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

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Impaired emotion recognition and expression in individuals with autism spectrum disorder (ASD) may contribute to observed social impairment. The aim of this study was to examine the role of visual attention directed toward nonsocial aspects of a scene as a possible mechanism underlying recognition and expressive ability deficiency in ASD. One recognition and two expression tasks were administered. Recognition was assessed in force-choice paradigm, and expression was assessed during scripted and free-choice response (in response to emotional stimuli) tasks in youth with ASD (n = 20) and an age-matched sample of typically developing youth (n = 20). During stimulus presentation prior to response in each task, participants' eye gaze was tracked. Youth with ASD were less accurate at identifying disgust and sadness in the recognition task. They fixated less to the eye region of stimuli showing surprise. A group difference was found during the free-choice response task, such that those with ASD expressed emotion less clearly but not during the scripted task. Results suggest altered eye gaze to the mouth region but not the eye region as a candidate mechanism for decreased ability to recognize or express emotion. Findings inform our understanding of the association between social attention and emotion recognition and expression deficits.

Facial emotion recognition and emotion expression are separate, but highly related, constructs (Insel & Cuthbert, 2009). Several studies show that difficulty in either recognition or expression greatly affects the quality of social interactions, including nonverbal communication (Nuske, Vivanti, & Dissanayake, 2013). Emotion recognition and expression in individuals with autism spectrum disorder (ASD) are often impaired in the natural environment, even if impairments are not consistently apparent in laboratory paradigms, which for the most part use static, intense, or artificial stimuli. Altered eye-gaze patterns to facial emotions may underlie this shared deficit across both emotion recognition and expression. If altered gaze patterns are mechanistically related to these impairments, then altered, or pathological, social visual attention could be targeted in prevention and intervention efforts.

Nonverbal emotion expression and recognition are fundamental for successful social interactions. The ability to discriminate certain expressions typically develops early on in childhood. At 3 months of age, humans are able to distinguish happy, sad, and surprised emotions from static, nonverbal cues alone (Young-Browne, Rosenfeld, & Horowitz, 1977) and, by 7 months, babies can discriminate dynamic happy and angry faces (Soken & Pick, 1992). By 4 years of age, typically developing (TD) children can accurately verbally label most basic emotions (Widen & Russell, 2003). Although emotion recognition develops early in childhood, young children with ASD experience more difficulty with recognition of certain expressions compared to their TD peers (Rump, Giovannelli, Minshew, & Strauss, 2009). By 10 years of age, children with ASD perform more poorly than TD peers on tasks involving labeling of basic expressions (Lindner & Rosén, 2006; Tantam, Monaghan, Nicholson, & Stirling, 1989). Most studies show that from 12 years of age through adulthood, individuals with ASD do not show impairment in recognition of basic, prototypical emotions (Capps, Yirmiya, & Sigman, 1992; Grossman, Klin, Carter, & Volkmar, 2000); however, difficulty rises when stimuli are subtle or presented briefly and emotions are complex (Humphreys, Minshew, Leonard, & Behrmann, 2007). Unfortunately, emotional expressions in the natural environment are often brief, complex, and subtle rather than static and intense.

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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. Although 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, Kasari, Sigman, & Mundy, 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) found that children, adolescents, and young adults with ASD showed difficulty with both imitation and instructed expression of facial emotion communication. Specifically, they found that individuals with ASD had much more difficulty in the expression of emotion compared to individuals with Down syndrome, and they produced odd and mechanical expressions. This atypical nonverbal emotion expression in individuals with ASD makes social communication challenging, regardless of intact verbal abilities.

As children with ASD grow into adolescents, they become increasingly more impaired relative to their TD peers (Klin et al., 2007). Adolescents with ASD face substantial social interaction challenges. A large part of this challenge may stem from difficulty with emotion recognition and expression. 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).

Although many studies have investigated facial emotion recognition and emotion expression deficits in individuals with ASD separately, the extant research has 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 and adolescents with ASD have been found to smile less often and to lack self-conscious affect compared to TD peers (Dawson & McKissick, 1984; Mundy & Sigman, 1989; Neumann & Hill, 1978; Spiker & Ricks, 1984). Even though these deficits in emotion expression have been well documented, further studies are needed to explore the mechanism(s) 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 plays in these observed deficits. Understanding the nature of observed recognition and expression deficits can inform evaluation and treatment. 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.

