence how adults with an Autism Spectrum Disorder (ASD) look at other people. We plan to compare gaze patterns across three groups of participants: (1) adults with ASD, (2) adults with SP, and (3) adults without ASD or SP. We hope to complete eye-tracking sessions with a total of 60 to 90 adults (20 to 30 per group), ages 16 to 45.

In order to decide whether or not you wish your child to be a part of this research study, you should know enough about its risks and benefits to make an informed decision. This consent form gives you detailed information about the research study, which a study investigator will also discuss with you.

Procedures

If you and your child choose to participate in this research study, you will be asked to come to our lab at 252 Williams Hall (the psychology department building) on Virginia Tech's campus for one appointment. The session length will vary between 1.5 to 2.5 hours. It is important that your child not wear mascara to this appointment, as it interferes with the eye-tracking technology. At the appointment, you and your child will first meet with a study investigator to further discuss this permission form and address any questions you may have. Once you have all your questions answered, you will sign the permission form if you wish to continue with the research study. You will remain in the waiting area and complete a brief questionnaire about your child's interests and behaviors, while your child accompanies a study investigator to a separate room in Williams Hall for the eye-tracking task. S/he will be seated approximately 70 cm from a computer screen, on which a series of faces will appear showing different emotional expressions. The stimuli will appear quickly, and the computer technology will record the movements of your child's eyes as s/he looks at the screen. We will also ask your child to rate some of the facial expressions on how emotional they appear to him or her. We will be videotaping your child's face during the eye-tracking task, so we can record his/her facial expressions. This eye-tracking task should take less than 20 minutes.

Following the eye-tracking task, your child will be asked to complete a few brief questionnaires about his/her behaviors, interests, and experiences. His/her time commitment to complete these questionnaires is under 30 minutes. After the questionnaires, s/he will complete a brief assessment of cognitive functioning (approximately 20 minutes), followed by a brief interview about his/her previous or current psychological diagnoses, current medication use, ASD symptoms, and social anxiety symptoms (approximately 30 minutes). Lastly, any participant with an ASD diagnosis will complete a videotaped assessment of ASD characteristics, which involves interacting with the investigator for approximately 30-45 minutes.

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Risks and Benefits

Participants in this study may experience anxiety during some of the tasks. During the eye-tracking task, faces depicting a range of both positive and negative emotional expressions (e.g., happy, disgust) will be presented. Although these expressions are no more unusual than what might be encountered during everyday social interactions, they could possibly be upsetting to some people. Also, your son/daughter might experience anxiety or discomfort being videotaped or answering questions about situations that make him/her anxious. A second risk is related to confidentiality. We have procedures to ensure confidentiality and protection of your and your child's personal information (see below), but the risk of compromised confidentiality is still somewhat present.

There is no immediate, direct, or indirect benefit to you or your child for participating in this study. No promises of benefits have been made to encourage you or your child to participate. However, we hope that results of this project can help in designing future research and interventions to benefit students and adults in the greater community. In addition, if you would like to watch the replay of your child's eye-tracking patterns when you finish the task, please let us know. Some parents are curious to see what their child's gaze patterns look like with eye-tracking technology, so we offer the replay immediately after the session for anyone interested.

Costs and Payment for Participation

There is no cost for participating in this study. You will be given a small honorarium ($20.00) at the completion of the consent process. Participants driving more than 30 miles to and from the study appointment will also receive mileage reimbursement ($0.50 per mile traveled, with a maximum mileage reimbursement of $50.00). Participants requesting mileage reimbursement will need to provide their home zip code in order to calculate the distance traveled. If you or your child chooses to stop the study before the data collection is complete, you still keep the money.

Confidentiality

Any identifiable information that is obtained in connection with this study will remain confidential and will be disclosed only with your permission or as required by U.S. or State law. Examples of information that we are legally required to disclose include suspected abuse of a child or elderly person, suicidality, and intention to harm identifiable others. Each person who participates in this study will be assigned a unique, identifying number. This number will be used to identify all research data within our database. The master list, which will contain your child's name and the unique identifying number, will be kept separate from all other data. Only the investigators of the study will have access to this master list. All video files of the eye-tracking sessions are password protected on a computer in the eye-tracking room, which is locked at all times. All video recordings of the interaction task will be kept separate from identifying information, in a secure locked filing cabinet. Only the investigators and trained lab personnel will have access to these recordings. All identifying information will be destroyed within five years of data collection. However, if you indicate on this consent form that you would like to be contacted about future studies, your contact information will be maintained in a secure, password-protected file that is kept separate from all data related to this study, so that we are able to contact you about other studies unless you indicate to us in writing that you want to be removed from the contact list.

When the results of the research are published or discussed in conferences, no information will be included that would reveal your identity or your child's identity. It is possible that the Institutional Review Board (IRB) may view this study's collected data for auditing purposes. The IRB is responsible for the oversight of the protection of human subjects involved in research. These individuals are required to keep all information confidential.

