The Broad Autism Phenotype in the General Population: Evidence Through Eye-Tracking

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ABSTRACT

The broad autism phenotype (BAP) has been defined both behaviorally and biologically. There has been little research on the association of the BAP, behaviorally defined, with neural or cognitive biomarkers typically associated with Autism Spectrum Disorder (ASD). People diagnosed with ASD tend to show reduced gaze fixation toward the eye region, but much less eye-tracking research has been done related to the BAP (Boraston & Blakemore, 2007). In this study, we sought to assess eye gaze patterns in people with the behaviorally defined BAP, as defined by a score of 30 or above on the Autism Spectrum Quotient (AQ; Baron-Cohen et al., 2001). It was hypothesized that the BAP group participants would exhibit longer average fixation duration to the eye region during an emotion recognition condition, relative to a free-viewing condition, whereas the comparison group participants (defined as an AQ score of 24 and below) would not show a difference in fixation duration to the eye region between conditions. Nine hundred and thirty-nine undergraduates completed an online survey, and 45 of these students (15 BAP group and 30 comparison group) participated in the eye-tracking session, where they viewed a series of human faces, each presented twice within a condition. Results revealed a significant negative relationship between social anxiety and eye region fixation duration in the free-viewing condition, for both presentations of faces. Contrary to expectation, BAP predicted longer eye region fixation duration in the free-viewing condition, for the second presentation of faces. Possible explanations for these surprising findings are discussed.

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1.0 - Introduction

Autism Spectrum Disorder (ASD) is a pervasive developmental disorder characterized by marked social impairments, communication deficits, and restricted or repetitive patterns of behavior (Losh et al., 2009). As the name implies, the deficits characteristic of ASD exist along a spectrum or continuum, ranging from clinical to subclinical expressions. This notion is reflected in the change in diagnostic labels from the current Diagnostic and Statistical Manual of Mental Disorders (DSM-IV-TR; American Psychiatric Association, 2000), which identifies separate disorders (i.e., Autistic Disorder, Asperger's Disorder, Pervasive Developmental Disorder-Not Otherwise Specified), to a single label of "Autism Spectrum Disorder" in the upcoming DSM-5 (American Psychiatric Association, 2012). Indeed, recent research supports the existence of a continuous severity gradient, proposing that ASD is the extreme end of a continuously distributed trait (e.g., Constantino & Todd, 2003; Ring, Woodbury-Smith, Watson, Wheelwright, & Baron-Cohen, 2008; Spiker, Lotspeich, Dimiceli, Myers, & Risch, 2002). Traits of ASD can be viewed as quantitatively, not qualitatively, distributed in the general population (Bölte, Westerwald, Holtmann, Freitag, & Poustka, 2011). That is, ASD characteristics are patterns of thoughts, feelings, and behaviors that exist in everyone to some degree. Following this broad, continuous spectrum model of ASD, the broad autism phenotype (BAP) now describes an even wider range of individuals who exhibit similar social-behavioral, language, and personality characteristics at a subclinical level (Hurley, Losh, Parlier, Reznick, & Piven, 2007).

1.1 - Broad Autism Phenotype

The original work on the BAP emphasized the underlying genetic liability for ASD expressed in first-degree relatives (i.e., parents or siblings) of individuals with ASD, as shown through characteristics of ASD that are milder than, but qualitatively similar to, ASD diagnostic criteria (Dalton, Nacewicz, Alexander, & Davidson, 2007; Hurley et al., 2007). Research in this area may help inform the search for genetic biomarkers of ASD, although environmental effects in the family must also be considered when examining parents and siblings (Shaked & Yirmiya, 2004). Previous studies, using both family history and direct assessments, have found higher rates of deficits in the social, communication, and stereotyped-repetitive domains in first-degree relatives of individuals with ASD than in the general population (Bailey et al., 1995; Bishop et al., 2004; Bolton et al., 1994; Landa et al., 1992; Piven et al., 1994). Additional research with family members of people with ASD has suggested that the BAP is associated with specific

personality features, such as rigidity (Piven, Palmer, Jacobi, Childress, & Arndt, 1997) and aloofness (Murphy et al., 2000). Losh and colleagues (2009) also demonstrated that the parents of individuals with ASD evidenced BAP characteristics and were less accurate on behavioral tasks of social cognition, such as interpreting the emotional content of complex scenes and inferring emotions from subtle variations in facial expressions, relative to the parents with no family history of ASD. Thus, individuals with the biologically defined BAP showed behaviors characteristic of ASD, despite not having an ASD diagnosis. As evident in these studies, most BAP research to date has focused exclusively on parents and siblings of individuals with ASD (i.e., the biologically defined BAP).

Baron-Cohen, Wheelwright, Skinner, Martin, and Clubley (2001), however, changed the conceptualization of the BAP when they found evidence of the full range of ASD characteristics in a non-clinical sample of undergraduate students, not just in the parents or siblings of individuals with ASD. They created the Autism Spectrum Quotient (AQ), a brief, self-administered questionnaire to measure characteristics of ASD in the general population, based on the assumption that these traits exist along a continuum. Several studies have shown that the AQ is effective at distinguishing individuals with Asperger's Disorder or high-functioning ASD from typically-developing individuals (e.g., Hoekstra, Bartels, Cath, & Boomsma, 2008; Wakabayashi, Baron-Cohen, & Wheelwright, 2006; Woodbury-Smith, Robinson, Wheelwright, & Baron-Cohen, 2005). Baron-Cohen and colleagues (2001) determined the AQ clinical cut-off with binary scoring (i.e., each response is given a score of one if characteristic of ASD and zero if not characteristic of ASD) to be a total score of 32 or higher, indicating symptoms in the range of an ASD diagnosis. In their sample of 58 adults with Asperger's Disorder or high-functioning ASD, 79.3% scored at or above 32 on the AQ, while only 2% of their sample of 174 non-ASD participants met that cut-off. However, the authors emphasize that the AQ is not a diagnostic measure. For any given person with an AQ score of 32 or above, an ASD diagnosis is only warranted if the individual is experiencing a clinical level of impairment as a result of his or her ASD characteristics.

When Baron-Cohen and colleagues (2001) administered the AQ to 840 college students (mean age 21 years), they found that students majoring in science or mathematics scored significantly higher on the AQ than did students majoring in humanities or social sciences. Within the sciences, mathematicians scored the highest. In this same sample of students, males

scored significantly higher than females overall, which is consistent with observations that ASD is more common in males than in females (Rice et al., 2010). The AQ has also been shown to effectively identify subclinical characteristics of ASD, both in parents of individuals with ASD (e.g., Bishop et al., 2004) and in the general population (e.g., Austin, 2005; Hurst, Mitchell, Kimbrel, Kwapil, & Nelson-Gray, 2007; Jobe & White, 2007). The AQ's sensitivity to differences in mild ASD characteristics in the general population supports the idea of ASD as the extreme end of a quantitative continuum.

Woodbury-Smith and colleagues (2005) evaluated the utility of the AQ as a screening questionnaire in clinical practice with 100 consecutive adults referred to a national Asperger's Disorder diagnostic clinic in the United Kingdom. Their findings led to the recommendation of an AQ threshold score of 26, which led to the greatest number of correct classifications of ASD versus non-ASD in their sample. The authors suggested that a threshold score of 26 would limit the frequency of false negatives in the clinical setting. However, in the general population, the higher cut-off of 32 is still optimal to minimize false positives.

Regardless of the chosen cut-off score, the validation of the AQ is an important landmark in BAP research because it brought more recognition that ASD characteristics are normally distributed in the general population, indicating that perhaps the BAP should not be restricted to family members of individuals with a diagnosed ASD. The initial AQ work of Baron-Cohen and colleagues (2001) stimulated many replication studies showing the normal distribution of ASD characteristics in the general population cross-culturally, such as in the United States (e.g., Hurst et al., 2007a), United Kingdom (e.g., Austin, 2005), Netherlands (e.g., Hoekstra, Bartels, Verweij, & Boomsma, 2007), and Japan (e.g., Wakabayashi, Baron-Cohen, Wheelwright, & Tojo, 2006). The original pattern of males and/or mathematical science majors scoring higher on the AQ has also been replicated in studies around the world (e.g., Austin, 2005; Kunihira, Senju, Dairoku, Wakabayashi, & Hasegawa, 2006; Wakabayashi et al., 2006b). A few samples, however, have not revealed any significant difference in AQ scores between males and females (e.g., Chen & Yoon, 2011; Hurst, Nelson-Gray, Mitchell, & Kwapil, 2007; Ingersoll, 2010; White, Ollendick, & Bray, 2011b).

Particularly relevant to the current study is previous research using the binary scoring of the AQ in non-clinical undergraduate samples. The characteristics of these college-based studies are summarized in Table 1. Based on these studies, which clearly demonstrate the existence of

ASD characteristics in the general population, it would be expected that even in a non-clinical sample, higher AQ scores would be related to the deficits or problems most commonly seen in people with ASD diagnoses (i.e., the behaviorally defined BAP). For example, Jobe and White (2007) found that college students who scored higher on the AQ evidenced interpersonal deficits, reporting fewer and shorter duration friendships, in addition to greater feelings of loneliness, relative to participants with lower AQ scores. Similarly, Kunihira and colleagues (2006) showed that, compared to low-AQ (defined as 18.5 and below for males and 16.75 and below for females) university students, high-AQ (defined as 27 and above for males and 25 and above for females) university students were more likely to report an obsessional personality, higher depression and anxiety, and higher frequency of being bullied, all of which parallel the patterns in people with ASD.

Ingersoll (2010) found that participants who scored higher on the AQ performed more poorly on measures of nonverbal specificity than did participants with lower AQ scores. Nonverbal specificity is the ability to interpret and use the nonverbal aspects of communication, such as eye gaze, gestures, and facial expressions. Impairment in this type of nonverbal behavior is part of the diagnostic criteria for ASD (American Psychiatric Association, 2000). Ingersoll's results from 102 undergraduate students supported her hypothesis that subclinical symptoms of ASD are associated with deficits in interpreting nonverbal aspects of social communication. These findings suggest that ASD characteristics have broader relevance for describing and predicting social behavior in the general population.

Despite growing research about the BAP, experts in the field of ASD are still unsure about its precise boundaries and components. There is some agreement that ASD represents an extreme on a continuum, but debate persists from the opposing perspective that ASD is a qualitatively distinct disorder with determinants not found in the general population (Best, Moffat, Power, Owens, & Johnstone, 2008). Thus, a key question must be answered to establish support for the behaviorally defined BAP: How broadly does the BAP apply? In other words, does the BAP refer only to first-degree relatives of individuals with formal ASD diagnoses who also display ASD-like characteristics without meeting diagnostic criteria? Or, does the BAP extend more into the general population, regardless of a direct genetic relationship to ASD? One way to investigate this issue is to find physiological or behavioral indicators that distinguish people with the BAP from typically developing individuals. One potential indicator to consider is

gaze patterns using continuous eye-tracking, an innovative technology and useful research tool. It is well-known that people with ASD have distinct eye gaze patterns, as shown through recent eye-tracking studies, but much less eye-tracking research has been done to investigate gaze patterns in people with the behaviorally defined BAP (Boraston & Blakemore, 2007).

1.2 - Eye-Tracking Technology

Modern eye-tracking technology documents where an individual foveates by recording the reflection of an infrared light source 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 one can assess what an individual attends to or avoids (e.g., social or non-social cues) in his or her environment (Pelphrey et al., 2002). Eye-tracking data can shed light on the strategies and processes of visual attention by measuring fixations to small regions of interest, such as specific facial features (Haith, 2004; Hayhoe, 2004). Human eye gaze behavior is important for multiple reasons, particularly in social contexts. For example, eye gaze can provide information, enhance communication, and express intimacy (Kleinke, 1986).

A particular area of interest in eye-tracking research is the eye region of a human face. It has been argued that the eyes yield the largest amount of social information from a face (Baron-Cohen, Wheelwright, & Jolliffe, 1997). Indeed, Baron-Cohen (1995) coined the term "language of the eyes" to highlight the eyes as a vital source of information about the mental or internal states of others (p. 97). Several studies have demonstrated that eye contact is important for accurate emotion recognition (e.g., Baron-Cohen et al., 1997; Kirchner, Hatri, Heekeren, & Dziobek, 2011), especially when viewing complex emotions (e.g., guilty, bored). The correct identification of emotional facial expressions plays a key role in everyday social interactions and contributes to the ability to understand the intentions of others (Hernandez et al., 2009). Eye contact is also essential for joint attention, or the orientation of attention towards a stimulus in response to another person's shift in gaze (Falck-Ytter, Fernell, Hedvall, von Hofsten, & Gillberg, 2012). This shared awareness based on eye gaze underlies typical social interactions and communication.

