Eye-Gaze Analysis of Facial Emotion Expression in Adolescents with ASD

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ABSTRACT

Prior research has shown that both emotion recognition and expression in children with Autism Spectrum Disorder (ASD) differs from that of typically developing children, and that these differences may contribute to observed social impairment. This study extends prior research in this area with an integrated examination of both expression and recognition of emotion, and evaluation of spontaneous generation of emotional expression in response to another person’s emotion, a behavior that is characteristically deficient in ASD. The aim of this study was to assess eye gaze patterns during scripted and spontaneous emotion expression tasks, and to assess quality of emotional expression in relation to gaze patterns. Youth with ASD fixated less to the eye region of stimuli showing surprise ($F(1,19.88) = 4.76, p = .04$ for spontaneous task; $F(1,19.88) = 3.93, p = .06$ for the recognition task), and they expressed emotion less clearly than did the typically developing sample ($F(1, 35) = 6.38, p = .02$) in the spontaneous task, but there was not a significant group difference in the scripted task across the emotions. Results do not, however, suggest altered eye gaze as a candidate mechanism for decreased ability to express an emotion. Findings from this research inform our understanding of the social difficulties associated with emotion recognition and expression deficits.
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**Introduction**

Nonverbal emotion expression and recognition are fundamental for successful social interactions. The ability to discriminate certain expressions typically develops early on in childhood. Babies as young as 3 months of age show the ability to distinguish happy, sad, and surprised emotions from static cues (Young-Browne et al., 1977) and, by 7 months, they are able to discriminate dynamic happy and angry faces (Soken & Pick, 1992). By 4 years of age, typically developing children can accurately verbally label most basic, prototypical emotions (Widen & Russell, 2003). While emotion recognition develops early in childhood, young children with ASD experience more difficulty with recognition of certain expressions compared to their typically developing peers (Rump et al., 2009). By 10 years of age, children with ASD are worse than typically developing peers at labeling basic expressions (Lindner & Rosen, 2006; Tantam et al., 1989). While most studies show that from 12 years of age through adulthood individuals with ASD do not show impairment in basic, prototypical emotions (Capps et al., 1992; Grossman, Klin, Carter, & Volkmar, 2000), they show difficulty when stimuli are more subtle or complex, and presented briefly (Humphreys et al., 2007), such as the natural emotions that are encountered in everyday social interactions.

**Emotion Recognition and Emotion Expression**

Facial emotion recognition and emotion expression are highly related and while the evidence is not conclusive, several studies show that difficulty in either recognition or expression greatly affects the quality of social interactions. Difficulty in these processes affects one’s ability to infer emotions of others as well as one’s ability to express own emotions to others, both of which are crucial in social interactions, including nonverbal communication (Nuske, Vivanti,
Although the inter-relation between emotion expression and facial emotion recognition has been established, there is lack of research exploring the two processes within the same paradigm. In addition, the extant research has not addressed differences in how the emotion expression is elicited (natural response to a viewed emotion vs. a scripted expression of a labeled emotion).

Saarni (1999) defined emotional competence as the capacity for self-efficacy in social transactions, which is highly dependent on awareness of one’s emotions and those of others, in addition to the capacity to use emotion expression adaptively. Young people with ASD differ in their quality and quantity of visual emotional expression. While expression of emotion encompasses vocal as well as visual characteristics, most of the research thus far in ASD has focused on the visual expression. Individuals with ASD display fewer nonverbal expressions of affect (Yirmiya et al., 1989). In addition, their facial expressions are often flat, inappropriate, or peculiar (Langdell, 1981; Macdonald et al., 1989; Yirmiya et al., 1989). Loveland et al. (1994) explored imitation of expressions and production of expressions of facial affect on instruction in children, adolescents, and young adults. The authors found that individuals with ASD had much more difficulty in the expression of emotion compared to individuals with Down’s syndrome, and produced odd and mechanical expressions. Their results show difficulties in both types of tasks: imitation and expression. This atypical emotion expression in individuals with ASD makes social communication challenging, even when the verbal abilities are intact.

**Facial Emotion Recognition and Expression in ASD**

While many studies have investigated facial emotion recognition and emotion expression deficits in individuals with ASD separately, these studies have not explored both processes together. Studying both processes in a similar paradigm within the same sample could inform
how they might be related as well as distinct from each other. In addition, very little is known about the mechanisms underlying recognition and expression difficulties in this population. Studies have shown that children with ASD have been found to smile less often and to lack self-conscious affect compared to typically developing peers (Dawson & McKissick, 1984; Mundy & Singman, 1989; Neumann & Hill, 1987; Spiker & Ricks, 1984). Even though these deficits in emotion expression have been well documented, further studies are needed in order to explore the mechanism behind the deficit, the nature of the deficit (e.g., undeveloped skill or inefficient use of skill), and the role that the interaction between emotion recognition and emotion expression play in these observed deficits.

Understanding the nature of observed expression deficits can inform evaluation and treatment. Is there a social component to the deficit in emotion expression? Does a response to an expressed emotion differ from a scripted generation of a labeled emotion? Further exploration of the mechanism is necessary in order to develop and refine treatment approaches targeting emotion expression difficulties. Almost all treatments thus far have focused on emotion regulation and emotion recognition in individuals with ASD. Emotion expression plays an equally important part in reciprocal social interactions, and therefore, new intervention systems need to address these challenges in individual’s ability to express socially appropriate emotions.

**Social Anxiety and Alexithymia in Eye-Tracking Research**

When exploring eye gaze using emotion recognition and emotion expression tasks in individuals with ASD, it is important to measure the presence of anxiety, especially social anxiety in all participants. Previous eye-tracking studies have shown that individuals with social anxiety show avoidance of facial features, specifically the eyes, which is similar to the eye gaze
patterns seen in individuals with ASD (Horley, Williams, Gonsalvez, & Gordon, 2003). Since the patterns of eye fixations are similar between individuals with social anxiety and individuals with ASD, the presence of social anxiety needs to be considered when conducting eye tracking research with children, adolescents, or adults with ASD, in order to assure that the effects are not due to aversion and avoidance of emotionally salient facial features due to the anxiety. Accounting for the amount of anxiety in the participants is critical when exploring eye gaze patterns in facial emotion recognition and emotion expression tasks.

Additionally, when measuring emotion recognition and emotion expression difficulties in individuals with ASD, it is important to consider alexithymia, which occurs in approximately 10% of the general population (Taylor, Bagby, & Parker, 1999), but in 50% of individuals with ASD (Berthoz & Hill, 2005; Hill et al., 2004; Lombardo et al., 2007). Alexithymia refers to a difficulty in identifying and describing specific emotions in self and others (Sifneos, 1973). When exploring ability to recognize and express emotions in a person with ASD, it is important to account for alexithymia, due to its high co-occurrence with ASD in order to understand the impairment behind the deficit. Accounting for alexithymia is important when evaluating the abilities of individuals in ASD to recognize and portray facial expressions.

Research with Adolescents

Although atypical emotion expression has been recognized and studied in children, it is important to explore the process in adolescents, especially cognitively unimpaired adolescents with ASD. Klin et al. (2007) found that cognitively high-functioning children with ASD scored two to three standard deviations below IQ on socialization scores based on the Vineland Adaptive Behavior Scales (Vineland; Sparrow, Balla, & Cicchetti, 1984). In addition, they found that the gap between individuals with ASD and their typical peers increases with age.
Therefore, as children with ASD grow into adolescents, they become increasingly more impaired relative to their typically developing (TD) peers. Many adolescents with ASD face challenges when it comes to social interactions. A large part of this challenge may stem from difficulty with emotion recognition and expression, which are critical in social interactions (Saarni, 1999). Adolescence is a crucial time in building and maintaining friendships. Research indicates that children and adolescents with ASD rarely develop typical peer relationships (e.g., Koning & Magill-Evans, 2001). High functioning adolescents with ASD often miss the subtle nonverbal cues, including facial expressions, and they are sometimes unable to share their own emotions, which can make the communication limited or odd (García-Pérez, Lee, & Hobson, 2007, Hobson & Lee, 1998). Therefore, focusing on the challenges that adolescents with ASD, especially those who are cognitively unimpaired, experience is extremely important, in order to develop effective intervention strategies that will make social interactions between people more comfortable.

**Eye-Tracking Research on Individuals with ASD**

Eye tracking technology has been employed in many studies evaluating differences in visual attention processes of individuals with ASD compared to individuals without ASD (e.g., Dalton et al., 2005; Klin, Jones, Schultz, Volkmar, & Cohen, 2002; Senju & Johnson, 2009). Collectively, these studies show that while typically developing individuals fixate mostly on the eye region of the face, individuals with ASD look more frequently toward the mouth region of the face or at other, usually non-social objects in the scene. Pelphrey and colleagues (2002) investigated the difference of eye gaze between adults with ASD and control adults when participants are specifically instructed to identify the emotions portrayed in the face stimuli. The authors found that, relative to control adults, adults with ASD spent less time viewing core features of the face, especially the eye region. Eye tracking provides a direct, objective way to
observe and quantify fixation patterns and therefore this measure is useful in evaluating attentional biases when perceiving certain stimuli, such as emotions. Eye tracking technology is also a useful measurement tool for exploring a mechanism that might be harder for individuals to report on, due to lack of awareness or lack of language necessary for its description. The use of eye tracking in this study will allow us to explore whether difficulties in emotion expression might be related to the difference in the way adolescents with ASD view social stimuli, especially emotions. Exploration of eye gaze during the emotion recognition task and during the emotion expression task will elucidate the mechanism behind the difficulties in social interactions in this population.

**Detection of Emotion Expression**

While the ability to recognize an emotion is relatively easy to measure with the use of questionnaires or verbal feedback, quantifying individuals’ expression of emotion is much more difficult. The majority of the studies exploring emotion expression has relied on human rating from video recordings of an expressed emotion (e.g., Hobson & Lee, 1998; Loveland et al., 1994; Yirmiya, Kasari, Sigman, & Mundy, 1989). While this rating approach is most widely used, it is neither convenient (i.e., use of the researcher’s time) or precise (i.e., due to human error). With the current technological advancements, 3D technology has been utilized for the purpose of emotion expression identification. Most of this technology, however, is expensive and requires extensive training. Microsoft’s Kinect system may offer a solution to these issues.