Freedom to Withdraw

You and your child do not have to participate in this study. If you do participate, you can stop at any time and without penalty, by telling the researchers that you want to stop the study. If you decide to not participate or to withdraw from the study, your involvement in any future study will not be jeopardized.

Questions

Please feel free to ask about anything you do not understand. In addition, consider this research and the consent form carefully – as long as you feel is necessary – before you make a decision. If you would like to speak with a member of the research team, please call Brenna Maddox or Dr. Susan White at the Psychosocial Interventions Lab at (540) 231-6744 or e-mail: bmaddox7@vt.edu.

If you should have any questions about the protection of human research participants regarding this study, you may contact: Dr. David Harrison, Chair of Departmental Human Subjects Committee, (540) 231-4422, e-mail: dwh@vt.edu, or Dr. David Moore, Chair Virginia Tech Institutional Review Board for the Protection of Human Subjects, telephone: (540) 231-4991; e-mail: moored@vt.edu; address: Office of Research Compliance, 2000 Kraft Drive, Suite 2000 (0497), Blacksburg, VA 24060.

Subject's Responsibility

As a participant in this study, you voluntarily agree to participate in this study. You have the following responsibilities:

1. Ask any questions you have about the study and the consent process.
2. Complete any measures to the best of your ability.

Subject's Permission

I have read the Parental Permission Form and conditions of this project. I have had all my questions answered. I hereby acknowledge the above and give my voluntary consent. My signature means that I am willing for my child to participate in this study.

_____

Name of child (youth) (PRINTED)

_____ _____

Parent/Guardian Name (PRINTED) Parent/Guardian Signature Date

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Approved June 21, 2013 to March 18, 2014

Study Investigator Name (PRINTED) Investigator Signature Date

If my child or I participate in other studies affiliated with the VT Autism Clinic (VTAC) or the VT Center for Autism Research (VTCAR), our data will be given a code and potentially combined with our other coded data. A master list will be maintained in order to match our current data with previously collected data. Our names from this master list will only be available to VTAC or VTCAR staff and will not be shared with others. I may be contacted for future studies if I give separate permission below.

Yes, I would like to be contacted for possible participation in future studies through VTAC or VTCAR. I understand I would be under no obligation to participate in these studies if contacted. I can decide at that time if I would like to participate.

Parent/Guardian Signature Date

Appendix Q

Local Counseling Resources

Thank you for participating in this study.

Should you want to talk with someone about this research project, please feel free to call the Psychosocial Interventions Lab directly (540-231-6744) or e-mail Brenna Maddox, the graduate student conducting this study at bmaddox7@vt.edu.

The following are some local resources available to you, should you need someone to talk with about mental health services or personal problems. There is no guarantee that the listed services will be available to see you, and it is your responsibility to pay any fees associated with such services. Cook Counseling Center provides services free of charge to Virginia Tech students who have paid their student health fees. The Raft Crisis Hotline is free to call. All other services may charge fees for their services.

ACCESS/Raft Crisis Hotline
(Emergency services clinicians)
(540) 961-8400
http://www.nrvcs.org/services.htm

Center for Family Services
(703) 538-8470
http://www.nvc.vt.edu/cfs

Cook Counseling Center
(540) 231-6557
http://www.ucc.vt.edu/

Mental Health Association of the New River Valley
(540) 951-4990; (800) 559-2800
http://www.mhanrv.org/

New River Valley Community Services
(540) 961-8400
http://www.nrvcs.org/

VT Psychological Services Center
(540) 231-6914
http://www.psyc.vt.edu/outreach/psc

Appendix R

Eye-Tracking Metrics Definitions and Calculations

Eye-Tracking Metric	**Definition**	**Calculation** (if applicable)
Fixation duration (FD)	Total length of time (in ms or s) that a participant fixates on a particular area of interest (AOI)	$FD_{trial1} + FD_{trial2} + \ldots FD_{trial\mathit{n}}$
Proportion of total FD	Total FD to each emotional face region, relative to the total FD to the screen during the corresponding trial	$\frac{\text{Total FD to AOI}}{\text{Total FD to screen}}$
First fixation direction	Percentage of trials with initial fixation toward emotional face AOI, relative to calm face AOI	$\frac{\text{\# of trials with first fixation on target picture}}{\text{Total \# of trials with target picture present}}$
Latency	Time from stimulus onset to first fixation on a face region, or how long it takes for a participant to fixate on a face region for the first time	-
First fixation duration	Duration of the initial fixation on a particular AOI	-
Proportion of fixation count	Number of fixations on a particular AOI, relative to the total number of captured fixations during the corresponding trial	$\frac{\text{Number of fixations on AOI}}{\text{Number of fixations on screen}}$