1.3 - Eye-Tracking and ASD

Recent studies have used eye-tracking to investigate how individuals with ASD attend to socially salient stimuli (Boraston & Blakemore, 2007). Some ASD researchers have called for a shift away from the emphasis on overall task performance and towards the study of the strategies

and processes underlying performance on these tasks (e.g., Volkmar, Lord, Bailey, Schultz, & Klin, 2004). Eye-tracking can be used for this purpose. The social interaction deficits evident in ASD may stem, in part, from impaired perception of social information. Eye-tracking research in this area can provide important insight into the potential processes, including social perception and attention, behind the observed social difficulties. Certain differences in gaze patterns between individuals with ASD and individuals 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; Senju & Johnson, 2009; Spezio, Adolphs, Hurley, & Piven, 2007). When viewing faces, participants without ASD fixate mostly on the eyes, whereas participants with ASD look more frequently at the mouth or at other objects in the scene. For example, Klin and colleagues (2002) used eye-tracking technology and video clips with a sample of 15 males with ASD (mean age 15.4 years) and 15 males without ASD (mean age 17.9 years) to demonstrate that reduced eye region fixation time was the best predictor of ASD, with the ASD group participants focusing over two times less on the eye region relative to age- and verbal IQ-matched non-ASD participants.

Pelphrey and colleagues (2002) investigated whether this ASD-associated pattern of looking less at the eye region still holds when the participants are specifically instructed to identify the emotions portrayed in the faces. In the first eye-tracking condition, the five participants with ASD (mean age 25.2 years) and five participants without ASD (mean age 28.2 years) were shown 12 faces and instructed to look at the photographs in any manner they selected. In the second eye-tracking condition, the participants were shown 24 additional faces and instructed to identify the emotion portrayed in each photograph, with a list of the six basic emotions presented during the interstimulus interval. Relative to the non-ASD participants, the ASD group participants spent a greater percentage of time viewing non-feature areas of the faces and spent a smaller percentage of time examining core features (i.e., eyes, nose, and mouth) of the faces, particularly the eyes. This scanpath pattern did not differ as a function of the instructions given to the participants. That is, even when explicitly told to identify the emotions portrayed in the faces, the participants with ASD failed to visually explore the entire face, rarely fixating on the eyes.

However, not all eye-tracking studies have found differences in gaze behavior between individuals with ASD and individuals without ASD (e.g., Bar-Haim, Shulman, Lamy, &

Reuveni, 2006; Sawyer, Williamson, & Young, 2011; van der Geest, Kemner, Verbaten, & van Engeland, 2002). Some research findings revealed similar eye region fixation duration for participants with and without ASD, and no preference for the mouth region in the participants with ASD. Possible explanations for the contradicting reports include the nature of the facial stimuli (e.g., static or dynamic), 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 (Hannigen, Best, Rump, Minshew, & Strauss, 2009; Speer, Cook, McMahon, & Clark, 2007).

1.4 - Eye-Tracking and the BAP

In contrast to the comparative abundance of eye-tracking studies with ASD samples, eye-tracking studies with a BAP sample, however defined, are quite limited. The studies that do exist have focused almost exclusively on infant siblings of individuals with ASD in order to investigate genetic influences on gaze patterns. One such study with naturalistic photographs of human faces found no significant differences in duration of gaze fixation to the eye area between the BAP siblings and the diagnosed ASD group (Dalton et al., 2007). The BAP group showed significantly briefer gaze fixation to the eye area than did the non-ASD comparison group.

Bayliss and Tipper (2005) hypothesized that college students scoring high on the AQ (defined as 18 or greater) would display less attentional cueing towards social stimuli (i.e., targets appearing on a face) than those with low scores on the AQ (defined as 13 or lower). Indeed, the high-AQ group (n = 9) displayed greater cueing to targets appearing on scrambled face parts than to targets appearing on faces, whereas the low-AQ group (n = 11) showed the opposite tendency. The authors suggested that the scrambled faces contained high levels of details and were therefore more appealing to the detail-oriented cognitive style of high-AQ individuals.

Chen and Yoon (2011) used the median AQ score to separate their sample of 38 undergraduate students into a low-AQ group (n = 16) and a high-AQ group (n = 19), excluding three students with a median-equivalent AQ score. All participants viewed two brief videos (i.e., two minutes each) of two same-gender actors speaking about neutral topics. The gender of the actors was matched to the participant's gender. The videos were order counterbalanced across two conditions, during which the actors either directly looked into the video camera (i.e., direct condition) or the actors looked 45 degrees away from the camera (i.e., averted condition).

Through the use of eye-tracking technology, the researchers found that the low-AQ participants spent a greater percentage of time fixating on directed eyes relative to averted eyes, a tendency not found in the high-AQ participants. One notable distinction in this study's methodology is the use of only four of the five AQ subscales. The participants completed an abbreviated AQ measure due to a strict time limitation placed on questionnaire completion. Chen and Yoon removed the Imagination subscale items, which they deemed least relevant to their theoretical questions, so interpretation of their participants' overall AQ scores (M = 14.3, SD = 5.7) is inconsistent with previous AQ research. Chen and Yoon recommended that future studies use the full AQ for more direct comparisons, as well as include a broader range of visual stimuli, such as faces with various emotional expressions, to test generalizability of their findings.

1.5 - Eye-Tracking and Social Anxiety

It is important to note an additional consideration when assessing the eye gaze patterns of individuals with the behaviorally defined BAP. The presence of social anxiety, or self-consciousness in social situations, is common in individuals with ASD who do not have co-occurring intellectual disability, with recent comorbidity (ASD and social anxiety) estimates ranging from 11.7% to 57.1% (e.g., Bellini, 2004; de Bruin, Ferdinand, Meester, de Nijs, & Verheij, 2007; Kuusikko et al., 2008). Prior eye-tracking studies have demonstrated that individuals with high social anxiety tend to show reduced eye region fixation duration, similar to that of individuals with ASD, especially when viewing emotional faces with direct gaze (e.g., Horley, Williams, Gonsalvez, & Gordon, 2003; Moukheiber et al., 2010; Roelofs et al., 2010). This abnormality in eye gaze found in people struggling with social anxiety is believed to stem from their aversion to, and active avoidance of, emotionally salient, potentially threatening facial features (Garner, Mogg, & Bradley, 2006). Given that the eye gaze patterns of someone with social anxiety can be remarkably similar to those of someone with ASD, the presence of social anxiety should be considered when conducting ASD or BAP eye-tracking research.

1.6 - Specific Aims and Hypotheses

The current study followed the recommendations of Chen and Yoon (2011) to investigate the relationship between ASD characteristics and eye gaze in the general population, with the aim of providing a link between the BAP and an objectively measured, socially relevant behavior. To firmly establish the general conceptualization of the BAP as proposed by Baron-Cohen and colleagues (2001), research must demonstrate that individuals with more ASD

characteristics also exhibit deficits, albeit less severe, in areas of functioning associated with an ASD diagnosis. The overall goal of this eye-tracking study was to take this next step in validating the behaviorally defined BAP in the general population by demonstrating that individuals with high AQ scores (i.e., BAP group participants) have distinct eye gaze patterns, relative to individuals with low AQ scores (i.e., comparison group participants). Eye gaze patterns were examined in two conditions: a free-viewing condition and an emotion recognition condition.

It was expected that BAP participants would exhibit briefer fixation duration to socially salient cues (i.e., the eye region of faces) compared to the comparison group participants during the free-viewing condition, a finding consistent with many eye-tracking studies in the ASD literature (e.g., Klin et al., 2002; Pelphrey et al., 2002). The main hypothesis involved an interaction between AQ score and condition (i.e., free-viewing or emotion recognition) on eye region fixation duration. More specifically, it was predicted that BAP participants would exhibit longer average fixation duration to the eye region during the emotion recognition condition, relative to the free-viewing condition, whereas the comparison group participants would not show a difference in fixation duration to the eye region between conditions. Support for this hypothesis would suggest that people with the BAP, behaviorally defined, have a natural tendency to not visually attend to others' eye gaze, yet they still understand the importance of attending to the eyes for social information. In other words, they *know* where to look when they are given a specific task of labeling emotions, but they would *prefer* to not fixate on direct eye gaze if feasible, as shown in the free-viewing condition.

A secondary objective of the current study was to examine the distribution of AQ scores and associated gender differences in a non-clinical college population, similar to the original study by Baron-Cohen and colleagues (2001). Few studies have examined AQ scores in a technical university with strong engineering and computer science programs (White et al., 2011b), where one would expect higher AQ scores based on previous research showing higher scores for science majors (e.g., Baron-Cohen et al., 2001). It was predicted that males would have higher AQ scores than females. It was also hypothesized that participants with high AQ scores would report differences in their own social behavior and mental health diagnoses, relative to participants with low AQ scores. More specifically, high AQ scores would likely be

associated with less frequent social interactions with friends and more problems with anxiety and/or depression.

2.0 - Method

2.1 - 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 2.1 software. The Tobii T60 has a stable data accrual rate of 60 Hz (i.e., 60 gaze data points per second are collected for each eye; Tobii Technology, 2011). Before data collection, the eye-tracking system was calibrated to each participant's eyes, meaning that it measured the eye characteristics needed to accurately calculate gaze direction. The calibration task involved tracking a blue pulsating circle at five different locations across the screen (i.e., the four corners and the center of the screen). The degree of accuracy with this calibration system was 0.5 degrees, with less than 0.3 degrees of visual drift. The T60 monitor was arm-mounted to allow for repositioning to maximize the quality of the tracking for each participant. The eye-tracker collected raw eye movement data points every 16.7 ms and sent them to the analysis application database on the connected computer. The data points were then processed by the Tobii Fixation Filter algorithm into fixations, which can be depicted in a screen shot showing all of the fixations a participant made on a specific image.

Face stimuli were centered color photographs (22.2 cm long X 17.3 cm wide) taken from the NimStim Set of Facial Expressions (Tottenham et al., 2009). At the viewing distance of 70 cm, each image subtended 18.0˚ X 14.1˚ visual angle. The faces represented both males and females, from different ethnic groups (European-American, African-American, and Asian-American), displaying various emotions (i.e., happiness, sadness, disgust, anger, surprise, and fear). Tottenham and colleagues found that, in general, untrained individuals showed high agreement with identification of the emotional expressions. All face stimuli used in the current study had at least 80% rater agreement (from original validation study; Tottenham et al., 2009) on the depicted emotion. Two brief (i.e., less than 30 seconds) videos were also shown. The videos portrayed two undergraduate students, one male and one female, in an angry interaction and a happy interaction. The purpose of the videos was to offer a short break to the participants, in order to maintain their interest during the eye-tracking task.

2.2 - Procedure

Study procedures were approved by the university's Institutional Review Board (IRB; Appendix A). Both phases of this study took place during the Fall 2011 semester. Participants provided separate consents for both phases of participation. (See Appendix B for the Phase I information sheet and Appendix C for the Phase II consent form.) Phase I, beginning in the first week of classes, involved completion of an online survey (specific questionnaires described below), which took approximately 20 minutes to complete. To avoid potential response bias, the survey was described as a questionnaire about personality and social concerns in college, rather than as an assessment of ASD characteristics. All survey participants received a list of local counseling resources at the end of the survey, with a statement encouraging participants to contact one of the agencies if they would like to talk to someone about personal problems or mental health services (Appendix D). Before beginning the online survey, the students were informed of the chance that they may be contacted about participating in Phase II of the study (i.e., the eye-tracking session). Survey respondents provided their answers electronically via a secure server, and their e-mail addresses were used to provide Sona credit (if eligible), enter them into a cash prize raffle (if applicable), and link data for Phase II of the study. The online survey remained open for six consecutive weeks.

Phase II of the study was conducted in the Developmental Research Suite in Williams Hall. The single session lasted approximately 15 minutes, and each participant received $10.00. During the eye-tracking procedure, participants sat in a chair approximately 70 cm from the computer screen in a darkened room. All participants were calibrated to the task before data collection, as described above. If insufficient data were collected to complete the initial calibration task, the participant repeated the calibration task up to three times. After calibration, the images of human faces were presented for four seconds each. No more than two negative emotions (e.g., disgust), two positive emotions (e.g., happiness), or two same-gendered faces were presented consecutively. Eye movement data were recorded continuously during the presentation of each photograph.

The eye-tracking task consisted of two conditions, similar to the design by Pelphrey and colleagues (2002). In the free-viewing condition, participants were told to look at the photographs in any way they wish (i.e., "Please look at the following faces however you want.").

They then saw a total of 24 faces with one male and one female face for each of the six emotions (i.e., happiness, sadness, disgust, anger, surprise, and fear), with each face shown twice. A black screen was presented for one second between stimuli. The angry video clip was shown at the end of the free-viewing condition, in order to maintain the participants' interest and attention.

In the emotion recognition condition of the eye-tracking task, participants were instructed to identify the emotion portrayed in each photograph (i.e., "Please name the emotion shown in each of the following faces."). They then saw a total of 24 faces with one male and one female face for each of the six emotions listed above, with each face shown twice. The faces were different from the faces shown in the free-viewing condition. A list of the six emotions in alphabetical order was presented during the 5-second interstimulus interval to assist the participants in verbally answering which emotion was portrayed. Two practice trials were also administered before the start of this condition to ensure that each participant understood the emotion recognition task. A trained research assistant recorded the participant's verbal responses for each emotional expression. The happy video clip was shown at the end of this task. Any participant interested in seeing the replay of his or her eye-tracking data was given the opportunity to do so immediately after the session.