Microsoft’s Kinect has become a commercial success as part of the Xbox 360 gaming system. Its primary use has been as a sensor for full-body pose and gesture recognition. Recently, we have proposed a system that uses a 3D sensor (Microsoft’s Kinect) to detect facial expressions (R03HD081070; PIs Abbott & White). The only study to our knowledge that has
used the Kinect for this purpose is the work of Seddik et al. (2013). In their study, they tested 20 adults and found an accuracy of 81% for detecting smiles, and lower accuracies for the other emotions. Our proposed system extends beyond this research by allowing for rotations of the head, expanding the system to accommodate children and adolescents, and utilizing a larger number of subjects for training of the machine. This system is innovative in its noninvasive, low-cost, and unobtrusive nature. The Kinect system captures a standard RGB video, and a registered set of 3D data points. The 3D data points are associated with important features of the faces, such as corners of the mouth, pupils of the eyes, and apex of the nose. Microsoft includes a standard software package that automatically detects locations of the facial features (121 in total) using the Kinect. The software utilizes these 3D points to determine which facial expression is being presented by a subject.

Combining the coding (human or Kinect) of adolescents’ expression of emotion, with the eye tracking technology, allows us to explore atypical visual processing as a possible mechanism underlying emotion expression deficits. In addition to the novel technology and the co-examination of gaze and expression, the paradigm allows for an in depth analysis to determine the degree to which emotion expression difficulties emerge due to the inability to show the target emotion (i.e., skill deficit) or the inability to do so spontaneously (i.e., deployment deficit).

**Current Study and Hypotheses**

The purpose of this study was to compare adolescents with ASD to a comparison sample of TD adolescents, on emotion expression (using human ratings) and emotion recognition, in three different tasks. The first aim of the study was to determine whether eye gaze is related to the ability to recognize and express emotions in adolescents with ASD. It was hypothesized that adolescents with ASD would show less cumulative gaze duration to the eye region of the stimuli.
compared to TD adolescents (hypothesis 1). In addition, it was hypothesized that for the adolescents with ASD, greater fixation duration to the eye region would predict the accuracy of identified and expressed emotion (hypothesis 2). The second aim of the study was to investigate the difference in ability to express emotion in a structured task with instruction to make a specific facial expression, compared to a more spontaneous expression in response to viewing of an expression, without a labeled emotion. It was hypothesized that adolescents with ASD would be less likely to express the correct emotion compared to the TD peers on both emotion expression tasks (hypothesis 3). In addition, it was hypothesized that the expressed emotions of the adolescents with ASD would be more accurate in the scripted condition (i.e., when asked to make a specific emotion) than in the spontaneous condition where they are asked to respond to the video making unlabeled expressions (hypothesis 4). The third aim of the study was to explore the strength of association between eye gaze patterns and amount of self- and parent-report of anxiety and self-report of alexithymia. No hypotheses were made regarding the third aim, due to the exploratory nature of the aim.

Method

Participants

Participants included adolescents aged 12 to 17 years, inclusive. Two groups were recruited: TD adolescents, and adolescents with ASD. Each group was comprised of 20 participants, matched on age. A target sample of 20 per group was established based on an a priori power analysis to detect within-group differences (.70 power to detect medium effect size) using G*Power software (Faul, Erdfelder, Lang, & Buchner, 2007). Adolescents in the ASD group all received a formal diagnosis of ASD, which was confirmed by the Autism Diagnostic Observation Schedule, Second Edition (ADOS-2; Lord et al., 2012).
ASD and TD adolescents were screened for accompanying psychopathology by parent report on a demographics questionnaire. Any TD participant with psychopathology, or with an immediate family member diagnosed with ASD, was excluded. TD participants were recruited through flyers in the Blacksburg community (e.g., churches, schools, restaurants) and existing research registry databases. Adolescents with ASD were recruited through the university-affiliated assessment clinics, local ASD support groups, and participants from prior studies who agreed to be contacted about future research. Each adolescent received $20.00 for completing the study. Before the computerized task began, all youth gave informed written assent and their parent/caregiver provided an informed written consent for their child’s participation.

**Measures**

**Autism Diagnostic Observation Schedule, Second Edition (ADOS-2; Lord et al., 2012).** The ADOS-2 is a semi-structured assessment of ASD characteristics and is considered the gold standard for assessment of ASD. Module 3 or Module 4, designed for verbally fluent adolescents, was administered by the primary investigator who is research reliable on the administration and scoring of the measure.

**Demographic Information Questionnaire.** Parents of participants answered questions about the adolescents’ gender, age, race, grade, and ability to express a range of facial expressions. In addition, they answered questions regarding both parent’s (when available) educational information and income, and questions regarding their child’s diagnoses, treatments, and medications. They were also asked to share if the child, the child’s parents, child’s grandparents, or child’s siblings have any current medical or psychological diagnoses by endorsing a checklist of various disorders, one of which was ASD.

**Screen for Child Anxiety Related Disorders, Child and Parent Version (SCARED;**
**Birmaher et al., 1997.** A self-report and parent-report measure of anxiety, the SCARED consists of 41 items rated on a 3-point Likert scale. The purpose of this measure is to screen for signs of anxiety disorders in children. SCARED produces a score for Panic Disorder, Generalized Anxiety Disorder, Separation Anxiety, Social Anxiety, and School Avoidance, in addition to a Total Score.

**Social Responsiveness Scale, Second Edition, Parent Version (SRS-2; Constantino & Gruber, 2012).** The SRS-2 is comprised of 65 items measuring parent report of ASD-related social impairments. SRS-2 assesses awareness of others and social information, the ability to engage in reciprocal social communication, social anxiety/avoidance, and other autistic features. The SRS-2 provides a T-score that suggests the degree of interference in everyday life situations that are often associated with ASD. This measure was used to characterize social impairments in both TD and ASD participants.

**Toronto Alexithymia Scale for Children (TAS-C; Rieffe et al., 2006).** TAS-C is a self-report scale adapted from the 20 item Toronto Alexithymia Scale developed for adults (TAS-20; Bagby et al., 1994). TAS-C is comprised of 20 items measuring difficulties with understanding, processing, or describing emotions in children. While TAS-C has not often been utilized in studies with adolescents with ASD, many studies with adults with ASD have employed the original TAS-20 as a measure of alexithymia (e.g., Hill, Berthoz, & Frith, 2004; Bird, Press, & Richardson, 2011). Results from Rieffe at al. (2006) demonstrate the usefulness of the Difficulty Identifying Feelings and Difficulty Describing Feelings factors of TAS-C for identification of alexithymia in children.

**Wechsler Abbreviated Scale of Intelligence, 2nd edition (WASI-2; Wechsler, 2011).** WASI-2, a measure of cognitive functioning, was administered to all participants. WASI-2
provides an estimate of verbal, performance, and full scale IQ. Two subtests of the WASI-2 were administered (Vocabulary and Matrix Reasoning) to get an abbreviated full scale IQ-2. 4-subtest and 2-subtest WASI-2 scores correlate at .93 and decrease administration time by half.

**Apparatus and Stimuli**

**Eye tracking.** Eye-tracking was completed using a Tobii T60 XL eye tracker. Participants sat approximately 60 cm from the eye tracker screen (1920x1200 pixels screen resolution) and they were instructed to look at the video stimuli on the screen. Each stimulus video was 38 cm long x 20 cm wide; subtending 35° visual angle, with a black border around the video. Prior to each stimulus display, a centered “X” (1.5 cm x 1.5 cm wide) appeared on screen for 1 second in order to centralize the participants’ attention. Before data collection, the eye-tracking system was calibrated to each participant’s eyes to accurately calculate gaze direction. A five-point calibration procedure was used; a red circle moved to five predefined locations across the screen (i.e., the four corners and the center of the screen). The study investigator visually inspected each display before advancing the participant to the eye-tracking task. Any missing calibration points or points with excessive error were recalibrated to achieve acceptable quality. The calibration procedure generally took less than one minute. Participant’s eye gaze patterns and fixations were collected through the Tobii studio and analyzed using a Matlab code (MatlabR2014b, Mathworks Inc., MA).

**Emotion expression coding.** The expression of emotions was recorded using a Kinect system. The Kinect system captures a standard RGB video, and a registered set of 3D data points associated with important features of the faces, such as corners of the mouth, pupils of the eyes, and apex of the nose. Microsoft includes a standard software package that automatically detects these important features of the participant’s face using the Kinect. Kinect classification
of the emotion is based on ongoing pattern analyses, instead of a single frame. The system recorded the 3D data points to be later used for analyses. In addition, the system saved RGB video frames of each adolescent’s facial expressions at a rate of 30 frames per second, which was later used to confirm the system’s ability to detect each participant’s facial expression. This backup method allowed for human coding of emotion expressions in case of program failure to accurately detect the expressions. This backup was put in place because the Kinect system is new for this purpose and is still in the process of being tested (R03HD081070; PIs Abbott & White).

**Stimuli.** Stimuli were comprised of short videos (2.73 seconds in length) of young adult males and females expressing one of six basic emotions (happiness, sadness, fear, anger, surprise, and disgust). The videos were taken from the training phase of the Kinect system (Aly et al., 2015), from participants who gave permission for their videos to be used for this purpose. Three independent coders rated all available videos in terms of accuracy of emotion. The top rated videos were used as stimuli for the tasks. Six videos were used for each emotion for each task, resulting in 36 videos for each of the two tasks, for a total of 72 stimuli videos. Figure 1 displays a sample image from a stimuli video of female actor expressing anger.