Eye-tracking technology has been employed in many studies evaluating differences in visual attention processes of individuals with ASD compared to individuals without. Collectively, the results across studies are inconsistent. In a review of eye-tracking studies in ASD, Guillon and colleagues (2014) found that, although the majority of the extant research indicates decreased visual attention to social stimuli in individuals with ASD, the results do not generalize across contexts, as including several people interacting, for example, increases the likelihood of decreased attention to faces. In addition, they found little support for robustness of excess mouth and diminished eye-gaze pattern across age range. Several studies, however, show that, although TD 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 nonsocial objects in the scene (e.g., Dalton et al., 2005; Klin, Jones, Schultz, Volkmar, & Cohen, 2002; Senju & Johnson, 2009). Pelphrey and colleagues (2002), in an investigation of gaze differences between adults with ASD and typical adults who were specifically instructed to identify the emotions portrayed in the face stimuli, found that, relative to controls, 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 research on emotion perception and recognition. Socially directed gaze augments processing of social cues, because information derived from facial cues is necessary to successfully recognize and be able to express the presented emotion. As such, diminished gaze to socially salient cues may contribute to impaired recognition and expression of nonverbal emotion. Due to the shown effects of anxiety and alexithymia on eye gaze and emotion recognition and expression (e.g., Hill, Berthoz, & Frith, 2004; Horley, Williams, Gonsalvez, & Gordon, 2003; White, Maddox, & Panneton, 2015), research looking at eye-gaze patterns during emotion recognition and expression tasks should account for these co-occurring disorders.

The purpose of this study was to examine the role of eye gaze as a possible mechanism underlying deficits in emotion recognition and emotion expression in adolescents with ASD. Specifically, we explored whether difficulties in emotion recognition and expression might be related to the difference in the way adolescents with ASD view social stimuli, especially emotions. Combining the coding of adolescents' expression of emotion with the eye-tracking technology allows exploration of atypical visual processing as a possible mechanism underlying emotion expression deficits. The paradigm, which uses three tasks, allows for an in-depth analysis to determine the degree to which emotion expression difficulties are related to the inability to show the target emotion or impaired ability to show emotion when clear prompt of what to do is absent. It was hypothesized that adolescents with ASD would show less cumulative gaze to the eye region of facial stimuli compared to TD adolescents (Hypothesis 1). Given prior research identifying the eye region as particularly important for facial emotion recognition among adults with ASD (e.g., Baron-Cohen, Wheelwright, & Jolliffe, 1997), it was hypothesized that for the adolescents with ASD, greater fixation duration to the eye region would predict accuracy of identified and expressed emotion (Hypothesis 2). The second aim of the study was to investigate differences in ability to express emotion within a scripted, structured task in which the youth was instructed to make a specific facial expression, compared to a more free-choice response expression in response to viewing an expression, without a labeled emotion. It was hypothesized that adolescents with ASD would be less likely to express the intended emotion compared to the TD peers on both emotion expression tasks (Hypothesis 3), given prior research highlighting difficulties of adolescents with ASD in expression of emotion (e.g., Loveland et al., 1994). In addition, it was hypothesized that the adolescents with ASD would be more accurate in expressing emotions in the scripted condition compared to mirroring the expressed emotion in the free-choice response condition (Hypothesis 4), given that recognition of the portrayed emotion, which is often impaired in individuals with ASD, was required in the free-choice response condition but not in the scripted condition.

METHOD

Participants

Participants were adolescents 12 to 17 years of age. TD adolescents (n = 20) were used as a comparison group, matched on age to a group of 20 adolescents with ASD. To attain a small effect size, as was established by other eye-tracking studies using dynamic stimuli with adolescents with ASD (e.g., Freeth, Chapman, Ropar, & Mitchell, 2010), a target sample of 60 per group would be needed, as established based on an a priori power analysis to detect within-group difference using G*Power software (Faul, Erdfelder, Lang, & Buchner, 2007). Because this sample size was not feasible to obtain, we based the a priori target sample to detect a medium effect size. A target sample of 20 individuals per group was established to be needed to detect within-group differences (.70 power to detect a medium effect size). 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 current psychopathology (i.e., mood or anxiety disorder, attention deficit hyperactivity disorder, personality disorder) or with an immediate family member diagnosed with ASD was excluded. TD participants were recruited through flyers in the community and existing research registry databases. Adolescents with ASD were recruited through 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 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

ADOS-2 (Lord et al., 2012)

The ADOS-2 is a semistructured 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.

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. Derived internal consistency for the current sample was high for parents (α = .952) and adolescents (α = .909).

Social Responsiveness Scale, Second Edition, Parent Version (SRS-2; Constantino & Gruber, 2012)

The SRS-2 comprises 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. Derived internal consistency for the current sample was high (α = .898).

Toronto Alexithymia Scale for Children (TAS-C; Rieffe, Oosterveld, & Meerum Terwogt, 2006)

TAS-C is a self-report scale adapted from the 20-item Toronto Alexithymia Scale developed for adults (TAS-20; Bagby, Parker, & Taylor, 1994). The TAS-C comprises 20 items measuring difficulties with understanding, processing, or describing emotions in children. Although the 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., Bird, Press, & Richardson, 2011; Hill et al., 2004). Results from Rieffe et al. (2006) demonstrate that although the Externally-Oriented Thinking factor showed low factor loadings and low reliability, the study demonstrated usefulness of the Difficulty Identifying Feelings and Difficulty Describing Feelings factors of the TAS-C for identification of alexithymia in children. The study found that the three-factor model is an acceptable representation of the alexithymia questionnaire for children. In the present sample, the internal consistency on the TAS-C was acceptable ($\alpha = .718$).

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. Four-subtest and two-subtest WASI-2 scores correlate between .91 to .95 for children ages 12 to 17 (Wechsler, 2011).