The two eye-tracking conditions (i.e., free-viewing and emotion recognition) were counterbalanced across participants, to control for any order effects of the conditions. Approximately 50% of the Phase II participants (n = 23; 15 comparison group participants and 8 BAP participants) experienced the free-viewing condition before the emotion recognition condition, and approximately 50% of the Phase II participants (n = 22; 15 comparison group participants and 7 BAP participants) experienced the emotion recognition condition before the free-viewing condition. The entire eye-tracking task, with both conditions and videos, lasted for approximately 8 minutes.

2.3 - Participants

All participants were undergraduate students at Virginia Tech. For Phase I of the study (i.e., online survey), students were recruited through flyers posted on campus, the psychology department's Sona system, and email notifications from their undergraduate advisors (see Appendices E, F, and G for recruitment materials). All participating students eligible for Sona extra credit (55.5% of the sample) received one credit for study participation. Survey respondents not eligible for Sona extra credit (44.5% of the sample) received entry into a raffle

for a chance to win one of three $25 cash prizes. Sona eligibility was determined by the participant's response to a survey item about Sona credit, and the response was also confirmed by the Sona online sign-up list for the survey.

Nine hundred and ninety-eight students started the online survey. Fifty-nine respondents did not complete the entire survey, and their data were excluded from any analyses (see missing data analyses below). A total of 939 data sets was retained. Demographic information for the Phase I participants is provided in Table 2. A subset of these participants was invited to participate in Phase II (i.e., the eye-tracking session). The Phase II sample included 15 BAP participants and 30 comparison group participants, as defined below. A power analysis was conducted in order to compute the needed sample size for Phase II of the study. Given the limited literature on eye-tracking and the BAP, the current study assumed a medium effect size (f = .25). Because a power analysis for the exact design (i.e., repeated-measures ANCOVA) was unavailable, a power analysis using G*Power software (Faul, Erdfelder, Lang, & Buchner, 2007) for a 2 (group: BAP versus comparison) X 2 (condition: free-viewing or emotion recognition task) repeated-measures ANOVA without the covariate of social anxiety was conducted to determine the required sample size, with alpha of .05. The power analysis indicated that n = 46 would achieve adequate power (0.80) to detect a medium effect of the group-by-condition interaction, assuming a conservative correlation (r = 0.3) among the repeated measures. For the current study, a target sample of 45 participants (15 BAP and 30 comparison group) was determined to be reasonable and feasible. Support for this sample size goal comes from a recent eye-tracking study (Chen & Yoon, 2011), which examined eye gaze patterns of college students with high AQ scores compared to those with low AQ scores. The researchers found significant group differences in gaze fixation time with only 38 participants total.

During the first round of Phase II recruitment, invitations (Appendix H) were e-mailed to the 16 survey respondents (13 females) scoring 32 or above on the AQ, based on the clinical cut-off with binary scoring established by Baron-Cohen and colleagues (2001). Out of these 16 students, 11 females responded to the invitation and completed the eye-tracking session. An additional 6 survey respondents (3 females) were e-mailed Phase II invitations, moving systematically down the list of Phase I participants, arranged from highest AQ score (i.e., 39) to

lowest AQ score (i.e., 5). Four of these students (2 females) responded to the invitation and completed the eye-tracking session, which resulted in the desired sample size of 15 BAP participants.

The sampling frame for the comparison group consisted of students with an AQ score less than 30, which was the lowest score of the BAP participants. After each BAP participant completed the eye-tracking session, a list of matched comparison group survey respondents was generated. These comparison group participants were matched to the BAP participant on gender and on current or expected academic major, as grouped by field of study (i.e., Agriculture and Life Sciences, Architecture and Urban Studies, Biological Sciences, Business, Computer Science, Engineering, Liberal Arts and Human Sciences, Mathematics, Natural Resources and Environment, Physical Sciences, Psychology, University Studies, or Veterinary Medicine). Once these matches were determined, a random number generator was used to select 10 comparison group participants (or less, if 10 who met the matching criteria were not available) from the matches for each BAP participant. The first two randomly selected comparison group participants were e-mailed an eye-tracking invitation. The invitation specified that all students had 72 hours to respond before their eye-tracking session was offered to someone else. If no response was received from the participant(s) after 72 hours, the eye-tracking invitation was e-mailed to the next comparison group participant(s) on the list of randomly selected matches, and so on. Using this iterative matching procedure, each BAP participant (n = 15) was matched to two comparison group participants (n = 30). Twenty percent of the BAP participants and 40% of the comparison group participants came from the psychology department's experimental database (i.e., Sona). Demographic data for the Phase II sample (n = 45) are provided in Table 3.

2.4 - Measures

Demographics. The Demographic Information Questionnaire was used to collect information about all participants' gender, age, race/ethnicity, declared or expected college major, class year, dating status, and social interaction frequency (Appendix I). Some of the social interaction items were based on the Friendship Questionnaire (Baron-Cohen & Wheelwright, 2003). Participants also reported whether they, their parents, or their siblings have formally received any psychological diagnoses (e.g., through an evaluation with a written report) by

endorsing a checklist of various disorders (i.e., Anxiety Disorder, Attention-Deficit/ Hyperactivity Disorder, ASD, Depression, Intellectual Disability/Mental Retardation, Learning Disorder).

Primary measures.

Autism Spectrum Quotient (AQ; Baron-Cohen et al., 2001; Appendix J). The AQ is a 50-item self-report questionnaire designed to measure characteristics of ASD in adults of normal intelligence. The AQ 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: "definitely agree," "slightly agree," "slightly disagree," and "definitely disagree." 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. In order to avoid response bias, approximately half of the items are worded to produce a "disagree" response and half an "agree" response in a high-scoring person with ASD. Items are randomized with respect to both their domain and the expected response from a high-scorer.

Approximately half of the items are reverse-scored, and the item scores are then summed for a total score ranging 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. Although binary scoring is recommended by Baron-Cohen and colleagues, previous researchers have also used continuous scoring by treating the response scale as a four-point Likert scale, scoring each item from one to four, and summing for a total score ranging from 50 to 200, in order to yield higher item-item correlations (e.g., Austin, 2005).

Several recent studies have suggested a four-factor (Stewart & Austin, 2009), three-factor (Austin, 2005; Hurst et al., 2007a), or two-factor (Hoekstra et al., 2008) model of the AQ, in contrast to the five subscales originally proposed by Baron-Cohen and colleagues (2001). Given that recent estimates of internal consistency for the AQ subscales are less than acceptable (e.g., Austin, 2005; Hurst et al., 2007a), White, Bray, and Ollendick (2011a) suggested that sole

reliance on the AQ total score may be the most useful method, and subscale scores should be interpreted with caution. The current study used the binary scoring of the AQ for participant selection purposes because this approach provides the clinical cut-off score of 32. For all primary data analyses, however, the four-point Likert scale approach was used, in order to provide a wider range on this continuous variable.

The AQ has been used extensively with adults, demonstrating reliability across time and culture (Wheelwright, Auyeung, Allison, & Baron-Cohen, 2010). AQ scores from a general adult population sample and a Cambridge University student sample were not significantly different, which implies that IQ and socioeconomic status do not affect AQ responses (Baron-Cohen et al., 2001). It has high internal consistency (α = .82; Austin, 2005) and test-retest reliability (.70; Baron-Cohen et al., 2001) in college samples.

Social Interaction Anxiety Scale (SIAS; Mattick & Clarke, 1998; Appendix K). The SIAS is a reliable and valid self-report measure of social anxiety. The SIAS assesses general fears of social interaction (e.g., speaking with someone in authority, saying something embarrassing). 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. Three items are reverse-scored before summing. Total SIAS scores range from 0 to 80, with higher scores indicating greater levels of social interaction anxiety. High levels of internal consistency (α = 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). In an undergraduate sample (n = 482), Mattick and Clarke found the mean SIAS score to be 19.0 (SD = 10.1).

Social Phobia Scale (SPS; Mattick & Clarke, 1998; Appendix L). The SPS, another reliable and valid self-report measure of social anxiety, is the companion instrument to the SIAS. Specifically, the SPS assesses the fear of being watched or observed by others during daily activities (e.g., writing in front of other people, eating in front of a stranger at a restaurant). All items are rated on a 5-point scale (0 to 4) regarding the degree to which the respondent feels the given statement is characteristic or true of him or her. The 20 item scores are summed for a total score ranging from 0 to 80. Higher scores on the SPS are indicative of greater anxiety about being observed. Similar to the SIAS, the SPS boasts high levels of internal consistency (α = 0.90) and test-retest reliability (0.91). It shows convergent validity with other measures of social

anxiety, in addition to discriminant validity with measures of depression, state and trait anxiety, and social desirability. In an undergraduate sample (n = 482), Mattick and Clarke found the mean SPS score to be 14.1 (SD = 10.2). Previous studies have shown that the SIAS and the SPS possess incremental validity and can be summed together to assess social anxiety (e.g., Brown et al., 1997; Gore, Carter, & Parker, 2002). For the current study, the summed scores from the SIAS and SPS were used as a composite measure of social anxiety for each participant.

Gaze patterns. The primary measure of eye gaze patterns was fixation duration, defined as the total length of time in milliseconds that a participant fixated on a particular area of interest (AOI) of a given photograph. The eye region (i.e., both left and right eye areas excluding the bridge of the nose, but including the eyebrows), mouth region (i.e., the mouth area excluding the chin), and total face region (i.e., the entire face with a boundary at the hairline, ears, and neck) were defined as the AOIs. These regions were defined prior to data analyses using the oval-shaped AOI tool available in the Tobii T60 (Studio Professional) platform.

2.5 - Primary Data Analyses

Data were analyzed with IBM SPSS Statistics Version 20. To test the hypotheses as outlined above, a repeated measures general linear model (GLM) with covariates, also considered an analysis of covariance (ANCOVA), was conducted, with fixation time to the eye region (averaged across participants) as the dependent variable, AQ and social anxiety scores as continuous covariates, counterbalanced order as the between-subject factor (2 levels: free-viewing before emotion recognition, emotion recognition before free-viewing), and two within-subject factors: condition (free-viewing or emotion recognition) and presentation (first or second presentation of a face). Because the counterbalanced order appeared, in initial analyses, to affect gaze duration, it was included in the primary analyses as a between-subject factor. Although AOIs were created for the face and mouth, only the eye region AOI was used in analyses based on prior hypotheses and the social significance of this facial region. In addition, the duration data for the face and mouth AOIs were not normally distributed, whereas the eye AOI duration data followed a normal distribution.

3.0 - Results

3.1 - Missing Data Analyses

Fourteen students (1.4%) who began the online survey only entered their e-mail address, so they were not included in the following comparisons. The remaining forty-five students with

missing survey data (4.5%) completed the demographics questionnaire, so they were compared to the 939 Phase I participants with complete data. The two groups did not differ on age, $t(982) = -0.86$, $p = 0.391$, or year in college, $t(982) = -1.39$, $p = 0.166$. Additionally, the groups did not differ on race/ethnicity (African American: Fisher's exact test p (2-sided) = 1.000; Asian/Asian American: Fisher's exact test p (2-sided) = 1.000; Caucasian/European American: $\chi^2(1) = 0.47$, $p = 0.493$; Latino, Hispanic, or Chicano: Fisher's exact test p (2-sided) = 0.483; Native American: Fisher's exact test p (2-sided) = 1.000; Pacific Islander: Fisher's exact test p (2-sided) = 1.000; Bi-/Multi-Racial: Fisher's exact test p (2-sided) = 0.358). For the 8 students who did not complete the survey, but completed the AQ items, group comparisons with the survey-completers on the continuous total score were conducted. The groups did not differ on continuous AQ score, $t(945) = 0.79$, $p = 0.430$.

3.2 - Descriptives

Descriptive statistics were computed for all demographic variables (i.e., gender, age, race/ethnicity, declared or expected college major, class year, mental health diagnoses in self or immediate family, dating status) to characterize both the Phase I and Phase II samples (Tables 2 and 3, respectively). Descriptive statistics were also computed for the AQ, SIAS, and SPS measures in both the Phase I and Phase II samples (Tables 4 and 5, respectively). Computed internal consistency coefficients for these questionnaires were all high ($\alpha \geq .90$).

3.3 - Preliminary Data Analyses

Preliminary data analyses were conducted to examine if eye gaze patterns differed as a function of participant gender or as a function of emotion portrayed in the stimulus face. No significant differences were found, so the subsequent analyses were conducted with the eye-tracking data collapsed across these two variables. None of the 45 participants showed a major loss of tracking integrity, as determined by their percentage of valid eye-tracking samples, measured by the Tobii software (Tobii Technology, 2010). For example, a percentage of 100% means that both eyes were recorded continuously throughout the task. The average percentage of valid eye-tracking samples in the current sample was 87%. Visual inspection of the individual recordings, using the Tobii Replay function, confirmed that participants were attending to the screen during the eye-tracking task.