**Procedures**

Individuals interested in participating in the study were directed to contact the study investigator through phone or email. Before scheduling the participant, the study coordinator conducted a brief screener in order to determine current diagnosis of ASD. Individuals with an ASD diagnosis were scheduled to come in for a session as part of the ASD group. Individuals without ASD were scheduled to come in for a session as part of the TD group.
The sessions took place at a university-affiliated assessment clinic. Every participant completed one session, lasting approximately 2.0 hours for participants in the ASD group and 1.5 hours for the participants in the TD group. At the start of the session, all adolescents provided informed written assent while their parents/caregivers provided parental permission for their child to participate. Afterward, all adolescents completed a computerized battery of tasks to assess emotion recognition and emotion expression, both scripted and spontaneous. In the first condition [spontaneous expression task], participants were seated in front of the monitor, and were shown pre-recorded videos of adults expressing the 6 basic emotions (happiness, sadness, fear, anger, surprise, and disgust). Each expression was presented 6 times, for a total of 36 stimuli videos. After the presentation of each video, participants were asked to respond, using a facial expression, to the video model displaying an emotion (Instructions: “You will now see brief videos of individuals making different facial expressions. After each video, please respond appropriately to the video, as you would if you interacted with the person in real life, using a specific facial expression. In other words, after each video, act as though you were actually interacting with the person in the video, and show this using facial expressions.”). In the second condition [emotion recognition task], after the presentation of each video, participants were asked to tell the examiner which emotion they saw after a presentation of the video (Instruction: “please tell the examiner the name of the emotion that best describes the emotion portrayed in the video you just saw”). In the third condition [scripted expression task], they were asked to make an expression of a verbally presented emotion, without seeing a video (Instructions: “Look straight ahead, and please make a (happy) expression. Make a (happy) face.”; ‘happy’ was replaced with the other 5 emotions). The second and third conditions were counterbalanced to account for order effects. The spontaneous condition was always presented first in order to
minimize training effects of emotion expression from the other tasks. Completion of the computerized battery of tasks took approximately 20 minutes.

After the computerized task, all participants completed a test of cognitive functioning (WASI-2) and filled out two questionnaires (SCARED and TAS-C, described above using a paper and pencil format). The adolescents were given privacy to fill out the questionnaires but were provided with opportunities to ask clarification questions. The questionnaires took approximately 10 minutes to fill out. Additionally, participants in the ASD group completed the ADOS-2, in order to confirm the ASD diagnosis, unless they had completed an ADOS-2 from a research-reliable evaluator prior to the study.

While the adolescent completed the protocol tasks and measures, their caregiver filled out three questionnaires (Demographic Information Questionnaire, SCARED, and SRS-2, described above) after they provided consent for participating in the study. They were given privacy to fill out the questionnaires, but were given opportunities to ask clarification questions. The caregiver portion of the study took approximately 20 minutes.

Data Analyses

Preliminary analyses. Descriptive statistics were computed for all demographic variables (i.e., gender, age, race/ethnicity, grade, personal and family mental health diagnoses) to characterize the sample. All data were entered and verified by two trained undergraduate assistants. Data were analyzed with IBM Statistical Package for Social Sciences (SPSS 23). All data were checked for outliers and highly influential data points.

Two undergraduate research assistants coded the participant’s expressions. The assistants coded the emotion expressed (e.g., anger, disgust), as well as the quality of the expression rated. 25% of all collected expressions, for both tasks, were co-coded by the second
undergraduate assistant. Inter-rater agreement was calculated for the co-coded data in order to establish the agreement between the two assistants’ codes for expression of emotion.

Preliminary analyses were conducted to examine if gaze patterns and ability to make an intended emotion expression, collapsed across the types of emotions, differed as a function of age, gender, IQ, self-reported social anxiety symptoms or self-reported alexithymia. Social anxiety symptoms and alexithymia are important to account for due to the extant research, highlighted above, emphasizing the effects of anxiety and alexithymia on eye gaze and emotion recognition and expression. Any significant effects from these preliminary analyses would have been included as covariates in the primary analyses.

**Eye-tracking data analyses.** For the eye-tracking data, any trial showing a major loss of tracking (i.e., less than 50% of the viewing time per stimulus) was excluded from data analysis. The Tobii eye tracker collected the raw eye movement data points, which were processed into fixations. A fixation was defined as a set of consecutive gaze coordinates for a duration of at least 100 milliseconds. The areas of interest (AOIs), including the face, eye region, mouth region, and the background, were predefined, using the oval-shaped AOI tool available in the Tobii T60 (Studio Professional) platform, for each face by the principal investigator. Figure 2 displays a sample image from a video with AOIs for face, mouth, and eyes. The duration of fixations made to these regions and the region of first fixation was calculated using an in-house Matlab code.

**Statistical hypothesis-testing.** Preliminary analyses were conducted to examine if eye gaze patterns and accuracy of emotion expression differed as a function of participant gender, age, IQ, self-reported anxiety symptoms, or self-reported alexithymia symptoms, as potential
covariates. No significant differences were found, so the subsequent analyses were conducted without covariates.

For the primary analyses, to test the hypothesis of lower gaze duration to the eye region of adolescents with ASD compared to typically developing adolescents, we used linear-mixed model (LMM) with maximum likelihood (ML) estimation. This approach was chosen because it allows for handling of data that are missing at random and also because it takes into account the non-independence of observations within the participant. Group (TD vs. ASD) and emotion type were tested as fixed factors, participant as a random factor, and fixation duration and latency of fixation on AOI as dependent variables. This was completed independently for both the emotion recognition and spontaneous conditions. In order to test the second hypothesis that fixation duration to the eye region predicts accuracy in emotion recognition and expression within the ASD group, a LMM was run with fixation duration and emotion as fixed factors, participant as a random factor, and accuracy of emotion identification and expression as the dependent variables. To test the third hypothesis (differences in ability to express the expected emotion across groups), a one-way ANOVA was conducted with group (TD vs. ASD) as the between-subjects factor, and accuracy in expression for each emotion as dependent variables to explore the difference in percentage of correct emotion recognition and expression between ASD and TD adolescents. To explore differences in recognition and expression across the emotions, emotion type was be added to the analysis using ANOVA to explore the interactions between the groups per different emotion stimuli. Lastly, in order to investigate possible differences in ability of adolescents with ASD to express the emotion between a spontaneous versus the scripted conditions, a paired $t$-test was conducted to look at the difference in ability to express an emotion based on the different tasks across emotion types, and McNemar’s test was used to explore
difference in ability to express each emotion type between the two tasks given the non-independence in the data. An $\alpha$ level of .05 was used for all statistical tests.

**Results**

**Descriptive Statistics and Preliminary Results**

Data were first assessed for normality and possible outliers. Descriptive statistics were computed for all demographic variables to characterize the sample (Table 1). The groups did not differ in age, $t(38) = -1.69$, $p = .10$ (ASD: $M_{age} = 14.65$ years, $SD = 1.79$; TD: $M_{age} = 13.75$ years, $SD = 1.59$). In addition, the ASD group (14 males) and TD group (9 males) did not differ in sex composition, $\chi^2(1) = 2.56$, $p = .20$ or race, $\chi^2(2) = 1.33$, $p = .51$. Group descriptive statistics were also computed for all questionnaires, FSIQ-2 based on WASI-2, and ADOS-2 data (see Table 1 for descriptive statistics and significant group differences on the self-report measures). No participants in the TD group exceeded the cutoff on the SRS-2 and there was no parental report of current psychopathology. All participants in the ASD group, except for one, exceeded the threshold on the ADOS-2, according to the evaluator’s coding or prior report. The one individual who did not exceed the threshold on the ADOS received an ASD diagnosis from a thorough evaluation completed by the study investigator prior to the present study.

**Eye-tracking.** All participants were successfully calibrated for the eye-tracking task, meaning that corneal reflection pictorials showed detection of gaze within all five predefined areas with minimal scatter. There was not a significant difference in on-task percentage scores between groups on either condition, $t(38) = .27$, $p = .79$ for spontaneous task and $t(38) = -.60$, $p = .55$ for recognition task, indicating that the two groups did not differ on the amount of data collected. However, not all participants showed on-task percentage scores above 50%, which is a common benchmark within ASD eye-tracking studies for including participants in analyses.
(e.g., Fischer et al., 2014; Swanson, Serlin, & Siller, 2013), due to technical difficulties. For the recognition task, only 7 TD participants and 10 ASD participants met the 50% cutoff. For the spontaneous task, 8 of the 20 TD participants and 9 of the 20 ASD participants met the cutoff. Given the variable on-task percentages across the entire task, in order to preserve as much valid data as possible, the eye tracking data were analyzed per stimuli, instead of on a per-subject basis. The on-task percentage scores above 50% per stimulus were used. 12 out of 20 TD participants and 14 out of 20 ASD participants showed on-task percentage scores above 50% for at least one stimulus during a recognition task. For the spontaneous task, 16 out of 20 TD participants and 14 out of 20 ASD participants showed on-task percentage above 50% for at least one stimulus. The groups did not differ in the amount of valid stimuli used for analysis ($\chi^2(5) = 1.29, p = .94$ for recognition task; $\chi^2(5) = 6.19, p = .29$ for spontaneous task). Therefore, data loss was determined to be random and not systematic based on group.

**Emotion expression.** Comparison between the newly developed computerized system using Kinect and the human coding for the scripted task revealed low agreement (66% agreement that emotion was correct and 76% agreement that expressed emotion was incorrect [i.e., not the stimulus emotion] across all emotions). The percentage of agreement differed by emotion, ranging from 16% agreement of correct expression (for fear), to 97% agreement (for happiness), with ‘correct’ defined as showing the same emotion presented in the stimulus. Table 2 displays the human and computer (Kinect) judgement for each expression across all subjects. Agreement was calculated for scripted task only, as it was predicted to yield higher agreement with the human coders compared to the spontaneous task.

Given the low agreement, and the fact that the machine classification is still in development, human coding was used for main analyses. Two undergraduate students coded
each participant’s expression for each stimuli presentation. 25% of the videos were co-coded in order to establish rater agreement. Cohen's $\kappa$ was run to determine if there was agreement between two raters’ judgements on what emotion the participant portrayed. There was excellent agreement between the two raters' judgements, $\kappa = .926$ (95% CI, .88 to .97), $p < .01$ for the scripted condition, and substantial agreement $\kappa = .742$ (95% CI, .69 to .79), $p < .01$ for the spontaneous condition.