3.4 - Aim 1: BAP, Social Anxiety, and Gaze Duration

Results from the repeated measures ANCOVA revealed a significant main effect of counterbalanced order, $F(1, 41) = 6.00$, $p = .019$. Individuals who experienced the free-viewing condition before the emotion recognition condition demonstrated a greater average fixation duration to the eye region overall ($M = 1.87$, $SD = .12$), relative to the individuals who experienced the emotion recognition condition first ($M = 1.45$, $SD = .12$). We also found a significant main effect of social anxiety, $F(1, 41) = 6.44$, $p = .015$, and a significant two-way interaction between condition and presentation, $F(1, 41) = 8.62$, $p = .005$. Interpretations of these main effects and two-way interactions are qualified by the significant three-way interactions between AQ score, condition, and presentation, $F(1, 41) = 9.18$, $p = .004$, and between social anxiety score, condition, and presentation, $F(1, 41) = 4.85$, $p = .033$. No other effects were significant in the model. This same pattern of significant results was found with the six participants with greater than four errors in the emotion recognition task removed from the analysis.

To interpret these results, we used repeated measures ANCOVA to decompose each of the two significant three-way interactions into separate two-way interactions (condition X AQ score and condition X social anxiety score) for the first presentation and for the second presentation. In probing the significant three-way interactions, we chose to test the condition by AQ score and condition by social anxiety score two-way interactions at each level of presentation because this perspective related most directly to the primary hypotheses – that those with the BAP would display briefer eye region fixation duration only in the free-viewing condition. Therefore, this approach was judged to be the most pertinent scientifically and theoretically sound. In addition, interpreting all of the possible interactions would be overly complicated and cumbersome (Maxwell & Delaney, 1990).

We found that the two-way interaction between condition and AQ was significant for the second presentation of faces, $F(1, 41) = 7.14$, $p = .011$, but not significant for the first presentation, $F(1, 41) = 0.12$, $p = .728$. Similarly, the two-way interaction between condition and social anxiety was significant for the second presentation of faces, $F(1, 41) = 6.22$, $p = .017$, but not significant for the first presentation, $F(1, 41) = 0.66$, $p = .422$. We also examined the parameter estimates of these models. Figures 1 and 2 represent the relationship between condition and AQ score on the average fixation duration to the eye region, within presentation (holding social anxiety score constant at the mean and holding counterbalanced order constant at

free-viewing first/emotion recognition second). Figures 3 and 4 depict the relationship between condition and social anxiety score on the average fixation duration to the eye region, within presentation (holding AQ score constant at the mean and holding counterbalanced order constant at free-viewing first/emotion recognition second). In the first presentation of faces, the effect of social anxiety on the average eye region fixation duration was significant in the free-viewing condition only, b = -.01, $t(39)$ = -2.25, p = .030. In the second presentation of faces, the effect of AQ on the average eye region fixation duration was significant in the free-viewing condition only, b = .03, $t(39)$ = 2.83, p = .007. The effect of social anxiety on the average eye region fixation duration was also significant in the free-viewing condition of the second presentation, b = -.02, $t(39)$ = -3.31, p = .002. No other parameter estimates for AQ or social anxiety were significant.

We also computed bivariate correlations between AQ score, social anxiety score, and average eye region fixation duration (Table 6). It should be noted that the bivariate relationship between AQ score and eye region fixation duration, although not significant, was in the negative direction for three of the four presentation by condition combinations, when social anxiety was not considered.

To further explore the eye-tracking data, we compared eye region fixation duration of the BAP participants (n = 15) and the comparison group participants (n = 30) with another repeated measures GLM with the covariate of social anxiety (i.e., same design as the primary analysis, except that AQ score was treated as a between-subject factor, instead of as a within-subject factor). The results revealed a significant main effect of counterbalanced order, $F(1, 40) = 5.65$, p = .022. No other factors were significant in this model.

3.5 - Aim 2: BAP in a College Sample

Phase I data were used to examine the AQ distribution and associated differences of gender, social behavior, and mental health diagnoses. For these analyses, alpha was set conservatively at .01, to protect against Type I error with multiple comparisons. All tests were one-tailed due to the directional *a priori* hypotheses. Table 4 indicates that the AQ skewness and kurtosis values do not depart from normality, and Figure 5 provides a graphical display of the continuous distribution of ASD characteristics. There was no significant difference in AQ score between males (M = 108.59, SD = 12.96) and females (M = 106.49, SD = 13.50), $t(937) = 2.07$, p = .019. Significant differences based on AQ score were found in self-reported social behavior

and mental health diagnoses. More specifically, individuals who reported eating more meals alone in a typical week had significantly higher AQ scores (M = 111.49, SD = 13.84) than individuals who reported eating more meals with other people in a typical week (M = 104.30, SD = 12.36), $t(937) = 8.25$, $p < .001$. In addition, individuals who reported a personal diagnosis of depression (n = 95) had significantly higher AQ scores (M = 112.54, SD = 14.79) than individuals without a self-reported diagnosis of depression (n = 844; M = 106.39, SD = 13.09), $t(937) = 4.28$, $p < .001$. A similar AQ pattern was seen in individuals with a self-reported diagnosis of an anxiety disorder (n = 76, M = 111.37, SD = 15.96), relative to individuals without a self-reported anxiety disorder diagnosis (n = 863, M = 106.62, SD = 13.09), $t(937) = 2.97$, $p < .001$. Further support for this relationship between ASD characteristics and anxiety comes from the significant bivariate correlations between the AQ and SIAS (r = .68, $p < .001$) and between the AQ and SPS (r = .53, $p < .001$).

Comparisons between AQ score and the ordinal social interaction variables were analyzed with the Mann-Whitney U test, using the binary scoring of the AQ to determine high- and low-AQ groups (i.e., participants scoring 32 or above and participants scoring below 32, respectively). The results, shown in Table 7, revealed significant differences in the expected direction between the low-AQ and high-AQ group participants on frequency of social interaction (i.e., frequency of hanging out with a friend or a group of friends in a typical week, the minimum social contact needed to get through a day, the minimum social contact needed to get through a week).

4.0 - Discussion

This study investigated the relationship between ASD characteristics and eye gaze patterns in the general population, with the primary aim of providing a link between the behaviorally defined BAP and an objectively measured, socially relevant behavior. Results did not support our hypotheses that BAP participants would exhibit (1) briefer fixation duration to the eye region compared to the comparison group participants during the free-viewing condition, and (2) longer fixation duration to the eye region during the emotion recognition condition, relative to the free-viewing condition. Instead, we only found a significant effect of AQ score on eye region fixation duration in the free-viewing condition for the second presentation of faces, and this effect was in the unexpected direction (i.e., higher AQ scores predicted longer eye region fixation duration). We found social anxiety to be the more salient predictor of reduced eye

region fixation duration, relative to AQ scores, for both presentations of faces in the free-viewing condition.

The unexpected relationship between BAP and gaze duration requires further investigation. The eye-tracking results were surprising because higher AQ scores were not related to reduced eye region fixation time, which is inconsistent with multiple other studies reporting less fixation to the eye region in samples with ASD diagnoses or ASD characteristics (e.g., Dalton et al., 2005; Dalton et al., 2007; Hernandez et al., 2009; Klin et al., 2002; Norbury et al., 2009; Senju & Johnson, 2009; Spezio et al., 2007). However, not all eye-tracking studies have found differences in gaze behavior between individuals with ASD and individuals without ASD (e.g., Bar-Haim et al., 2006; Sawyer et al., 2011; van der Geest et al., 2002). The current study used static images as stimuli, meaning that the testing environment did not resemble a natural, live social context with other people. This artificial nature of the task may explain the lack of observed eye gaze differences in the BAP participants (Speer et al., 2007; Volkmar et al., 2004), although other studies with static images have demonstrated eye gaze differences between participants with and without ASD (e.g., Pelphrey et al., 2002). In addition, the facial stimuli in the current study only displayed the basic emotions, and not any complex emotions (e.g., guilty, bored, puzzled). Some studies have found reduced eye region fixation time for people with ASD when viewing faces displaying complex emotions, but not simple emotions (e.g., Rutherford & Towns, 2008).

The more surprising result is that higher AQ scores predicted *increased* eye region fixation duration during the second presentation of faces in the free-viewing condition. This finding raises the issue that high AQ scores may not necessarily equate to the behaviorally defined BAP. Although the AQ is a widely accepted measure of ASD characteristics, recent studies have led to varying conclusions about the AQ's subscales or factors (e.g., Austin, 2005; Hoekstra et al., 2008; Stewart & Austin, 2009). It is possible that high AQ scores reflect behaviors that are outside the scope of the behaviorally defined BAP, such as theory of mind deficits or restricted interests (White et al., 2011a). In addition, perhaps high AQ scores reflect an increased degree of social confusion or social paranoia, so more time is spent looking at the socially salient features of the face when the individual suspects or remembers that they have seen that particular face previously. In addition, we know that individuals with ASD often take more time to process facial expressions (e.g., Rump, Giovannelli, Minshew, & Strauss, 2009), so

perhaps it took longer (i.e., not until the second presentation of faces) for the BAP participants to examine the eye region fully, whereas the comparison group participants may have been distributing their attention to the eye region more evenly across presentations. This explanation, however, is inconsistent with previous research showing a negative relationship between AQ score and face or eye region fixation duration (Bayliss & Tipper, 2005; Chen & Yoon, 2011).

Our results also call into question whether the eye region is the most valuable and informative area for emotion recognition. Participants did not exhibit more eye region fixation duration in the emotion recognition condition. Although previous research has emphasized the importance of the eyes for identifying emotions (e.g., Baron-Cohen, 1995), more recent studies have cast doubt on this idea, finding that individuals with ASD performed better on emotion recognition tasks when shown only a human mouth, not the eyes (e.g., Sawyer et al., 2011). Other studies have found increased fixation time to the mouth region when viewing full faces during an emotion recognition task (e.g., Kirchner et al., 2011). The NimStim Set of Facial Expressions (Tottenham et al., 2009), used in the current study, includes several faces with notably expressive mouth regions, such as a tongue sticking out to indicate disgust. These considerations may explain why the BAP participants did not demonstrate more eye region fixation duration during the emotion recognition condition.

The secondary aim of the current study was to examine the distribution of AQ scores and associated differences in a non-clinical college population. We partially supported the original findings from Baron-Cohen and colleagues (2001), showing that AQ score is normally distributed among college students. This normal distribution supports the conceptualization of ASD as an extreme end of a continuous spectrum. Unlike the original study from Baron-Cohen and colleagues, where males tended to score higher on the AQ relative to females, our sample did not reveal a gender difference. These results are consistent with previous AQ research conducted at Virginia Tech (White et al., 2011b), with many of the high-AQ (i.e., binary score $\geq$ 32) survey respondents in this sample being female students (81%). One hypothesis is that this female majority may reflect something unique about the university's student composition, possibly reflective of the school's focus on engineering and the sciences.

We also found differences based on AQ score in self-reported social behavior and mental health. Individuals with higher AQ scores were more likely to report eating more meals alone, spending less time hanging out with friends, and desiring less social contact. In addition, these

individuals were more likely to report diagnoses of depression and/or anxiety disorder. These findings demonstrate that students with more ASD characteristics also exhibit deficits in areas of functioning associated with an ASD diagnosis, which lends support for the general conceptualization of the BAP as proposed by Baron-Cohen and colleagues (2001).

A major finding of the current study is that ASD characteristics and social anxiety exerted unique effects on gaze duration to the eye region. Social anxiety emerged as a more salient predictor of reduced eye region fixation duration than AQ score. In general, our Phase II sample reported greater social anxiety than other, non-anxious college samples (e.g., Mattick & Clarke, 1998). Based on established clinical cut-off scores for the SIAS (≥ 34) and SPS (≥ 24) recommended by Heimberg and colleagues (1992), 22 of the 45 Phase II participants were above the clinical threshold. These 22 socially anxious participants included all 15 BAP participants, so a substantial overlap between the behaviorally defined BAP and social anxiety is clearly present.

The high level of anxiety in our sample may also relate to the main effect of counterbalanced order. That is, participants who experienced the free-viewing condition before the emotion recognition condition demonstrated a greater average fixation duration to the eye region overall, relative to participants who experienced the emotion recognition condition first. Observational data from the eye-tracking sessions indicated that several participants seemed surprised and uncomfortable when initially presented with the emotion recognition condition. For example, one participant visibly grimaced as she labeled the emotional expressions, and another participant described the task as "more intense" than she expected. The task demand may have affected participants' subsequent gaze behavior by triggering, quite unintentionally, performance-based anxiety. Individuals who experienced the free-viewing condition first had no demands for the first half of the session, so they had time to become comfortable with the unfamiliar eye-tracking equipment and darkened room before receiving instructions to name the emotion shown in each face.

4.1 - Strengths

To our knowledge, the current study is the first to investigate the relationship between eye region fixation duration and the behaviorally defined BAP, as measured by the full AQ score, in a college sample. We treated AQ score as a continuous variable in the primary data analyses, with no artificial cut-offs or dichotomization of high- and low-AQ groups. This approach seems to more accurately reflect the continuum of ASD characteristics in the general

population. Few other studies have examined the distribution of AQ scores in a technical university with strong engineering and computer science programs, which may result in different findings related to gender. In addition, previous eye-tracking studies in the field of ASD have not typically considered counterbalancing or presentation order as design variables. Perhaps most importantly, we took into account the high overlap between BAP and social anxiety, which revealed that these two factors exerted effects in opposing directions on eye region fixation duration. As shown by the negative bivariate relationship between AQ score and eye region fixation duration, our data could have been interpreted quite differently, if the factor of social anxiety were not included.

4.2 - Limitations

The current study (both Phase I and Phase II) included mostly female participants, which could be a confounding variable. There is fairly little empirical research on females with ASD or females with high levels of ASD characteristics. What we do know is that females with ASD often present differently than males with ASD (e.g., Giarelli et al., 2010; Lai et al., 2011), and these differences may apply to individuals with the behaviorally defined BAP as well. Perhaps females with ASD have different eye gaze patterns than males with ASD, but we did not have enough males in our sample to adequately power a comparison based on gender. Another limitation is that the eye-tracking sample included only people who took the survey and accepted to come to an in-lab session. College students who have more pronounced social deficits or struggle with severe social anxiety may be unlikely to accept an invitation to this type of study, so we were unable to access the full range of ASD characteristics and social anxiety on campus.

As mentioned above, the current study used static photographs for the facial stimuli. One could argue that the results lack ecological validity because it is unnatural to see a human face against a plain background. In reality, we see faces in scenes, and these results do not allow us to predict how high AQ scores relate to eye gaze behavior in everyday social interactions.

Lastly, we experienced a limitation unrelated to the primary hypotheses, concerning the way that college major information was collected during the online survey. Based on the available choices for this questionnaire item, and because participants were allowed to designate multiple majors if applicable, we were unable to collapse the data in a way to potentially replicate previous findings that science majors have higher AQ scores than non-science majors (e.g., Baron-Cohen et al., 2001).

4.3 - Future Directions

Future research could investigate the relationship between the behaviorally defined BAP and eye gaze patterns in more dynamic and naturalistic scenes. Eye-tracking researchers should consider the factors of counterbalanced order and presentation order of faces, as collapsing across trials may mask these more subtle influences. Another important factor to consider, not examined here, is pupil size. Pupillometry, combined with eye-tracking, holds promise for detecting sensitive physiological and behavioral differences in people with ASD characteristics and/or social anxiety (Anderson, Colombo, & Shaddy, 2006).

4.4 - Conclusions

In conclusion, these results provide mixed support for the validity of the BAP, as defined behaviorally. Contrary to our expectations, the results indicate that the BAP is associated with longer gaze duration during a free-viewing, or uninstructed, presentation of faces. However, social anxiety predicted less eye region fixation duration in this relatively anxious college sample. We found support for the BAP in the general population through self-reported social interaction frequency and mental health diagnoses, which demonstrated that students with more ASD characteristics also exhibit deficits in areas of functioning associated with an ASD diagnosis. This study highlights the importance of considering certain design variables (e.g., counter-balanced order of condition, presentation order of faces), which are often ignored or at least not described in the current eye-tracking literature. In addition to these methodological and analytical considerations, our results highlight the importance of trying to discern the unique effects of ASD symptoms, given the frequent co-occurrence of other behavioral concerns, such as social anxiety, and associated relationships with gaze patterns. Future researchers should pay attention to these factors and consider the potentially opposing effects of ASD characteristics and social anxiety on eye gaze behavior.

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Table 1

Summary of Autism Spectrum Quotient (AQ) Research in Non-Clinical College Samples

Author(s)	Sample Size & Setting	Participant Age (years)	Gender	AQ Total Score
Baron-Cohen et al. (2001)	*N* = 840 UK	*M* = 21 *SD* = 2.9	454 males 386 females	Range 0-44 *M* = 17.6; *SD* = 6.4
Bayliss & Tipper (2005)	*N* = 24 UK	*M* = 20.3	5 male 19 females	*M* = 15.5; *SD* = 5.9
Hurst et al. (2007a)	*N* = 1005 USA	*M* = 19.36 *SD* = 3.89	221 males 784 females	*M* = 16.72; *SD* = 5.22
Hurst et al. (2007b)	*N* = 607 USA	*M* = 20.2 (males); 19.0 (females) *SD* = 5.8 (males); 3.5 (females)	135 males 472 females	Range 5-34 *M* = 16.96 (males); 16.59 (females) *SD* = 5.28 (males); 5.21 (females)
Ingersoll (2010)	*N* = 102 USA	*M* = 19.47 *SD* = 1.39	41 males 61 females	Range 7-30 *M* = 16.81; *SD* = 5.10
Ingersoll et al. (2011)	*N* = 626 USA	*M* = 19.68 *SD* = 2.02	150 males 476 females	*M* = 17.06 (males); 15.80 (females) *SD* = 5.91 (males); 5.41 (females)
Jobe & White (2007)	*N* = 97 USA	*M* = 19.4 *SD* = 2.28	32 males 65 females	Range 9-27
Kunihira et al. (2006)	*N* = 613 Japan	*M* = 19.34 *SD* = 2.51	351 males 262 females	*M* = 22.83 (males); 21.00 (females) *SD* = 6.13 (males); 6.29 (females)
Reed et al. (2011)	*N* = 60 UK	*M* = 20.8 *SD* = 2.6	60 males 0 females	Range 4-31 *M* = 16.5; *SD* = 6.6

Table 1 continued

Summary of Autism Spectrum Quotient (AQ) Research in Non-Clinical College Samples

Author(s)	Sample Size & Setting	Participant Age (years)	Gender	AQ Total Score
Wakabayashi et al. (2006a)	*N* = 320 Japan	*M* = 20.5 *SD* = 2.25	158 males 162 females	*M* = 20.9; *SD* = 6.73
Wakabayashi et al. (2006b)	*N* = 1050 Japan	*M* = 20.3 *SD* = 1.9	555 males 495 females	*M* = 20.7; *SD* = 6.38
White et al. (2011a)	*N* = 623 USA	Range = 18-22	202 males 421 females	Range 3-39 *M* = 17.05; *SD* = 5.91

Table 2

Demographic Information – Phase I (n = 939)

	M	*SD*	Minimum	Maximum
Age (in years)	20.20	1.89	17.42	46.92
			n	% of sample
Gender				
Male			231	24.6
Female			708	75.4
Race/Ethnicity				
African American			20	2.1
Asian/Asian American			82	8.7
Caucasian/European American			754	80.3
Latino, Hispanic, or Chicano			13	1.4
Native American			1	0.1
Pacific Islander			3	0.3
Bi-/Multi-Racial			66	7.0
Year in College				
First year			227	24.2
Second year			247	26.3
Third year			216	23.0
Fourth year			201	21.4
Fifth year			37	3.9
Sixth year or beyond			11	1.2
Major Field of Study[a]				
Agriculture and Life Sciences			143	15.2
Architecture and Urban Studies			14	1.5
Biological Sciences			230	24.5
Business			94	10.0
Computer Science			5	0.5
Engineering			89	9.5
Liberal Arts and Human Sciences			196	20.9
Mathematics			15	1.6
Natural Resources and Environment			7	0.7
Physical Sciences			41	4.4
Psychology			244	26.0
University Studies			16	1.7
Veterinary Medicine			6	0.6

Table 2 continued

Demographic Information – Phase I (n = 939)

	n	% of sample
Participant Diagnoses[a]		
Anxiety Disorder	76	8.1
Attention-Deficit/Hyperactivity Disorder	39	4.2
Autism Spectrum Disorder	2	0.2
Depression	95	10.1
Intellectual Disability/Mental Retardation	1	0.1
Learning Disorder	21	2.2
No diagnoses reported	780	83.1
Parent Diagnoses[a, b]		
Anxiety Disorder	72	7.7
Attention-Deficit/Hyperactivity Disorder	41	4.4
Autism Spectrum Disorder	2	0.2
Depression	154	16.4
Intellectual Disability/Mental Retardation	1	0.1
Learning Disorder	17	1.8
No diagnoses reported	730	77.7
Sibling Diagnoses[a, c]		
Anxiety Disorder	69	7.3
Attention-Deficit/Hyperactivity Disorder	138	14.7
Autism Spectrum Disorder	14	1.5
Depression	96	10.2
Intellectual Disability/Mental Retardation	5	0.5
Learning Disorder	57	6.1
No diagnoses reported	690	73.5
Relationship Status		
Not dating anyone	453	48.2
Casually dating one or more person	80	8.5
Have a significant other	406	43.2

[a]Participants could choose more than one answer for these questions. [b]Diagnoses that have been given to either of the participant's parents as a formal diagnosis (e.g., through an evaluation with a written report). [c]Diagnoses that have been given to the participant's sibling(s) as a formal diagnosis (e.g., through an evaluation with a written report).

Table 3

Demographic Information – Phase II (n = 45)

	M	*SD*	Minimum	Maximum
Age (in years)	20.22	1.43	17.92	22.92
			n	% of sample
Gender				
Male			6	13.3
Female			39	86.7
Race/Ethnicity				
African American			0	0.0
Asian/Asian American			1	2.2
Caucasian/European American			39	86.7
Latino, Hispanic, or Chicano			1	2.2
Native American			0	0.0
Pacific Islander			0	0.0
Bi-/Multi-Racial			4	8.9
Year in College				
First year			12	26.7
Second year			8	17.8
Third year			8	17.8
Fourth year			11	24.4
Fifth year			5	11.1
Sixth year or beyond			1	2.2
Major Field of Study[a]				
Agriculture and Life Sciences			3	6.7
Architecture and Urban Studies			0	0.0
Biological Sciences			15	33.3
Business			0	0.0
Computer Science			0	0.0
Engineering			6	13.3
Liberal Arts and Human Sciences			9	20.0
Mathematics			3	6.7
Natural Resources and Environment			0	0.0
Physical Sciences			6	13.3
Psychology			9	20.0
University Studies			0	0.0
Veterinary Medicine			0	0.0

Table 3 continued

Demographic Information – Phase II (n = 45)

	n	% of sample
Participant Diagnoses[a]		
Anxiety Disorder	4	8.9
Attention-Deficit/Hyperactivity Disorder	4	8.9
Autism Spectrum Disorder	1	2.2
Depression	5	11.1
Intellectual Disability/Mental Retardation	0	0.0
Learning Disorder	2	4.4
No diagnoses reported	35	77.8
Parent Diagnoses[a, b]		
Anxiety Disorder	5	11.1
Attention-Deficit/Hyperactivity Disorder	3	6.7
Autism Spectrum Disorder	1	2.2
Depression	8	17.8
Intellectual Disability/Mental Retardation	0	0.0
Learning Disorder	3	6.7
No diagnoses reported	33	73.3
Sibling Diagnoses[a, c]		
Anxiety Disorder	3	6.7
Attention-Deficit/Hyperactivity Disorder	7	15.6
Autism Spectrum Disorder	1	2.2
Depression	3	6.7
Intellectual Disability/Mental Retardation	0	0.0
Learning Disorder	4	8.9
No diagnoses reported	33	73.3
Relationship Status		
Not dating anyone	23	51.1
Casually dating one or more person	2	4.4
Have a significant other	20	44.4

[a]Participants could choose more than one answer for these questions. [b]Diagnoses that have been given to either of the participant's parents as a formal diagnosis (e.g., through an evaluation with a written report). [c]Diagnoses that have been given to the participant's sibling(s) as a formal diagnosis (e.g., through an evaluation with a written report).

Table 4

Descriptive Data for AQ, SIAS, and SPS – Phase I (n = 939)

	M (SD)	*Range*	*Skewness*	*Kurtosis*	*Cronbach's α*
AQ binary score	16.70 (5.98)	5 – 39	.75	.33	.76
AQ continuous score	107.01 (13.40)	66 – 148	.31	.07	.82
SIAS total score	23.92 (14.43)	0 – 71	.77	.18	.93
SPS total score	15.36 (12.85)	0 – 71	1.36	1.78	.93

Table 5

Descriptive Data for AQ, SIAS, and SPS – Phase II (BAP Group, n = 15; Comparison Group, n = 30; Full Sample, n = 45)

	M (SD)	*Range*	*Skewness*	*Kurtosis*	*Cronbach's α*
AQ binary score					
BAP Group	33.73 (2.82)	30 – 39			
Comparison Group	15.87 (4.57)	7 – 24			
Full Sample	21.82 (9.43)	7 – 39	.36	-1.28	.90
AQ continuous score					
BAP Group	139.80 (6.52)	127 – 147			
Comparison Group	103.83 (11.63)	66 – 119			
Full Sample	115.82 (19.92)	66 – 147	.00	-.57	.91
SIAS total score					
BAP Group	54.93 (8.15)	35 – 67			
Comparison Group	19.33 (11.30)	0 – 46			
Full Sample	31.20 (19.83)	0 – 67	.31	-1.31	.96
SPS total score					
BAP Group	45.33 (14.83)	22 – 71			
Comparison Group	13.07 (9.80)	0 – 38			
Full Sample	23.82 (19.23)	0 – 71	.81	-.39	.96

Table 6

Bivariate Correlations for AQ, Social Anxiety, and Average Eye Region Fixation Duration

	AQ	Social Anxiety
Presentation 1, Free-viewing	-.12	-.29
Presentation 1, Emotion Recognition	-.06	-.20
Presentation 2, Free-viewing	.02	-.25
Presentation 2, Emotion Recognition	-.14	-.24

Table 7

Mann-Whitney U Test Results for Social Interaction Frequency

	High-AQ Group $n = 16$	Low-AQ Group $n = 923$	Between-Group Difference
Weekly frequency[a]			U = 4810; $p = .006$
0 times per week	0.0%	0.5%	
1 time per week	12.5%	2.2%	
2 times per week	12.5%	4.0%	
3 times per week	25.0%	8.3%	
4 times per week	12.5%	9.0%	
5 times per week	6.3%	13.1%	
6 times per week	0.0%	9.5%	
7 times per week	0.0%	11.4%	
8+ times per week	31.3%	41.9%	
Minimum daily contact[b]			U = 4886; $p = .008$
No contact	31.3%	14.4%	
Just being near to people	25.0%	9.1%	
A casual chat	0.0%	8.3%	
One chat with friend	25.0%	30.2%	
2 to 3 chats with friends	18.8%	28.9%	
More than any of the above	0.0%	9.0%	
Minimum weekly contact[c]			U = 4451; $p = .003$
No contact	12.5%	2.7%	
Just being near to people	18.8%	2.2%	
Casual chats	12.5%	5.0%	
One chat with friend	12.5%	12.4%	
One chat every day with friend	18.8%	30.3%	
2 to 3 daily chats with friends	12.5%	25.8%	
More than any of the above	12.5%	21.7%	

Note: High- and low-AQ groups were defined by a binary score of ≥ 32 or below 32, respectively.