**Group Comparison of Emotion Recognition**

There was a significant group difference in ability to accurately identify some, but not all, emotions. The individuals in the TD group more accurately identified disgust ($t = 3.22, p = .003$) and sadness ($t = 3.54, p = .002$) compared to individuals in the ASD group. As shown in Figure 3, there was no significant difference in accuracy of emotion recognition for any of the other emotions (all $t < 1.46$, all $p$’s > .15).

**Group Comparison of Gaze to the Eye Region (Hypothesis 1)**

**Gaze fixation.** Inconsistent with our hypothesis that the participants in the ASD group would show lower gaze duration to the eye region of the stimuli compared to typically developing adolescents, there was not a significant between group difference, $F(1, 24.52) = 0.67$, $p = .42$. Participants in the TD group spent a similar amount of time looking at the eye region ($M = 973.66$ ms; $SE = 133.89$) compared to the participants in the ASD group ($M = 822.99$ ms; $SE = 125.93$) during the recognition task. In addition, there was no effect of emotion, $F(5, 472.54) = 1.66, p = .14$, on fixation duration to the eye region and no significant interaction effect between group and emotion type, $F(5, 472.54) = 1.59, p = .16$. Although not statistically significant, there was a trend for participants with ASD to spend less time looking at the eye region of
stimuli expressing surprise compared to the TD participants \( F(1, 20.41) = 3.93, p = .06 \). Table 3 displays the average gaze duration to the eye region per emotion.

The interaction between group and emotion type for fixation duration to the mouth region during the recognition task was statistically significant, \( F(5, 411.95) = 2.25, p = .049 \). Results from the linear mixed-model suggest no group difference in fixation duration to mouth region across emotions, \( F(1, 22.47) = .87, p = .36 \). However, there is a significant effect of emotion type on fixation to mouth region, \( F(5, 411.95) = 4.02, p = .001 \). Figure 4 displays the average gaze duration to the mouth region per emotion type. Participants with ASD spent more time looking at the mouth region for the surprise stimuli, compared to the TD participants, \( F(1, 18) = 4.93, p = .04 \).

An opposite pattern was observed for the spontaneous task, in which the participant was asked to respond to the video with a facial expression, but not told the emotion. While there was not a significant group difference across emotions \( F(1, 26.21) = 0.912, p = .35 \) in gaze duration to the eye region, there was a significant effect of emotion, \( F(5, 465.99) = 5.81, p < .01 \), and a significant interaction effect between group and emotion type, \( F(5, 465.99) = 2.74, p = .02 \), for fixation duration to the eye region. Figure 5 displays the gaze duration to the eye region per emotion type for the spontaneous task. The group difference in eye gaze duration is largely coming from surprise and disgust emotions, for which participants in the ASD group spent significantly less time on the eye region for stimuli showing surprise expression, relative to the TD participants.

Looking at the mouth region, inconsistent with the results found for the recognition task, there was not a significant effect of group on fixation duration to mouth region across emotions, \( F(1, 26.32) = .20, p = .66 \). There was also no significant interaction effect of group and emotion
type, $F(5, 332.74) = 1.13, p = .34$. Table 4 displays the average gaze duration to the mouth region per emotion type.

**Latency to AOI regions.** Examining latency to the stimulus eye region when the eye region was the first point of fixation for the participants, no significant between group differences emerged for either the recognition task, $F(1, 20.35) = .01, p = .93$, or the spontaneous task, $F(1, 14.29) = 1.47, p = .25$. In addition, when accounting for emotion type, there was no significant interaction effect of group and emotion type for the recognition task ($F(5, 209.08) = .49, p = .78$) or for the spontaneous task ($F(5, 298.74) = .84, p = .52$). Similarly, examining latency to the mouth region when the mouth region was the first point of fixation for the participants, no significant between group differences emerged for either the recognition task ($F(1, 12.34) = 1.06, p = .32$) or the spontaneous task ($F(1, 14.94) = 0.12, p = .65$). In addition, when accounting for emotion type, there was no significant interaction effect of group and emotion type for the recognition task ($F(5, 105.55) = .66, p = .65$) or for the spontaneous task ($F(5, 38.17) = .28, p = .89$).

**Eye Gaze predicting Accuracy (Hypothesis 2)**

Inconsistent with our hypotheses, in the ASD group, greater fixation duration to the eye region did not predict accuracy of emotion recognition or expression. For the recognition task, there was no significant effect of fixation duration to the eye region for recognition accuracy, $F(1, 263.00) = .21, p = .65$, and taking into account emotion type, there was not a significant interaction effect of fixation duration and emotion type on accuracy, $F(5, 263.00) = 1.03, p = .40$. Similarly, fixation duration to the eye region did not predict accuracy of expression of emotion for the spontaneous task, $F(1, 217.85) = .08, p = .77$. Taking into account emotion type, no
significant interaction effect was found between fixation duration and emotion type on accuracy of the expressed emotion, $F(5, 211.00) = 1.60, p = .16$.

However, there were significant effects of fixation duration to the mouth region on both recognition and expression accuracy for the youth with ASD. For the recognition task, there was a significant effect of fixation duration to mouth region on accuracy, $F(1, 233.00) = 3.98, p = .047$, and a significant direct effect of emotion on accuracy, $F(5, 233.00) = 6.56, p < .01$. There was significantly lower accuracy for the fear condition ($M = 26.3\%, SE = 6.4$) compared to all other emotions (anger: $M = 74.5\%, SE = 6.1$; disgust: $M = 64.9\%, SE = 6.5$; happy: $M = 97.8\%, SE = 6.7$; sad: $M = 81.9\%, SE = 6.4$; surprise: $M = 75\%, SE = 6.8$) and a significantly higher accuracy for happy emotion compared to the disgust emotion. Figure 6 displays the fixation duration for those stimuli that were correctly versus incorrectly identified by the participants with ASD. As can be seen, for sadness, when correctly identified, individuals with ASD spent significantly more time fixating to the mouth region, compared to when sadness was mis-identified. A different pattern emerges for the happy stimuli. Individuals with ASD spent almost twice the amount of time fixating on the mouth region of happy stimuli when they did not correctly identify it, compared to when they correctly identified it as happy. Given the wide distribution however, this difference was not statistically significant.

For the spontaneous expression task, there was no significant effect of fixation duration to the mouth region on accuracy of expression, $F(1, 149.24) = 1.89, p = .17$. However, when taking into account emotion type, there was a significant interaction effect of fixation duration and emotion type on accuracy of expression, $F(5, 142.03) = 6.21, p < .01$. As can be seen in

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1 These results are based on analyses per stimuli, and therefore there are incorrect responses for happy stimuli even though in Figure 3, there is almost perfect recognition of happy stimuli. Data for Figure 3 were analyzed per subject basis; data for Figure 6 were analyzed per stimuli basis.
Figure 7, a similar pattern emerges for the sad expression with more gaze toward the mouth region for correct compared to incorrect expressions. In addition, for the fear stimuli, individuals with ASD showed higher fixation to the mouth region for the incorrectly expressed emotions compared to correctly expressed emotions.

**Group Comparisons of Emotion Expression (Hypothesis 3)**

The third hypothesis, that the adolescents with ASD would be less accurate in emotion expression on both tasks, than the TD adolescents, was partially supported. Adolescents with ASD were less likely to express the intended emotion compared to TD peers in the spontaneous expression task. One-way ANOVA revealed a main effect of group, $F(1, 35) = 6.38, p = .02$. However, there was no group difference in the ability to express the intended emotions during the scripted expression task, $F(1, 37) = 1.73, p = .20$.

Figure 8 displays the accuracy of expected expression by emotion for the spontaneous task. Exploratory analyses revealed a significant main effect of emotion ($F(5, 210) = 4.03, p = .002$), but no emotion by group interaction effect, $F(5, 210) = .57, p = .72$. Pairwise comparisons with Bonferroni correction revealed that the accuracy in expression of intended emotion was significantly less with sad stimuli ($M = 55.23\%, SD = 35.76$) and disgust stimuli ($M = 53.51\%, SD = 37.93$), relative to happy stimuli ($M = 83.06\%, SD = 31.61$), $p = .004, d = .28$ and $p = .002, d = -.30$, respectively. The TD and ASD groups significantly differed in expression of intended emotion for happy, surprise, and fear expressions.

Figure 9 displays the accuracy of expected expression by emotion for the scripted task. Exploratory analyses taking into account emotion type revealed a significant main effect of emotion, $F(5, 220) = 3.50, p = .005$, but no main effect of group, $F(1, 220) = 2.24, p = .14$, or interaction effect of group by emotion, $F(5, 220) = 1.28, p = .27$. Pairwise comparisons with
Bonferroni correction revealed that the accuracy in expression of expected emotion was significantly less toward fear stimuli ($M = 69.23\%, \ SD = 49.56\%$), relative to happy stimuli ($M = 100\%, \ SD = 0.0\%), \ p = .001, \ d = -.308$. Regarding group differences, participants with ASD were significantly lower in their accuracy to express scripted expression only for the surprise emotion ($t = 2.25, \ p = .04$).

**Task Comparisons of Emotion Expression (Hypothesis 4)**

To evaluate whether the adolescents with ASD were able to more accurately express the emotion in the scripted condition, compared to the spontaneous condition (in which the intended response may not have been as clear), an aggregate of accuracy percentage for spontaneous condition was compared to the percent accuracy for the scripted task. As can be seen in Figure 10, a paired-sample $t$-test revealed a significant difference between conditions, with higher accuracy for the scripted condition ($M = 82.28\%, \ SD = 19.62\%$) compared to spontaneous presentations ($M = 54.58\%, \ SD = 27.94\%; \ t(18) = 4.03, \ p < .01$), as was hypothesized.