[a]In a typical week, how often do you hang out with a friend or a group of friends, outside of class time? [b]What would be the minimum social contact you would need to get through a day? [c]What would be the minimum social contact you would need to get through a week?

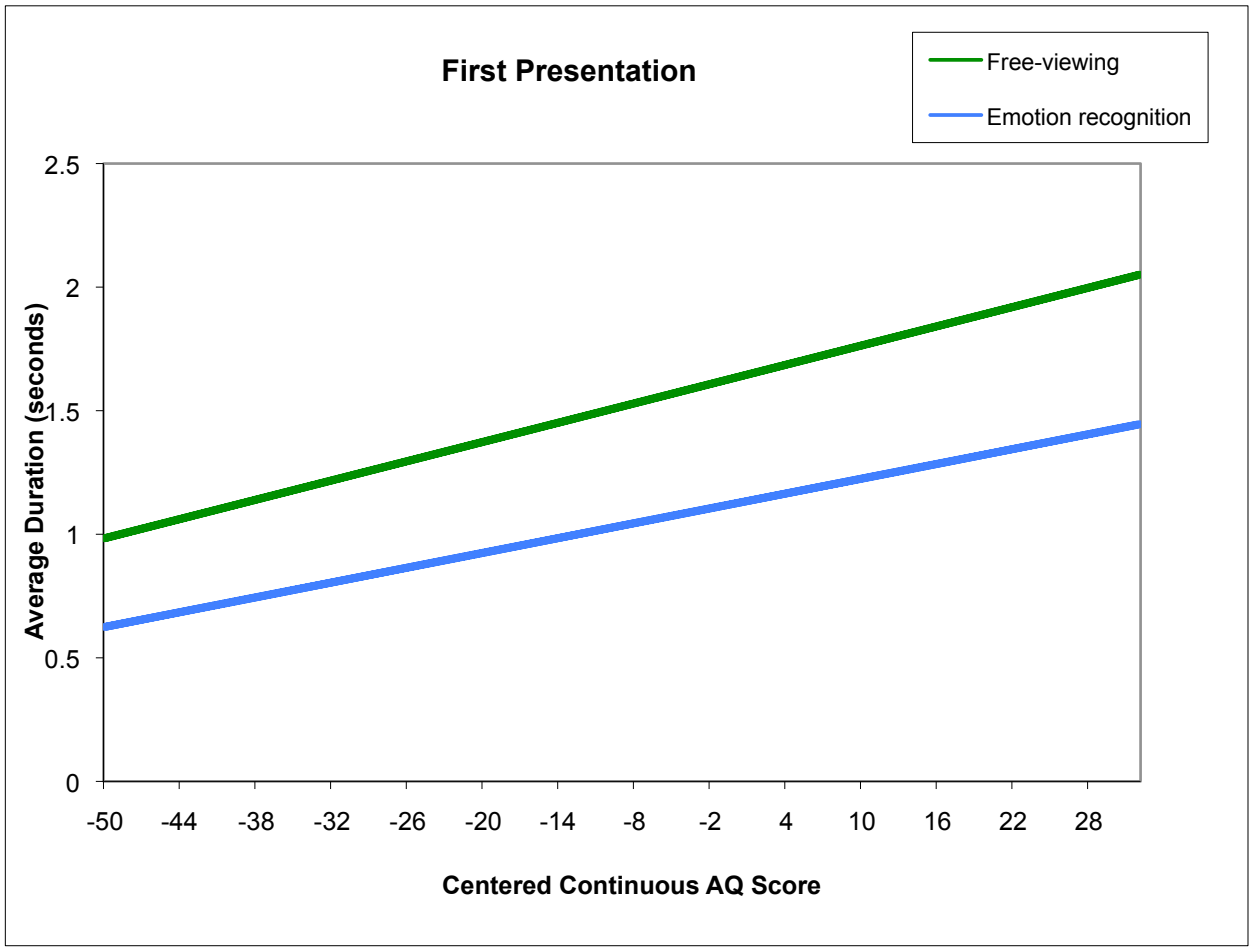

Figure 1. Estimated eye region fixation duration for the first presentation of faces in both conditions, as a function of centered AQ score.

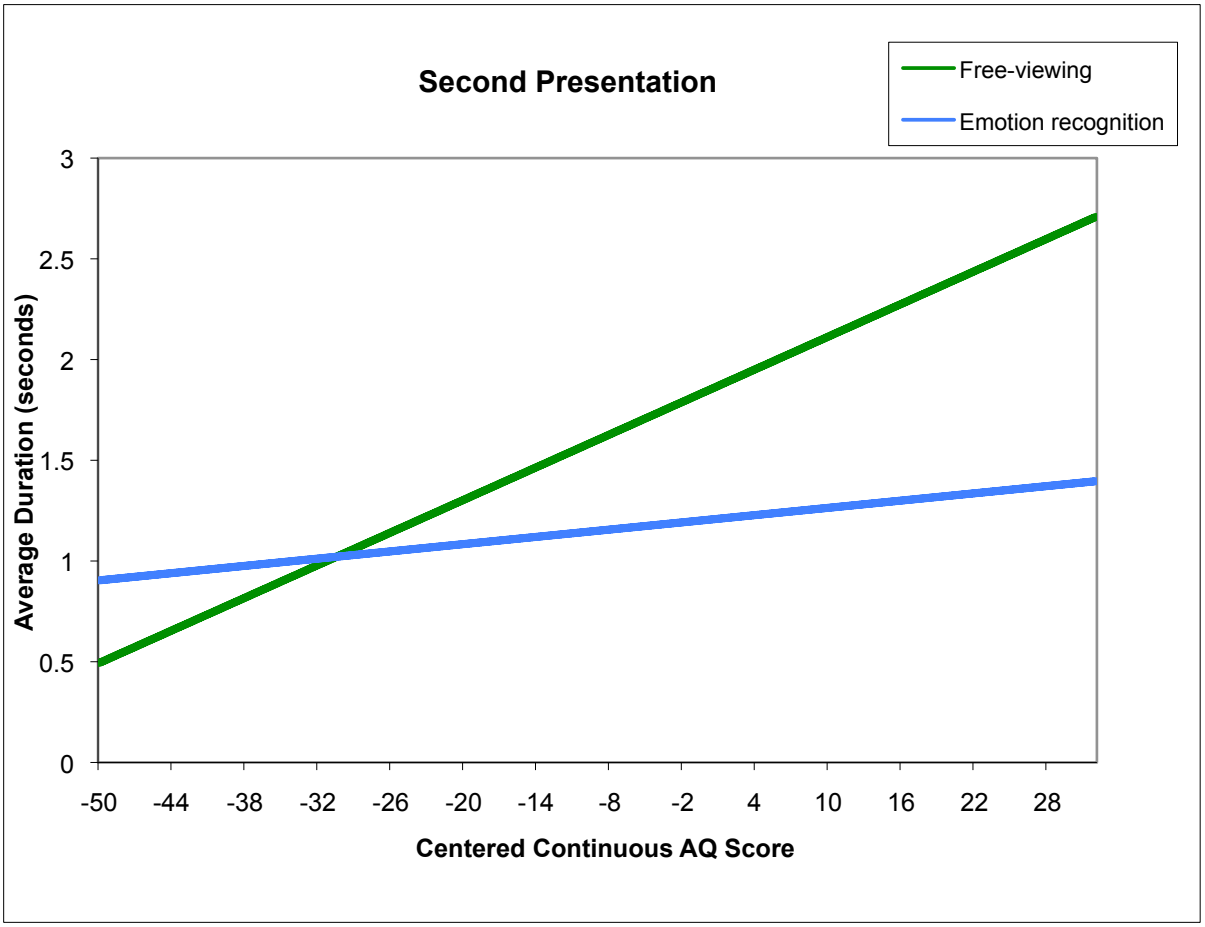

Figure 2. Estimated eye region fixation duration for the second presentation of faces in both conditions, as a function of centered AQ score.

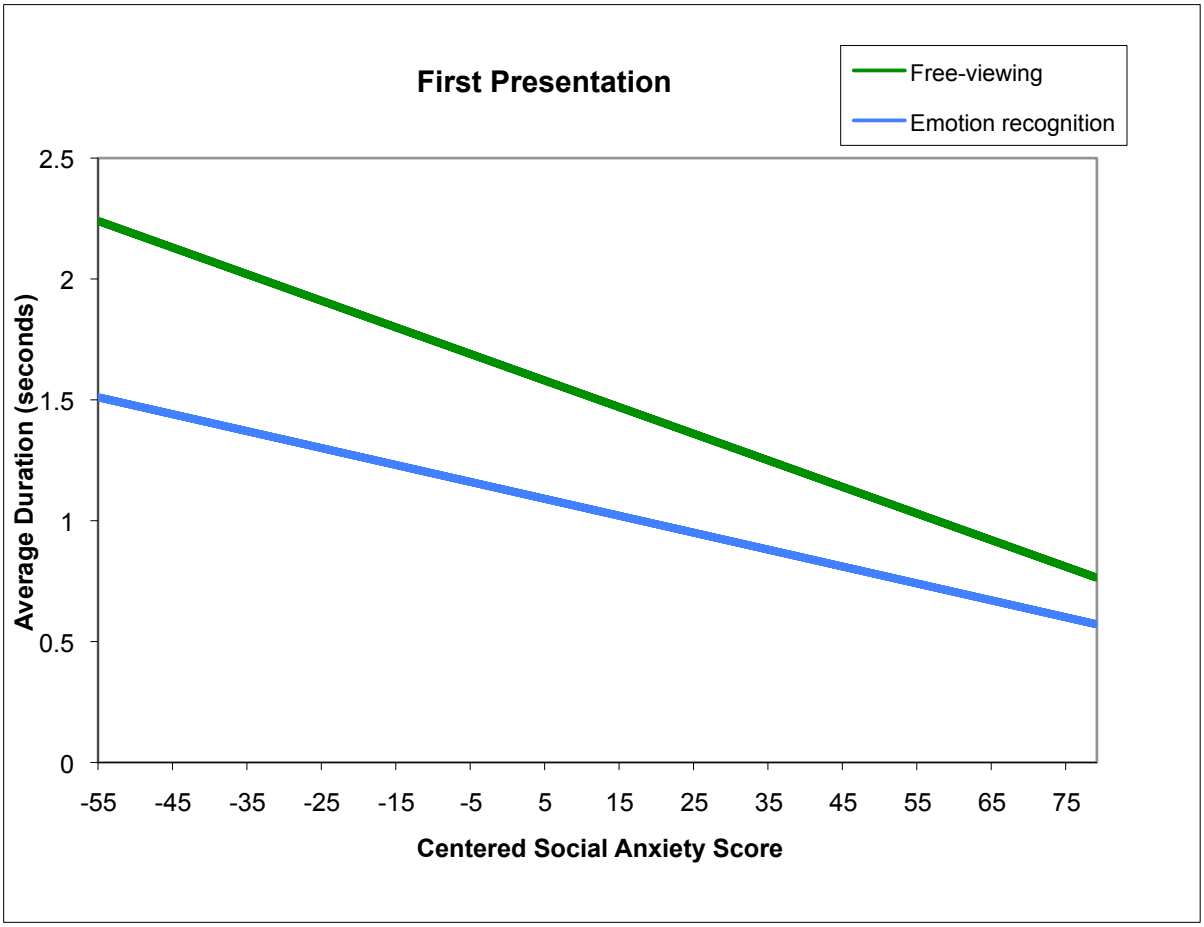

Figure 3. Estimated eye region fixation duration for the first presentation of faces in both conditions, as a function of centered social anxiety score.