When taking into account emotion type, each presentation of the spontaneous task was compared to the scripted task, given that each emotion was presented a total of six times during the task whereas, in the scripted task, the participant was asked to express each emotion only once. Results suggest that emotion expression in response to all presentations of the sad stimuli were significantly lower during the spontaneous task, compared to the scripted task (all $p < .02$). In addition, participants expressed disgust more accurately in the scripted task, than in the spontaneous task for all ($p < .02$) except for the fifth presentation ($p = .07$). Although the ASD group did not differ on accuracy of expression for happy and angry emotions across tasks, they differed in accuracy for 3rd and 4th presentation of fear ($p = .02, \ .01$ respectively) and 5th
presentation of surprise \((p = .04)\). See table 5 for breakdown of accuracy in expression for each emotion across conditions.

These results do not appear to be specific to adolescents with ASD. As can be seen in Figure 10, a paired-sample \(t\)-test revealed a significant difference between conditions for TD sample, with higher accuracy for the scripted condition \((M = 89.17\%, SD = 12.42)\) compared to spontaneous presentations \((M = 74.41\%, SD = 18.63; t(17) = 3.72, p < .01)\), similar to the pattern seen for adolescents with ASD.

**Discussion**

This study sought to assess the accuracy of facial emotion expression and recognition of facial emotion in adolescents with ASD, relative to adolescents without ASD. Specifically, we endeavored to examine the possible role of visual attention (gaze) toward emotional stimuli on facial emotion recognition and expression. In general, participants with ASD were significantly less accurate in identifying disgust and sad stimuli compared to TD participants, a finding that is consistent with prior research (e.g., Evers et al., 2015) and other studies suggesting deficits for recognition especially of negative emotions (e.g., Ashwin et al. 2006; and also see review: Harms et al. 2010).

Many studies show that high-functioning individuals with ASD look less at the eye region of emotionally expressive faces than do controls (e.g., Corden et al. 2008; Pelphrey et al. 2002). Our results failed to replicate these widespread findings. Recent research exploring visual saliency suggests it is important to account for the influence of different levels of visual input, including pixel-level and object-level properties, on gaze and scanning patterns, in addition to semantic-level attributes. Wang and colleagues (2015), for example, found that individuals with ASD looked more towards the center of the stimuli image in addition to
focusing more on pixel-level saliency (e.g., contrast) at the expense of semantic-level saliency (e.g., faces). Their findings highlight the importance in stimuli selection (i.e., complex naturalistic stimuli) in addition to multi-level analyses accounting for lower-level properties (e.g., color, contrast) in addition to semantic information.

Our results from the eye tracking suggest an effect of task, as well as emotion, on how participants view the video stimuli. Fixation duration to the eye region differed between TD and ASD for surprise stimuli only. However, results suggest that the fixation patterns differ between tasks. When asked to identify the emotion (i.e., recognition task), adolescents with ASD fixated more on the mouth region of the stimulus face. However, when asked to respond to the video using their face, while they still looked less at the eyes, they did not look significantly more to the mouth compared to the TD participants. This finding suggests that adolescents with ASD imbue salience to the mouth region when they are asked to identify the emotion portrayed but do not do so when asked to just show the emotion, compared to the typically-developing adolescents. While other studies have noted the difference in results based on task stimuli, this study highlights the difference in results based on the instructions, given that the stimuli (e.g., content, duration) and experimental set-up were the same across the two tasks. The results across the two tasks, however, highlight the difference in how adolescents with ASD view stimuli of surprise, with lower fixation to the eye region compared to TD participants and higher fixation to the mouth region compared to the TD participants, only during a recognition task.

While fixation duration to the eye region did not predict accuracy in recognition and expression of emotions, results suggest that accuracy of both recognition and expression for youth with ASD depends on amount of time they look at the mouth region of the stimuli. Across the two tasks, for the sad videos, adolescents with ASD more accurately identified and expressed
the sad emotion when they spent more time looking at the mouth region, suggesting the mouth region is especially important in distinguishing sadness from other emotions. Interestingly, the effect of fixation duration to mouth differed for fearful stimuli based on the task. While adolescents who spent more time looking at the mouth region during the recognition task evidenced slightly higher accuracy for recognition of fearful stimuli, during the spontaneous task, more time looking at the mouth region actually resulted in less accurate emotion expression. This result once again suggests the importance of task in terms of what the participant is asked to do (e.g., identify versus express emotion).

Results from the emotion expression tasks show a difference between TD and ASD participants in accuracy of spontaneously expressed emotion, and not scripted emotion, suggesting that youth with ASD have a harder time expressing emotion in response to another person making an expression, compared to TD participants. This was evident across several emotions, including happiness, surprise, and fear. When asked to make a specific expression (e.g., “make a happy face”), however, the two groups did not differ in their ability to express the emotion, with the exception of surprise emotion. Within the ASD group, across emotion types, our results suggest that adolescents with ASD are better at expressing emotions when told the emotion to show, compared to when they must respond to a shown emotion stimulus (i.e., a video of another person). Collectively, these results suggest that while adolescents with ASD are capable of expressing emotions as well as their non-ASD peers, they struggle with utilizing this skill. These results indicate the need for training accurate emotion expression in high-functioning adolescents with ASD in natural settings. Even when the ability (skill) is intact, its application in interpersonal interaction may lack.
Results suggest a difference in how adolescents with ASD view stimuli expressing surprise expression and in their ability of individuals with ASD to express the intended surprise emotion, compared to typically developing peers. However, adolescents with ASD do not appear to struggle with the recognition of the surprise emotion. As such, even though recognition may be intact in a discrimination task in which the youth with ASD is given a forced choice of the basic emotions, the individual may view the stimulus differently, which might affect the way the emotion is expressed. Overall, while individuals with ASD show differing patterns of viewing surprise expression and show deficits in expression of the surprise emotion, our results do not support our hypothesis that eye gaze patterns are a mechanism behind the diminished ability to express the appropriate emotion. Further research is needed in order to fully understand the impairments that individuals with ASD display in everyday social situations. For example, many of the emotions encountered in everyday life cannot be neatly categorized within one of the six basic emotions. In everyday interactions, individuals often feel and express a mix of emotions, with nuanced differences such as fearful surprise versus happy surprise, for example. Our findings implicating most differences for the surprise emotion across tasks suggest the complexity in interpretation of the surprise emotion based on context and the importance in reliance of multiple facial cues (e.g., eye region and mouth region).

Limitations

These findings should be considered in light of the limitations of this study. A primary limitation is the loss of eye tracking data for many participants due to technical problems with Tobii and set-up of the experiment. Although there was not a significant difference in the amount of data lost between groups, because the majority of the participants did not meet the recommended validity cutoff of 50%, data were analyzed per stimuli basis and the data therefore
differed between subjects. The mixed models analytic approach however accounted for the random effect of subject. In addition, a limitation of the current study’s eye-tracking paradigm was the lack of a pre-programmed method to ensure that all participants fixated on the centered fixation cross (i.e., “X”) before proceeding to the subsequent trial to ensure that the initial direction of eye gaze was controlled in all participants at stimulus onset.

Due to the major loss of eye tracking data in addition to small sample sizes, it is possible that there is not enough power to detect the relationship between fixation duration and expression ability (hypothesis 2). Similarly, given the number of different analyses both across and within emotions, as well as the varying patterns of results which emerged (e.g., differences only for certain emotions), the possibility of a type II error must be considered. While the differences found for fixation duration and emotion expression for surprise emotion appear to be consistent, other findings (e.g., lower fixation duration to eye region for disgust stimuli for individuals with ASD only for spontaneous task) are less consistent. Future research may benefit from grouping the positive emotions and the negative emotions separately, when exploring overall effects.

Another limitation was the focus on accuracy coding of expression by undergraduate research assistants. While the inter-rater reliability of the coders was high, there is subjectivity in coding of emotions by people. We originally sought to overcome this with the Kinect system; however, the system proved to have low sensitivity and specificity for most expressions. Currently, the system is being modified in order to increase the accuracy of the coding.

In terms of participant characteristics, the sample was predominately Caucasian, and these results may not generalize to individuals of other races and ethnicities. Similarly, while the typically developing sample did not have any co-occurring psychopathologies, the participants in the ASD group evidenced several diagnoses, including anxiety, depression, and learning disorder
among others. While we found no difference in eye tracking or expressions results based on anxiety or alexithymia, other factors (i.e., depression) have not been explored. In addition, many of the participants in the ASD group had a therapeutic history which might have involved training in emotion recognition or expression. The study did not allow for control of therapeutic history. Similarly, while IQ was not correlated with eye gaze and emotion expression variables, it is important to note that the groups were not matched on IQ, with four of the individuals in the ASD group having an IQ below the Average range. However, no participants scored below the Borderline range (IQ < 70), and therefore no participants evidenced an intellectual disability based on the WASI-2.

**Implications and Future Directions**

The current study provides results of practical relevance. As described in this study and elsewhere, emotion expression in young people with ASD differs both qualitatively and quantitatively from what is seen in typically developing individuals (Langdell, 1981; Yirmiya et al., 1989). Atypical expression of emotion can impede social discourse, making interactions with others awkward and development of peer relationships challenging. This challenge in a social interaction can occur even when verbal abilities are spared since nonverbal cues are a large part of social discourse. Nonverbal cues, including perception of emotion, play a big role in making judgments. For example, being able to perceive someone’s emotion is critical when determining whether someone should be approached or avoided. Similarly, emotion expression plays an important role in letting someone else know, for instance, whether you are open to an interaction and how you are feeling at that time. Individuals with ASD have a difficult time with both reading of other’s emotion and being able to portray their own emotions. This difficulty contributes to limited or negative social interactions. Findings from this study suggest that
spontaneous facial emotional expression may be impaired in the context of an intact ability to show emotions (when told what to show), and that visual attending to emotional stimuli differs as a function of task demands. Clinically, explicit instruction on how to visually process others’ affective cues may help adolescents with ASD both recognize and show emotions more naturally.