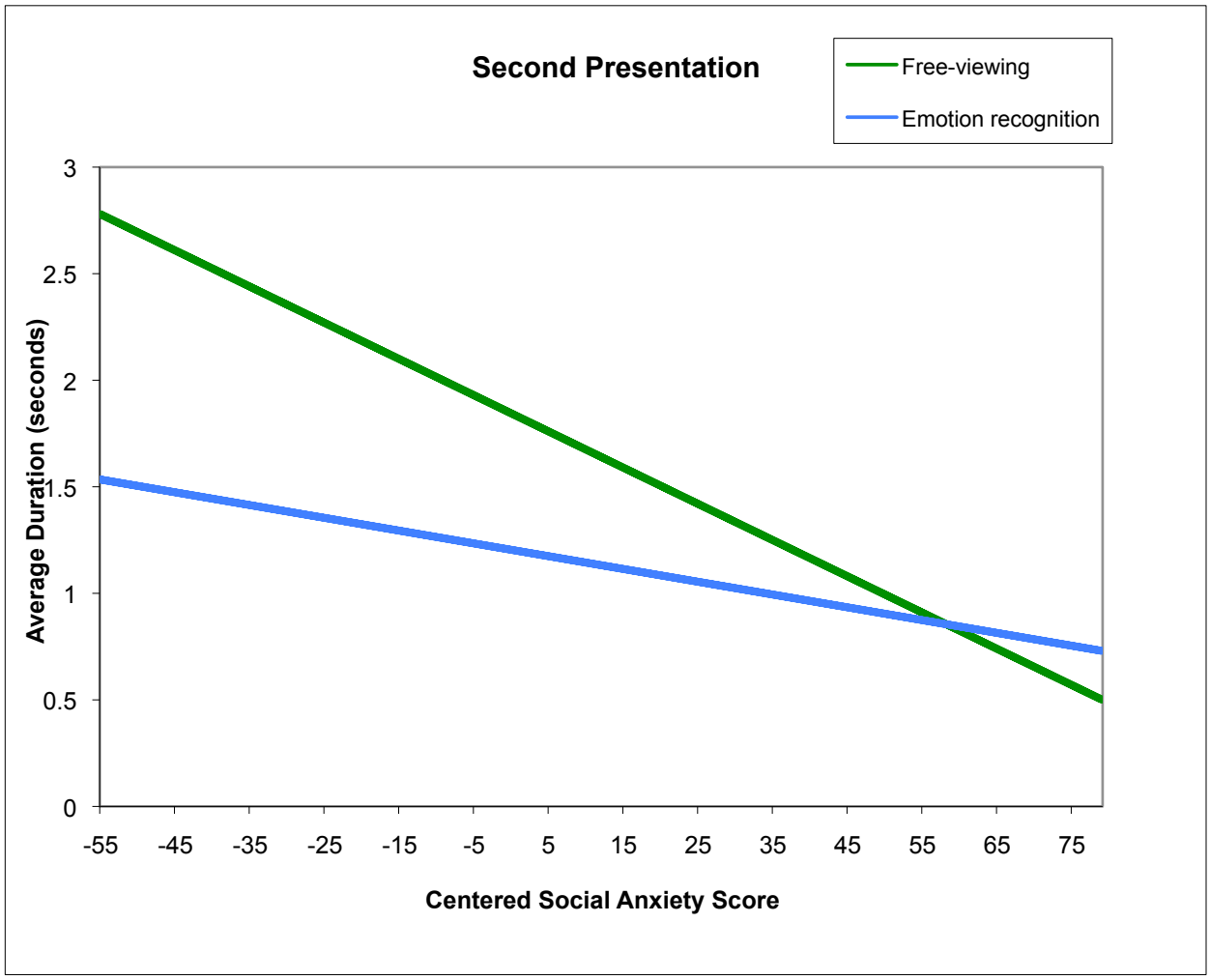

Figure 4. Estimated eye region fixation duration for the second presentation of faces in both conditions, as a function of centered social anxiety score.

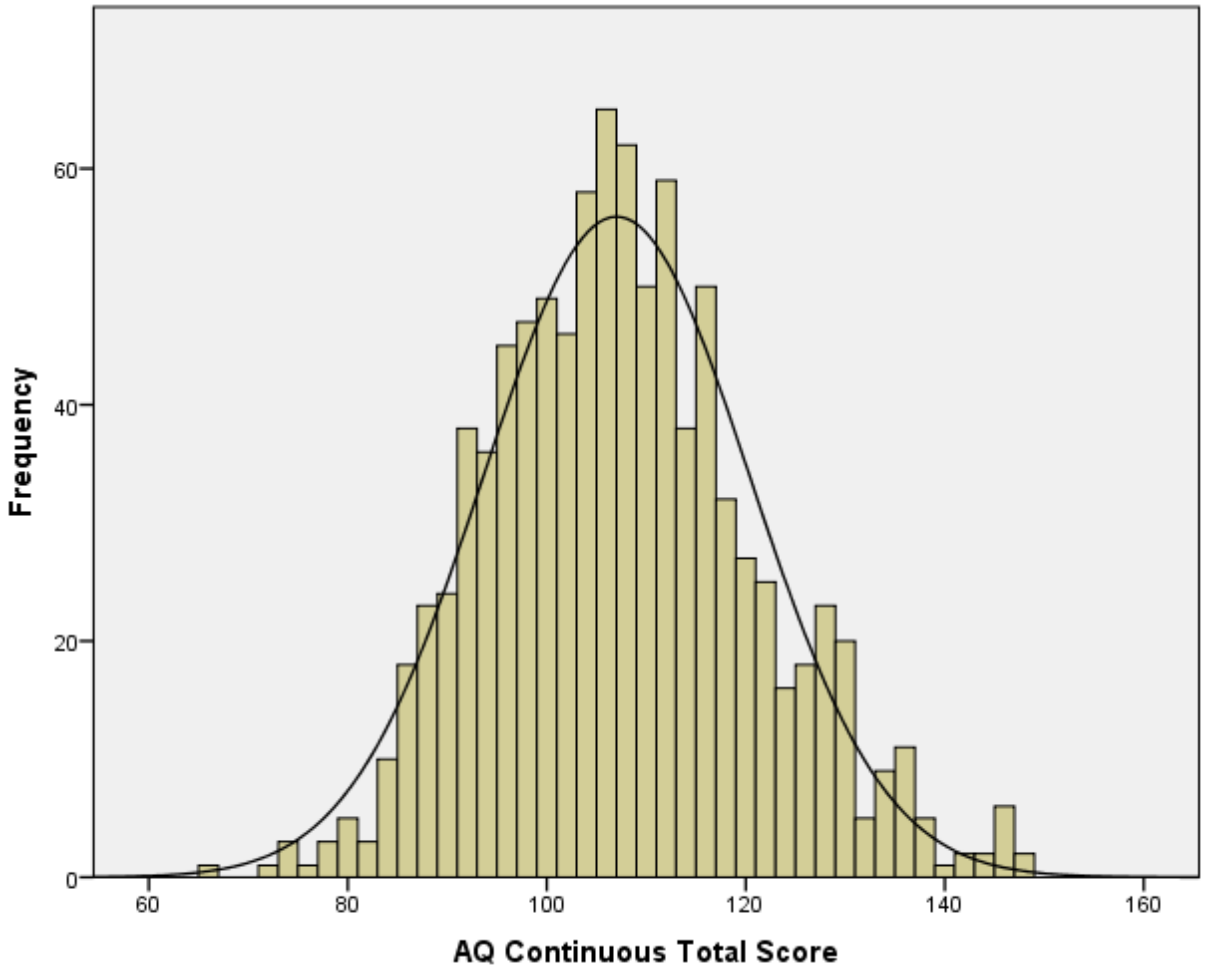

Figure 5. Distribution of AQ continuous total scores from Phase I sample (n = 939).

Appendix A

IRB Approval Letter

VirginiaTech

Office of Research Compliance
Institutional Review Board
2000 Kraft Drive, Suite 2000 (0497)
Blacksburg, Virginia 24060
540/231-4606 Fax 540/231-0959
e-mail irb@vt.edu
Website: www.irb.vt.edu

MEMORANDUM

DATE: July 6, 2011

TO: Susan White, Brenna Maddox, Robin Panneton

FROM: Virginia Tech Institutional Review Board (FWA00000572, expires May 31, 2014)

PROTOCOL TITLE: The Broad Autism Phenotype in the General Population: Evidence Through Eye-Tracking

IRB NUMBER: 11-100

Effective July 6, 2011, the Virginia Tech IRB Chair, Dr. 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 promptly 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 before the commencement of your research).

PROTOCOL INFORMATION:
Approved as: **Expedited, under 45 CFR 46.110 category(ies) 4, 6, 7**
Protocol Approval Date: **3/29/2011**
Protocol Expiration Date: **3/28/2012**
Continuing Review Due Date*: **3/14/2012**
*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 federally 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?

*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.

cc: File

Appendix B

Phase I Information Sheet

PERSONALITY AND SOCIAL CONCERNS SURVEY

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

Purpose and Procedure
The purpose of this study is to investigate the frequency of various personality traits and social concerns in undergraduate college students. It is estimated that about seven hundred college students from Virginia Tech will participate in this study. Your participation is completely voluntary. Approximately 45 survey respondents will be invited to participate in the second phase of the study, during which participants will watch various pictures and brief video clips on a computer screen that allows us to track their eye movements. Participation in Phase II is also completely voluntary. The eye-tracking session would last for approximately 15 minutes and includes $10.00 for your participation.

For this survey, you will be asked to complete a series of questions about your behaviors, feelings, and experiences. Please read each question carefully and try to answer each question to the best of your ability. It is estimated that it will take approximately 20 minutes to complete these questions. If you choose to participate in this study, you will be directed to a secure website to complete the survey.

Risks and Benefits
This survey should not take a great deal of time to complete, but it is time that you could spend doing other activities. A second risk concerns the social behavior and anxiety questions asked in the survey. These questions relate to problems in social situations (e.g., feeling tense when talking with another person or worrying about being ignored by other people), and they could make you feel uncomfortable or possibly trigger negative memories. Please remember that, at the end of the survey, we provide a list of several services available to help you if you would like someone to talk to. While some of the agencies listed provide services free of charge, some do charge for services. If you choose to seek treatment from a provider who does charge for the services, it is your responsibility to pay for these services. Also, if the questions are too distressing for you, please remember that you can stop at any time.

There is no immediate and direct benefit to you for completing this survey. However, we hope that results of this project can help in designing future research to benefit students. No promises or guarantees of benefits have been made to encourage you to participate.

Costs and Payment for Participation
There is no cost for participating in this survey, nor is any direct payment offered. However, if you are in a class that uses the Sona system, you will be offered one extra 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 survey, you will still be entered in the Sona system to receive the credit.
Some students are not in a class that uses the Sona system. If you are a student without access to Sona extra credit, you will be entered into a raffle with the chance to win one of three $25.00 cash prizes. Even if you do not complete the whole survey, you will still be entered in the raffle. Winners will be contacted by e-mail and asked to collect their cash prize from Williams Hall on campus.

Confidentiality

Your e-mail address is collected at the bottom of this page and will be used solely for the purposes of assigning credit on the Sona system, entering participants into the raffle, determining which participants have completed the survey, and inviting approximately 45 individuals to Phase II. In order to receive credit on Sona or be entered in the raffle, you MUST enter your e-mail address at the bottom of the page. Your e-mail address will be stored separately from your survey answers in a secure location, and subject numbers will be assigned for data storage. As such, all of your answers will be kept *strictly confidential*. You will not be asked to provide your name at any point during the survey. Sona administrators will be able to view who participated in the study for credit, but they will not have access to individuals' survey answers. Trained research assistants may also have access to a list of participant e-mail addresses not linked to participant data in order to assist with assigning credit on Sona. The list of participants will be deleted from the Sona system during the winter break following the Fall 2011 semester.

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. If you would like to contact the graduate student conducting this study or her advisor, you are welcome to do so. Contact information is at the bottom of this page.

You do not have to participate in this survey and, if you choose to participate, you can stop at any time. We do ask, however, that you try to answer every question completely to the best of your ability.

Questions/Contact Information

If you have any questions about the protection of human research participants regarding this study, you may contact 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 or David W. Harrison, PhD, Chair Departmental Institutional Review Board, telephone: (540) 231-4422 ; e-mail: dwh@vt.edu.

If you would like to speak with a member of this 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 or psyc.soc.interventions@gmail.com.

Before continuing on to the survey, we ask that you please print a copy of this form for your records.

By entering your e-mail address below and continuing to the survey, you acknowledge that you have read this document and that you voluntarily consent to participate in this study.

We appreciate your input and thank you for your time and help in this study!

E-mail address that is linked to your Sona account or that you provided when volunteering for the study: _____

To ensure accuracy, please re-type the e-mail address that is linked to your Sona account or that you provided when volunteering for the study: _____

Note: This information is required in order to receive credit on the Sona system or to be entered into the raffle. If you have multiple e-mail addresses, it is important that you provide the e-mail that is linked to your Sona account (if applicable), as it is the only information that we will be able to use to assign credit on Sona. If you are not eligible to receive Sona credit, we still need your e-mail address in order to mark off that you have completed the survey, enter you into the raffle, and possibly contact you with an invitation to Phase II of the study.