While facial expressions provide essential information in how one feels, in social interactions, these cues often occur within a given context. In addition to facial expressions, when evaluating the abilities of individuals with ASD to interpret other’s emotions as well as express how they are feeling themselves, it is important to look at other, non-facial communication. The recently published Research Domain Criteria (RDoC) framework segments the construct of Social Communication into four sub-constructs: (1) reception of facial communication; (2) production of facial communication; (3) reception of non-facial communication; and (4) production of non-facial communication. This study only focused on the facial communication subcontracts. Further research is needed to explore the influence of task demand on these processes.

**Conclusion**

The current study investigated facial emotion expression and emotion recognition along with eye gaze analysis in adolescents with ASD. Results show altered eye gaze in individuals with ASD as well as diminished ability to accurately express certain emotions, specifically surprise. However, looking patterns do not appear to be the mechanism by which individuals with ASD struggle with emotion expression. Further research is needed in order to fully understand the mechanisms behind the impaired emotion recognition and expression in individuals with ASD that contribute to the everyday social difficulties.
References


Developmental Disorders, 42, 161-174.


Table 1

Demographic Characteristics

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</table>

<table>
<thead>
<tr>
<th></th>
<th>(n) (% of total)</th>
<th>(n) (% of total)</th>
<th>(\chi^2) ((p))</th>
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<tbody>
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<td>Gender</td>
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<td>2.56 (.20)</td>
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<tr>
<td>Male</td>
<td>14 (70.00)</td>
<td>9 (45.00)</td>
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<tr>
<td>Female</td>
<td>6 (30.00)</td>
<td>11 (55.00)</td>
<td></td>
</tr>
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<td>Race</td>
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<td>1.33 (.51)</td>
</tr>
<tr>
<td>Caucasian</td>
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<td>18 (90.00)</td>
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</tr>
<tr>
<td>Non-Caucasian</td>
<td>2 (10.00)</td>
<td>2 (10.00)</td>
<td></td>
</tr>
<tr>
<td>Asian-American</td>
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<td>2 (10.00)</td>
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<tr>
<td>African-American</td>
<td>1 (5.00)</td>
<td>0 (0.00)</td>
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<td>Diagnoses</td>
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<td></td>
<td></td>
</tr>
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<td>Asperger’s</td>
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<td>Autism</td>
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<td></td>
</tr>
<tr>
<td>Anxiety</td>
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<td></td>
</tr>
<tr>
<td>OCD</td>
<td>3 (15.00)</td>
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<td></td>
</tr>
<tr>
<td>ADHD</td>
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</tr>
<tr>
<td>Depression</td>
<td>4 (20.00)</td>
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<td></td>
</tr>
<tr>
<td>ID/LD(^e)</td>
<td>5 (25.00)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Note. Significant between-group differences are indicated (*p < .01).

a FSIQ-2: IQ based on two subtests of the Wechsler Abbreviated Scale of Intelligence (WASI-2).

c TAS-C: Toronto Alexithymia Scale for Children, a self-report. Three factors: Difficulty Identifying Feelings, Difficulty Describing Feeling, and Externally Oriented Thinking make up the Total Score.
d SCARED: Screen for Child Anxiety Related Disorders, child and parent version. Five scales make up the total anxiety: Panic/Somatic, Generalized Anxiety (GAD), Separation Anxiety, Social Anxiety, and School Avoidance.
e Diagnoses: based on parent-report of adolescent’s current diagnoses
f ID: Intellectual Disability; LD: Learning Disability
<table>
<thead>
<tr>
<th></th>
<th>Happy</th>
<th>Kinect</th>
<th></th>
<th>Fear</th>
<th>Kinect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Correct</td>
<td>Incorrect</td>
<td></td>
<td>Correct</td>
</tr>
<tr>
<td>Human</td>
<td>Correct</td>
<td>97</td>
<td>3</td>
<td>Human</td>
<td>Correct</td>
</tr>
<tr>
<td></td>
<td>Incorrect</td>
<td>0</td>
<td>0</td>
<td>Incorrect</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Surprise</td>
<td></td>
<td></td>
<td>Anger</td>
<td></td>
</tr>
<tr>
<td>Human</td>
<td>Correct</td>
<td>85</td>
<td>15</td>
<td>Human</td>
<td>Correct</td>
</tr>
<tr>
<td></td>
<td>Incorrect</td>
<td>75</td>
<td>25</td>
<td>Incorrect</td>
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</tr>
<tr>
<td></td>
<td>Sad</td>
<td></td>
<td></td>
<td>Disgust</td>
<td></td>
</tr>
<tr>
<td>Human</td>
<td>Correct</td>
<td>63</td>
<td>38</td>
<td>Human</td>
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<td>50</td>
<td>50</td>
<td>Incorrect</td>
<td>17</td>
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</tbody>
</table>
Table 3

*Group Difference in Eye Gaze Duration by Emotion Type for the Recognition Task*

<table>
<thead>
<tr>
<th></th>
<th>ASD Mean (SE)</th>
<th>TD Mean (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anger</td>
<td>852.20 ms (139.38)</td>
<td>1108.72 ms (148.89)</td>
</tr>
<tr>
<td>Disgust</td>
<td>776.84 ms (143.62)</td>
<td>810.78 ms (153.63)</td>
</tr>
<tr>
<td>Fear</td>
<td>785.16 ms (141.72)</td>
<td>935.14 ms (148.90)</td>
</tr>
<tr>
<td>Happy</td>
<td>933.13 ms (142.37)</td>
<td>897.92 ms (150.27)</td>
</tr>
<tr>
<td>Sad</td>
<td>870.62 ms (142.56)</td>
<td>1035.38 ms (153.99)</td>
</tr>
<tr>
<td>Surprise</td>
<td>730.01 ms (143.40)</td>
<td>1054.03 ms (151.34)</td>
</tr>
</tbody>
</table>

*Note.* ~ indicates between group difference (*p* = .06)
Table 4

*Group Difference in Gaze Duration to Mouth Region for the Spontaneous Task*

<table>
<thead>
<tr>
<th></th>
<th>ASD Mean (SE)</th>
<th>TD Mean (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anger</td>
<td>855.77 ms (138.22)</td>
<td>750.74 ms (125.28)</td>
</tr>
<tr>
<td>Disgust</td>
<td>616.77 ms (148.13)</td>
<td>589.25 ms (146.59)</td>
</tr>
<tr>
<td>Fear</td>
<td>845.11 ms (137.47)</td>
<td>570.23 ms (128.45)</td>
</tr>
<tr>
<td>Happy</td>
<td>902.90 ms (134.36)</td>
<td>1026.02 ms (123.84)</td>
</tr>
<tr>
<td>Sad</td>
<td>849.65 ms (155.23)</td>
<td>723.13 ms (127.97)</td>
</tr>
<tr>
<td>Surprise</td>
<td>475.91 ms (131.74)</td>
<td>494.83 ms (136.87)</td>
</tr>
</tbody>
</table>
Table 5

Accuracy for Spontaneous versus Scripted Conditions

<table>
<thead>
<tr>
<th></th>
<th>Scripted Mean (SD)</th>
<th>Spontaneous Mean (SD)</th>
<th>McNemar’s Sig. value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anger</td>
<td>.84 (.37)</td>
<td>.79 (.42)</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>.61 (.50)</td>
<td>.61 (.50)</td>
<td>1.3</td>
</tr>
<tr>
<td></td>
<td>.63 (.50)</td>
<td>.53 (.51)</td>
<td>1.1</td>
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<tr>
<td></td>
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<td>.53 (.51)</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>.59 (.51)</td>
<td>.59 (.51)</td>
<td>1.2</td>
</tr>
<tr>
<td>Disgust</td>
<td>.89 (.32)</td>
<td>.39 (.50)</td>
<td>0.02*</td>
</tr>
<tr>
<td></td>
<td>.28 (.46)</td>
<td>.42 (.51)</td>
<td>&lt;.01*</td>
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<td></td>
<td>.47 (.51)</td>
<td>.47 (.51)</td>
<td>0.02*</td>
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<td>0.01*</td>
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<tr>
<td></td>
<td>.41 (.51)</td>
<td>.41 (.51)</td>
<td>0.01*</td>
</tr>
<tr>
<td>Fear</td>
<td>.79 (.42)</td>
<td>.67 (.48)</td>
<td>0.38</td>
</tr>
<tr>
<td></td>
<td>.53 (.52)</td>
<td>.53 (.52)</td>
<td>0.13</td>
</tr>
<tr>
<td></td>
<td>.26 (.45)</td>
<td>.37 (.50)</td>
<td>0.02*</td>
</tr>
<tr>
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<td>.37 (.50)</td>
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<td>.58 (.51)</td>
<td>0.38</td>
</tr>
<tr>
<td>Happy</td>
<td>.63 (.50)</td>
<td>.79 (.42)</td>
<td>0.45</td>
</tr>
<tr>
<td></td>
<td>.68 (.48)</td>
<td>.68 (.48)</td>
<td>1.0</td>
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<tr>
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<td>Sad</td>
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<td>.53 (.51)</td>
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<td></td>
<td>.44 (.51)</td>
<td>.44 (.51)</td>
<td>&lt;.01*</td>
</tr>
<tr>
<td>Surprise</td>
<td>.79 (42)</td>
<td>.67 (.49)</td>
<td>0.45</td>
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<tr>
<td></td>
<td>.63 (.50)</td>
<td>.63 (.50)</td>
<td>0.45</td>
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<tr>
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<td>.58 (.51)</td>
<td>.58 (.51)</td>
<td>0.22</td>
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<td>.53 (.51)</td>
<td>.53 (.51)</td>
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<td>.44 (.51)</td>
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<tr>
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<td>.61 (.50)</td>
<td>.61 (.50)</td>
<td>0.22</td>
</tr>
</tbody>
</table>

Note. * indicates significant difference between tasks (p < .05)
Figure 1. A single frame from a sample stimulus video of a female actor expressing anger.
Figure 2. Areas of Interest (AOIs) for face, eyes, and mouth for a sample image from a video stimuli.
Figure 3. Accuracy (%) of emotion recognition per emotion type. Standard errors are represented in the figure by the error bars attached to each column. * indicates significant between group difference ($p < .05$).
**Figure 4.** Fixation duration (ms) to the mouth region per emotion type for recognition task.

Standard errors are represented in the figure by the error bars attached to each column.* indicates significant between group difference ($p < .05$).
Figure 5. Fixation duration (ms) to the eye region per emotion type for spontaneous task. Standard errors are represented in the figure by the error bars attached to each column. * indicates significant between group difference (p < .05).
**Figure 6.** Fixation duration to the mouth region per accuracy for recognition task. Standard errors are represented in the figure by the error bars attached to each column. * indicates significant difference between responses \((p < .05)\).
Figure 7. Fixation duration (ms) to the mouth region per accuracy for spontaneous task. Standard errors are represented in the figure by the error bars attached to each column. * indicates significant between group difference ($p < .05$).
Figure 8. Accuracy (%) of Emotion Expression for Spontaneous Task. * indicates significant between group difference ($p < .05$).
Figure 9. Accuracy (%) of Emotion Expression for Scripted Task. Standard errors are represented in the figure by the error bars attached to each column. * indicates significant between group difference ($p < .05$).
Figure 10. Accuracy for Scripted and Spontaneous expression for ASD and TD participants.

Standard errors are represented in the figure by the error bars attached to each column. * indicates significant difference between tasks.
Appendix A

Experimental Task Conditions*

1. Spontaneous Expression of Emotion: Participants were asked to respond, using a facial expression, to the video model displaying one of the six basic emotions.

Specifically, participants received the following instructions:

“You will now see brief videos of individuals making different facial expressions. After each video, please respond appropriately to the video, as you would if you interacted with the person in real life, using a specific facial expression. In other words, after each video, act as though you were actually interacting with the person in the video, and show this using facial expressions.”

2. Emotion Recognition: Participants were shown pre-recorded videos of adults expressing the 6 basic emotions. After the presentation of each video, they were asked which emotion they saw.

Specifically, after the presentation of video with an actor expressing an emotion, participants saw words for the six basic emotions (anger, fear, sadness, happiness, disgust, and surprise) on the computer screen and they were asked to choose the emotion they saw.

Specifically, the following instructions were provided after each video presentation:

“Please tell the examiner the name of the emotion that best describes the emotion portrayed in the video you just saw”

3. Scripted Condition: Participants were asked to make an expression of a given emotion, without seeing a video.

Specifically, participants sat in front of a black screen and were be asked by the experimenter to express a specific emotion.

Participants received the following instructions:

“Look straight ahead, and please make a (happy) expression. Make a (happy) face.”

Happy was replaced in the instructions with each of the six basic emotions. The order of the emotions was randomized across participants.

* The emotion expression task and scripted condition task were counterbalanced across participants to avoid any ordering effects. All participants were presented with the spontaneous task first.
Appendix B

Demographics Form

**Personal History**

26. Your Child’s Name: ______________________________________________

2. Child’s Age: _________________ 

3. Child’s Date of Birth: ____/____/____

4. Address:

<table>
<thead>
<tr>
<th>Street &amp; Number</th>
<th>City</th>
<th>State</th>
<th>Zip</th>
</tr>
</thead>
</table>

5. Phone number (for parent): ________________________________

6. Email address (for parent) ________________________________

7. Mother’s name: ________________________________

8. Father’s name: ________________________________
Demographics Form

9. Today’s Date: ____/____/____

10. Child’s Gender: ___ M ___ F

11. Your relationship to the child: ________________________________

12. Child’s race and/or ethnicity? (Select all that apply)

  ___ White/Caucasian, non-Hispanic, non-Arab
  ___ Black/African, African-American, non-Hispanic or African, non-Hispanic
  ___ Hispanic/Latino(a)
  ___ American Indian/Alaskan Native
  ___ Arab/Middle Eastern or Arab American
  ___ Asian/Asian-American
  ___ Pacific Islander
  ___ Other (Please specify ______________________)
  ___ I do not wish to provide this information

Biological mother: ___ Stepmother:___ Adoptive Mother:___ Foster Mother:___ Other:____

13. Mother’s Education: ___ Completed 7th grade or less
   ___ Completed some high school
   ___ Graduated from high school
   ___ Graduated from trade school, business school or specialized training program
   ___ Completed an Associate degree
   ___ Graduated from college
   ___ Completed graduate school

Biological father: ____ Stepfather:___ Adoptive Father:__ Foster Father:___ Other:_____

14. Father’s Education: ___ Completed 7th grade or less
   ___ Completed some high school
   ___ Graduated from high school
   ___ Graduated from trade school, business school or specialized training program
   ___ Completed an Associate degree
   ___ Graduated from college
   ___ Completed graduate school

15. How many siblings does your child have? ________________________________
16. Income: What is your estimated gross annual family income?

___ < $20,000  
___ $21,000 - $40,000  
___ $41,000 - $60,000  
___ $61,000 - $80,000  
___ > $81,000

17. If currently in school, what grade is your child you in? _______________ (grade level)

18. Please check any of the following diagnoses that your child has been given:

____ Anxiety Disorder (for example, Social Anxiety Disorder or Generalized Anxiety Disorder)  
____ Obsessive-Compulsive Disorder  
____ Attention-Deficit/Hyperactivity Disorder (ADHD)  
____ Autism Spectrum Disorder  
____ Depression  
____ Bipolar Disorder  
____ Personality Disorder (any type)  
____ Intellectual Disability/Mental Retardation  
____ Learning Disorder  
____ None of the above

19. Has your child ever been treated or received services for social skills or emotional problems?

Yes ____   No ____

Please check which of the following your child participated in, if any.

<table>
<thead>
<tr>
<th>Check if child participated and specify which services the child received</th>
</tr>
</thead>
<tbody>
<tr>
<td>Behavioral Therapy (e.g., ABA, in-home, PECS,…</td>
</tr>
<tr>
<td>Pharmacological/Medication</td>
</tr>
<tr>
<td>Augmentative (equine therapy, special diets, vitamins,…</td>
</tr>
<tr>
<td>Therapy (e.g., for anxiety, CBT,…</td>
</tr>
<tr>
<td>Social Interventions (e.g., group, lunch bunch,…)</td>
</tr>
</tbody>
</table>
20. Does your child have any problems with his/her vision?  Yes___ No___

If yes, please specify_______________________________________________________________

21. Does your child currently wear (Select all that apply)
   ____ Glasses (Type: ________________________________)
   ____ Contacts

22. Has your child ever had any eye surgery?  Yes___ No___

If yes, please specify_______________________________________________________________

23. Does your child show a normal range of facial expressions? (for example, does s/he frown or pout or look embarrassed as well as laugh or cry?  Yes___ No___

If No, please describe __________________________________________________________

   Can s/he look guilty…or surprised…..or amused?  Yes___ No___
   Can you tell by her/his face when s/he is afraid or disgusted?  Yes___ No___
   Does s/he have the same range of facial expressions as other children?  Yes___ No___

24. Does your child’s facial expression usually seem appropriate to the particular situation as far as you can tell?  Yes___ No___

If No, please describe __________________________________________________________

25. Medications: If your child is currently taking any medications, please specify the name of the medication and the following: dosage, time of day the medicine is taken, and reason for medication.

   None ________
   ADHD medications ____________________________________________________________
   Anti-Depressant medications __________________________________________________
   Anti-Anxiety medications _______________________________________________________
   Anti-Seizure medications _______________________________________________________
   Allergy/Asthma medications ___________________________________________________
   Other medications ____________________________________________________________
   Other medications ____________________________________________________________
26. Please put an X for any of the following diagnoses that child’s father, mother, grandparents, or siblings have struggled with:

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>Father</th>
<th>Mother</th>
<th>Grandmother (maternal)</th>
<th>Grandfather (maternal)</th>
<th>Grandmother (paternal)</th>
<th>Grandfather (paternal)</th>
<th>Sibling(s)</th>
</tr>
</thead>
<tbody>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Obsessive-Compulsive Disorder (OCD)</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Attention-Deficit/Hyperactivity Disorder (ADHD)</td>
<td></td>
<td></td>
<td></td>
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<td>Autism Spectrum Disorder (ASD)</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Depression (include post-partum)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Bipolar Disorder</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personality Disorder (any type)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intellectual Disability/Mental Retardation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Learning Disorder</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Other (please specify)</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>
Appendix C

Participant Assent Form

INFORMATION FORM FOR RESEARCH PROJECT
Youth Assent Form

Project Title: *Eye-Gaze Analysis of Facial Emotion Expression in Adolescents with ASD*

Investigators

Principal Investigator:
Susan White, Ph.D., Associate Professor, Psychology Dept., Virginia Tech

Co-Investigator:
Andrea Trubanova, B.A., Graduate Student, Psychology Dept., Virginia Tech
Sherin Aly, M.S., Graduate Student, Computer Engineering, Virginia Tech
Zhao Chen, B.A., Graduate Student, Psychology Dept., Virginia Tech
Lynn Abbott, PhD, Associate Professor, Computer Engineering, Virginia Tech

Purpose of the Study

The purpose of the study is to develop a better understanding of how adolescents with Autism Spectrum Disorder recognize and express facial emotions. If you choose to participate, you will be asked to make different facial expressions such as happy, sad, and angry. You will also see some expression and the investigator will ask you what emotion you are seeing. Approximately 20 adolescents with autism and 20 without autism will participate in this study, which takes approximately an hour and a half to complete for adolescents without autism, and up to two and a half hours to complete for adolescents with autism.

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 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 research session.

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

If you choose to participate in this research study, you will need to come to our lab [at 460 Turner Street] for a 1 hour and 30 minute appointment. At the appointment, you and your parent will first meet with a study investigator to discuss this study and to 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 session.