Appendix C

Phase II Consent Form

INFORMED CONSENT FOR RESEARCH PROJECT
Project Title: *Personality and Social Concerns*
Phase II: Eye-Tracking Session

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

Purpose of the Study
The purpose of this research study is to develop a better understanding of how college students with certain personality or behavioral traits look at other people. You are being asked to participate in this phase of the study based on your responses to the online survey you previously completed.

We hope to complete eye-tracking sessions with a total of 45 Virginia Tech undergraduate students. 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 if you choose to come to the eye-tracking session.

Procedures
If you choose to participate in this research study, you will be asked to come to Williams Hall on campus for one 15-minute eye-tracking appointment. It is important that all eye-tracking participants not wear mascara to this appointment, as it interferes with the tracker technology. At the appointment, you will first meet with a study investigator in a waiting room 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 eye-tracking task. For this task, you will accompany the co-investigator to a separate room with the eye-tracking technology. You will be seated approximately 70 cm from an arm-mounted computer screen, on which a series of faces and two brief video clips will appear showing different emotional expressions. The stimuli will appear quickly, and the computer technology will record the movements of your eyes as you complete the task. We will also be videotaping your face as you watch the screen. The visit will take place in the Developmental Research Suite (Williams Hall 360/358) on the campus of Virginia Tech, Blacksburg, Virginia.

Risks and Benefits
One possible risk is experiencing anxiety during the eye-tracking task. Faces depicting a range of both positive and negative emotional expressions (e.g., happy, sad, disgust) will be presented. Although these expressions are no more unusual than what might be encountered during daily social interactions, they could possibly be upsetting to some people. 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 service programs to benefit

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students. 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 task is complete for anyone interested.

Costs and Payment for Participation

There is no cost for participating in this study. As a token of appreciation for your time, you will be offered a small honorarium ($10.00). You will be given $10.00 at the completion of the consent process. If you choose to stop the study before the eye-tracking 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 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.

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.

Eye-tracking sessions will be video-recorded for purposes of coding the data. 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 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.

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 or psyc.soc.interventions@gmail.com.

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 eye-tracking task 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

_____ _____

Study Investigator Name Investigator Signature Date

Please sign below IF you would like to be contacted in the future about other research studies, which may be of interest to you, conducted by or in affiliation with Dr. Susan White and the Virginia Polytechnic Institute and State University.

Yes, I would like to be contacted about future studies.

_____ _____

Subject signature Date

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Appendix D

List of Resources

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.

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/centers/psc/

Appendix E

Recruitment Flyer

Personality and Social Concerns Survey

If you are an undergraduate student at Virginia Tech and would be interested in completing an online survey about personality and social concerns in college, please take a slip below and visit the website provided for more information and to sign up for the study. If you have any questions, please contact Brenna Maddox at bmaddox7@vt.edu. ** Eligible for Sona extra credit? You will earn one extra credit point! * Not eligible for Sona extra credit? You will be entered in a raffle for a chance to win one of three $25 cash prizes! **

Personality and Social Concerns Survey https://www.surveymonkey.com/s/TTSB8PV bmaddox7@vt.edu	**Personality and Social Concerns Survey** https://www.surveymonkey.com/s/TTSB8PV bmaddox7@vt.edu	**Personality and Social Concerns Survey** https://www.surveymonkey.com/s/TTSB8PV bmaddox7@vt.edu	**Personality and Social Concerns Survey** https://www.surveymonkey.com/s/TTSB8PV bmaddox7@vt.edu	**Personality and Social Concerns Survey** https://www.surveymonkey.com/s/TTSB8PV bmaddox7@vt.edu	**Personality and Social Concerns Survey** https://www.surveymonkey.com/s/TTSB8PV bmaddox7@vt.edu

Appendix F

Study Description on Sona Website

Study Name: Personality and Social Concerns Survey

Abstract: Online survey about personality and social concerns in college students.

Description: This study involves an online survey regarding your personality and social concerns in college. After signing up for this study, you will receive an e-mail with a website address for the survey. The survey will be open through Sunday, October 2nd. You will receive a reminder e-mail each week until you complete the survey or remove yourself from the study.

Web Study: This is an online study. Participants are not given the study URL until after they sign up.

Eligibility Requirements: Virginia Tech undergraduate students only

Duration: Approximately 20 minutes

Credits: 1

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

Appendix G

E-mail to Undergraduate Advisors to Request Student Participation

Subject Line: Request for Student Participation in Research Project

Dear Virginia Tech Undergraduate Advisor,

I am a doctoral student in the VT's Clinical Psychology program, and I am seeking undergraduate students to participate in my thesis research involving personality and social concerns in college. 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 forwarding my survey to your undergraduate advisees. The hyperlink below takes students to an information sheet, which provides a more in-depth explanation of the study and the rights of a participant, and then continues on to the survey.

Briefly, the study calls for undergraduate students to complete an online survey, which should take approximately 20 minutes. All participating students eligible for Sona extra credit by participating in psychology research studies will receive one extra credit. Students not eligible for Sona extra credit will receive entry into a raffle for a chance to win one of three $25 cash prizes. In addition, approximately 45 survey respondents will be invited to participate in Phase II of this study, during which participants will watch various pictures and brief video clips on a computer screen that allows us to track their eye movements. This on-campus eye-tracking session would last for approximately 15 minutes and include a $10.00 honorarium for each participant. All individuals can decline the invitation to participate in Phase II.

https://www.surveymonkey.com/s/TTSB8PV

I greatly appreciate your willingness to share information about this study with your advisees. 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

Appendix H

E-mail to Invite Survey Respondents to Eye-Tracking Session

Subject Line: Research Opportunity with Eye-Tracking Technology – Earn $10!

Dear Virginia Tech Student,

Earlier this semester, you completed an online survey entitled "Personality and Social Concerns." A total of <INSERT TOTAL NUMBER OF SURVEY COMPLETERS> undergraduate students have completed the same survey. You are now receiving a personal invitation to participate in the second part of this research project based on your survey responses.

You are invited to join me in Williams Hall on campus for a brief 15-minute eye-tracking session. All participants will receive $10.00 for their time. The purpose of this research study is to develop a better understanding of how college students with certain personality or behavioral traits look at other people. During the eye-tracking session, you will be asked simply to watch the computer screen as a series of faces and video clips appears. The stimuli will appear quickly, and the computer technology will record the movements of your eyes as you complete the task. At the end of the session, if you would like, we can show you your exact eye gaze patterns.

Please let me know if you are interested in participating by <INSERT DATE AND TIME 72 HOURS FROM E-MAIL DATE AND TIME>, or your eye-tracking invitation will be offered to another eligible student. If you let me know that you are interested, I will promptly e-mail you the consent form, with more in-depth information about the project, for your review, and we can schedule a 15-minute session at your convenience.

Sincerely,

Brenna Maddox
(540) 231-6744

Appendix I

Demographics Information Questionnaire

INSTRUCTIONS: Please answer the following questions about yourself.

Gender

- Male
- Female

Age

Please give your age in years and months. For example, a 20-year-old with a birthday last month would answer 20 years, 1 month.

_____ Years
_____ Months

Race/ethnicity (Check all that apply)

- African American
- Asian
- Caucasian/European American
- Latino, Hispanic, or Chicano
- Native American
- Other

If you select Other, please specify: _____

College Major (Declared or expected). If you have more than one major, please check the appropriate boxes.

- Agriculture and life sciences (e.g., agricultural science, dairy science, horticulture)
- Architecture and urban studies (e.g., graphic design, interior design, studio art)
- Biological sciences (e.g., biochemistry, biology)
- Business, economics, finance, marketing, or hospitality (e.g., hospitality and tourism management)
- Computer science
- Engineering (e.g., aerospace engineering, chemical engineering, computer engineering)
- Liberal arts and human sciences (e.g., history, human development, philosophy, sociology)
- Mathematics (e.g., mathematics, statistics)
- Natural resources and environment (e.g., forestry, geography)
- Physical sciences (e.g., physics, chemistry, geology)
- Psychology
- Veterinary medicine
- Other

If you select Other, please specify: _____

Class Year in College

- First year
- Second year
- Third year
- Fourth year
- Fifth year
- Sixth year or beyond

Will you be receiving extra credit via Sona for participating in this survey?

- Yes
- No

Please check any of the following diagnoses that *you* have been given as a formal diagnosis (e.g., through an evaluation with a written report):

- Anxiety Disorder
- Attention-Deficit/Hyperactivity Disorder (ADHD)
- Autism Spectrum Disorder
- Depression
- Intellectual Disability/Mental Retardation
- Learning Disorder
- None of the above

Please check any of the following diagnoses that have been given to either of *your parents* as a formal diagnosis (e.g., through an evaluation with a written report):

- Anxiety Disorder
- Attention-Deficit/Hyperactivity Disorder (ADHD)
- Autism Spectrum Disorder
- Depression
- Intellectual Disability/Mental Retardation
- Learning Disorder
- None of the above

Please check any of the following diagnoses that have been given to *your sibling(s)* as a formal diagnosis (e.g., through an evaluation with a written report):

- Anxiety Disorder
- Attention-Deficit/Hyperactivity Disorder (ADHD)
- Autism Spectrum Disorder
- Depression
- Intellectual Disability/Mental Retardation
- Learning Disorder
- None of the above

In a typical week, how often do you hang out with a friend or a group of friends, outside of class time?

- 0 times per week
- 1 time per week

- 2 times per week
- 3 times per week
- 4 times per week
- 5 times per week
- 6 times per week
- 7 times per week
- 8 or more times per week

In a typical week, do you eat more of your meals alone or with other people?

- I eat more of my meals alone.
- I eat more of my meals with other people.

Do you currently have a significant other (e.g., boyfriend, girlfriend, fiancé, spouse, partner)?

- No, I am currently single and not dating anyone.
- I am currently dating one or more people, but I do not have an "official" significant other.
- I currently have a significant other.

What would be the minimum social contact you would need to get through a day?

- No contact – I don't really get lonely.
- Just being near to people, even if I am not talking to them
- A casual chat (e.g., with a store clerk or hairdresser)
- One chat with a friend
- Two or three chats with friends during the day
- More than any of the above

What would be the minimum social contact you would need to get through a week?

- No contact – I don't really get lonely.
- Just being near to people, even if I am not talking to them
- Casual chats (e.g., with a store clerk or hairdresser)
- One chat with a friend
- One chat every day with a friend
- Two or three chats every day with friends
- More than any of the above

Appendix J

Autism Spectrum Quotient (AQ)

The Adult Autism Spectrum Quotient (AQ)

Ages 16+

SPECIMEN, FOR RESEARCH USE ONLY.

For full details, please see:

S. Baron-Cohen, S. Wheelwright, R. Skinner, J. Martin and E. Clubley, (2001)
The Autism Spectrum Quotient (AQ) : Evidence from Asperger Syndrome/High Functioning Autism, Males and Females, Scientists and Mathematicians
Journal of Autism and Developmental Disorders 31:5-17

How to fill out the questionnaire

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

DO NOT MISS ANY STATEMENT OUT.

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	definitely	slightly	slightly	definitely

thing that I lose sight of other things.	agree	agree	disagree	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 K

Social Interaction Anxiety Scale (SIAS)

For each item below, please choose 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.					
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 L

Social Phobia Scale (SPS)

For each item below, please choose 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 become anxious if I have to write in front of other people.	0	1	2	3	4
2. I become self-conscious when using public toilets.	0	1	2	3	4
3. I can suddenly become aware of my own voice and of others listening to me.	0	1	2	3	4
4. I get nervous that people are staring at me as I walk down the street.	0	1	2	3	4
5. I fear I may blush when I am with others.	0	1	2	3	4
6. I feel self-conscious if I have to enter a room where others are already seated.	0	1	2	3	4
7. I worry about shaking or trembling when I'm watched by other people.	0	1	2	3	4
8. I would get tense if I had to sit facing other people on a bus or a train.	0	1	2	3	4
9. I get panicky that others might see me faint, sick, or ill.	0	1	2	3	4
10. I would find it difficult to drink something if in a group of people.	0	1	2	3	4
11. It would make me feel self-conscious to eat in front of a stranger at a restaurant.	0	1	2	3	4
12. I am worried people will think my behavior is odd.	0	1	2	3	4
13. I would get tense if I had to carry a tray across a crowded cafeteria.	0	1	2	3	4
14. I worry I'll lose control of myself in front of other people.	0	1	2	3	4
15. I worry I might do something to attract the attention of others.	0	1	2	3	4
16. When in an elevator, I am tense if people look at me.	0	1	2	3	4
17. I can feel conspicuous standing in a line of people.	0	1	2	3	4
18. I get tense when I speak in front of other people.	0	1	2	3	4
19. I worry my head will shake or nod in front of others.	0	1	2	3	4
20. I feel awkward and tense if I know people are watching me.	0	1	2	3	4