After providing consent for participation, you will complete two short tasks. In one, the study investigator will ask you to define some words and in the other, you will be asked to find a missing piece from a puzzle. Then, it will be time for data collection, which will be done in front
of a computer. First, you will be asked to sit near a computer screen and observe some videos that appear on the screen. We will ask you to tell us what emotion you see on the screen. Then, we will ask you to make some facial expressions. We are particularly interested in the following set of emotional expressions: happiness, sadness, anger, fear, surprise, and disgust. While you do these tasks, we will record your eye movements with the use of a Tobii eye tracker. We will also record your facial expression using a Kinect system. The system will record a video of your facial expression.

At the end of the session, you will be asked to fill out two questionnaires, which will ask questions about anxiety and emotion. Your parent/caregiver will also fill out several questionnaires about you and your family, and any social concerns.

The data that we collect using the eye tracker and the Kinect will be password protected and will be tied to an ID number instead of your name.

Risks and Benefits

There are no more than minimal risks involved in this study. You might experience discomfort in the knowledge that your facial expressions are being recorded by the Kinect, or that your eye gaze is being recorded by the eye tracker. Furthermore, some of the emotions that you will be asked to express are unpleasant, particularly sadness, anger, fear, and disgust. You will be asked to view videos of people showing these emotions.

You may also be uncomfortable with the fact that researchers will examine images and 3D representations that depict your facial appearance. Researchers may want to show short videos of you to demonstrate research results. The depictions of your face will in no way be used for commercial gain, nor will they be altered in any way that is intended to cause discomfort. You can choose to do this study, and not have your face used in presentations and papers if you would like.

A final risk is related to confidentiality. We have procedures to ensure confidentiality and protection of your personal information (see below) to make sure that your information is safe and secure, 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. However, we hope that results of this project can help in designing future research to benefit other adolescents. No promises or guarantees of benefits have been made to encourage you to participate.

What do I get if I am in this study?

There is no cost to you for participating in this study. You will receive $20 after completing the tasks for your participation.

Confidentiality
All 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.

It is possible that Virginia Tech’s 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.

**Do I have to be in this study?**

You do not have to be 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, read and consider this 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 contact Andrea Trubanova (540-231-2024, atruban@vt.edu) or Dr. Susan White (540-231-6744, vtpilab@gmail.com).

If you should have any questions about the protection of human research participants regarding this study, you may contact Dr. David Moore, Chair of the Virginia Tech Institutional Review Board, and Associate Vice President for Research Compliance, telephone: (540) 231-4991; e-mail: moored@vt.edu or David W. Harrison, PhD, Chair Departmental Institutional Review Board, telephone: (540) 231-4422 ; e-mail: dwh@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 following your participation in this study. There is no guarantee that the listed services will be available to see you and it is your responsibility to pay any fees associated with such services. The Raft Crisis Hotline is free to call. All other services may charge fees for their services.

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

**Center for Family Services**
(703) 538-8470
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 research appointment.

<table>
<thead>
<tr>
<th>Subject Name</th>
<th>Signature</th>
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<tr>
<th>Study Investigator Name</th>
<th>Investigator Signature</th>
<th>Date</th>
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(Optional) In addition to the above, I agree to my face/likeness to be used as an exemplar in scientific publications and presentations. (If I do not sign, then my face/likeness will not be used as an exemplar in such publications and presentations.)

<table>
<thead>
<tr>
<th>Signature of Subject</th>
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<tr>
<th>Investigator Name and Signature</th>
<th>Date</th>
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</table>
(Optional) In addition to the above, I agree to allow my face/likeness to be included in a database that will be distributed for scientific, noncommercial use to researchers outside Virginia Tech. (If I do not sign, then my face/likeness will not be distributed outside Virginia Tech.)

__________________________________________  ____________
Signature of Subject                             Date

__________________________________________  ____________
Investigator Name and Signature                Date
Appendix D

Parent Permission Form

PARENT PERMISSION TO PARTICIPATE IN A RESEARCH PROJECT

SUBJECT INFORMATION AND CONSENT FORM

TITLE: Eye-Gaze Analysis of Facial Emotion Expression in Adolescents with ASD
VT IRB NO: 14-185

Investigators

Principal Investigator:
Susan White, Ph.D., Associate Professor, Psychology Dept., Virginia Tech

Co-Investigator:
Andrea Trubanova, B.A., Graduate Student, Psychology Dept., Virginia Tech
Sherin Aly, M.S., Graduate Student, Computer Engineering, Virginia Tech
Zhao Chen, B.A., Graduate Student, Psychology Dept., Virginia Tech
Lynn Abbott, PhD, Associate Professor, Computer Engineering, Virginia Tech

Purpose of the Study

The purpose of the study is to develop a better understanding of how adolescents with Autism Spectrum Disorder recognize and express facial emotions. If your child participates in the study he/she will be asked to make different facial expressions and identify several emotions. Approximately 20 adolescents with autism and 20 without autism will participate in this study, which takes approximately an hour and a half to complete for adolescents without autism and up to two and a half hours to complete for adolescents with autism.

In order to decide whether or not you wish your son or daughter 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 research session.

Description of the Study and Your Child’s Involvement

If you and your child decide to be in this research study, you will be asked to sign this permission form after you have had all your questions answered and understand what will happen to your child.

If you and your child decide to be in this study, you will need to come to our lab at 460 Turner Street, in Blacksburg, for a 1 hour and 30 minute appointment. At the appointment, you will first meet with a study investigator to discuss this consent form and to 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 session.

After providing consent for participation, your son or daughter will complete two short tasks. In one, the study investigator will ask him/her to define some words and in the other, you child will be asked to find a missing piece from a puzzle. Then, it will be time for data collection, which will be done in front of a computer. First, your child will be asked to sit near a computer screen and observe some videos that appear on the screen. We will ask your child to tell us what emotion he/she sees on the screen. Then, we will ask your child to make some facial expressions. We are particularly interested in the following set of emotional expressions: happiness, sadness, anger, fear, surprise, and disgust. While your child completes these tasks, we will record his/her eye movements with the use of a Tobii eye tracker. We will also record your child’s facial expression using a Kinect system. The system will record your child’s emotion and will also take a video of your child while he/she is making the emotions.

At the end of the session, your child will be asked to fill out two questionnaires, which will ask questions about anxiety and emotion. While your child is completing the tasks described above, you will be asked to fill out several questionnaires, including a Demographics Form with information about your child and your family, and two questionnaires about any social concerns regarding your child.

The data that we collect using the eye tracker and the Kinect will be password protected and will be tied to an ID number instead of your child’s name.

**Risks and Benefits**

There are no more than minimal risks involved in participation in this study. Your child might experience discomfort in the knowledge that his or her facial expressions are being recorded by the Kinect or that his or her eye gaze data is being recorded. Furthermore, some of the emotions that he or she will be asked to express are unpleasant, particularly sadness, anger, fear, and disgust. Your child will be asked to view videos of individuals expressing these emotions.

You or your child may also be uncomfortable with the fact that researchers will examine images and 3D representations that depict your child’s facial appearance. Researchers may want to show short videos of your child to demonstrate research results. The depictions of your child’s face will in no way be used for commercial gain, nor will they be altered in any way that is intended to cause discomfort. Your child can choose to do this study without having his or her face used in presentations and papers.

A final 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 or your child 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 to benefit adolescents with Autism Spectrum Disorder.

Costs and Payment for Participation

There is no cost to you for participating in this study, aside from the time and transportation that are involved. Your child will receive $20 for his/her participation in the study after the completion of the tasks.

Confidentiality

All 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.

It is possible that Virginia Tech’s Institutional Review Board (IRB) may view this study’s collected data for auditing purposes. The IRB is responsible for the oversight of the protection of human subjects involved in research. These individuals are required to keep all information confidential.

Freedom to Withdraw

Your child does not have to participate in this study. If your child does participate, he or she can stop at any time and without penalty. 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 contact Andrea Trubanova (540-231-2024, atruban@vt.edu) or Dr. Susan White (540-231-6744, vtpilab@gmail.com).

If you should have any questions about the protection of human research participants regarding this study, you may contact Dr. David Moore, Chair of the Virginia Tech Institutional Review Board, and Associate Vice President for Research Compliance, telephone: (540) 231-4991; e-mail: moored@vt.edu or David W. Harrison, PhD, Chair Departmental Institutional Review Board, telephone: (540) 231-4422 ; e-mail: dwh@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 following your participation in this study. There is no guarantee that the listed services will be available to see you and it is your responsibility to pay any fees associated with such services. Cook Counseling Center provides services free of charge to Virginia Tech students who have paid their student health fees. The Raft Crisis Hotline is free to call. All other services may charge fees for their services.

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

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

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

**Mental Health Association of the New River Valley**  
(540) 951-4990; (800) 559-2800  

**New River Valley Community Services**  
(540) 961-8400  

**VT Psychological Services Center**  
(540) 231-6914  
[http://www.psyc.vt.edu/centers/psc/](http://www.psyc.vt.edu/centers/psc/)
PERMISSION
I have read this Consent Form and conditions of this project. I have had all my questions answered. My signature says that I am willing for my child to participate in this study. I hereby acknowledge the above and give my voluntary consent for data involving my child’s face/likeness to be collected and used by Virginia Tech researchers.

Name of Child

Name of Parent or Legal Guardian

Relationship to Child

Signature of Parent/Guardian

Date

(Optional) In addition to the above, I agree to allow my child’s face/likeness to be used as an exemplar in scientific publications and presentations. (If I do not sign, then my child’s face/likeness will not be used as an exemplar in such publications and presentations.)

Signature of Parent/Guardian

Date

Investigator Name and Signature

Date

(Optional) In addition to the above, I agree to allow my child’s face/likeness to be included in a database that will be distributed for scientific, noncommercial use to researchers outside Virginia Tech. (If I do not sign, then my child’s face/likeness will not be distributed outside Virginia Tech.)

Signature of Parent/Guardian

Date

Investigator Name and Signature

Date
(Optional) 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 Andrea Trubanova or Dr. Susan White and the Virginia Polytechnic Institute and State University.

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

________________________________________  _____________
Signature of Parent/Guardian            Date