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 (1920 × 1200 pixels screen resolution), and they were instructed to look at the video stimuli on the screen. Each stimulus video was 38 cm long × 20 cm wide, subtending 35° visual angle, with a black border around the video. Prior to each stimulus display, a centered X (1.5 × 1.5 cm wide) appeared on the screen for 1 s 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 5-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 1 min.

Stimuli

Stimuli were comprised of short videos (2.73 s) of young male and female adults expressing one of six basic emotions (happiness, sadness, fear, anger, surprise, or disgust). The videos were taken from the VT-KFER data set (Aly, Trubanova, Abbott, White, & Youssef, 2015). 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 (recognition and free-choice response 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 anger.

Procedures

Every participant completed one session, lasting approximately 2.0 hr. After providing consent, participants completed a computerized battery of tasks to assess emotion recognition and emotion expression, both scripted and free-choice response. In the first condition (free-choice response expression task), participants were seated in front of the monitor and were shown prerecorded videos of adults expressing the six basic emotions (happiness, sadness, fear, anger, surprise, and disgust). Each expression was presented six times, for a total of 36 stimuli videos presented randomly. 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."). Given these instructions and based on prior research indicating that people typically match the expression of person being observed (e.g., McIntosh, Reichmann-Decker, Winkielman, & Wilbarger,

FIGURE 1 A single frame from a sample stimulus video of a female actor expressing anger.

2006; Moody, McIntosh, Mann, & Weisser, 2007), it was assumed that the participants would show a similar expression to what was being shown. Prior studies utilizing dynamic stimuli have shown that mimicry is the more common response, rather than the complementary expression, in the nonclinical adult population (e.g., Hess & Blairy, 2001). However, the exact response was not known, as participants were not specifically asked to imitate the emotion. In the second condition (emotion recognition task), after the presentation of each video participants were asked to tell the examiner which emotion they saw (Instruction: "Please tell the examiner the name of the emotion that best describes the emotion portrayed in the video you just saw"). After each stimulus presentation the participants were provided with options of all seven emotions. 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."). The second and third conditions were counterbalanced to account for order effects. The free-choice response 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 min.

After the computer tasks, participants were administered the WASI-2 and ADOS-2, and at the end they completed the questionnaires (i.e., TAS-C, SCARED). While the child was completing the computerized tasks and the other assessment measures, their parent or caregiver completed the demographic form and all measures (i.e., SRS-2, SCARED).

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). All data were entered and verified by two trained research 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 research assistants coded the emotion expressed (e.g., anger, disgust), as well as the quality of the expression rated. Both coders were masked as to what emotion the participant was asked to express (scripted) or shown (free-choice response). Twenty-five percent of all collected expressions, for both tasks, were co-coded by the other undergraduate assistant. Cohen's κ was run to determine rater agreement on judgments on what emotion the participant portrayed. There was excellent agreement between the two raters' judgements, $\kappa = .926$, 95% confidence interval [.88, .97], $p < .01$, for the scripted condition, and substantial agreement, $\kappa = .742$, 95% confidence interval [.69, .79], $p < .01$, for the free-choice response condition.

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. As noted above, social anxiety symptoms and alexithymia are important to account for due to prior research emphasizing the high comorbidity of these disorders with ASD and the effects of anxiety and alexithymia on eye gaze and emotion recognition and expression (e.g., Hill et al., 2004; Horley et al., 2003). Any significant effects from these preliminary analyses would have been included as covariates in the primary analyses.

Eye-Tracking Data Analyses

Participant's eye-gaze patterns and fixations, tracked during stimulus presentation for each task, were collected through the Tobii studio and analyzed using a Matlab code (MatlabR2014b, Mathworks Inc., MA). 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 ms. 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 areas of interest (AOIs), including the face, eye region, and mouth region, were predefined using the oval-shaped AOI tool and background region was predefined using a rectangle-shaped AOI tool, available in the Tobii T60 (Studio Professional) platform, for each stimulus by the principal investigator. The background region was defined as the entire screen picture minus the other predefined regions. Figure 2 displays a sample image from a video with AOIs for face, mouth, and eyes. The duration of fixations made to these regions was calculated using inhouse Matlab code.

Statistical Hypothesis-Testing

Preliminary analyses were conducted to examine if eye-gaze patterns and accuracy of emotion expression

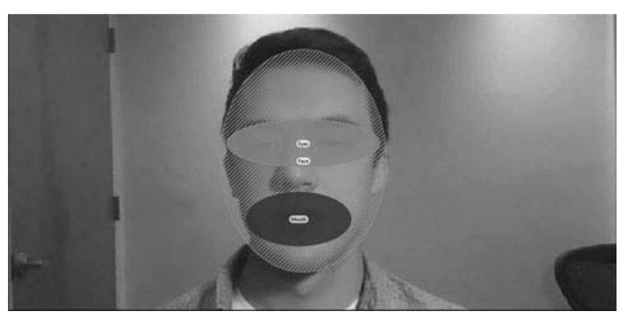

FIGURE 2 Areas of Interest for face, eyes, and mouth for a sample image from a video stimuli.

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 TD adolescents, we used linear-mixed model with maximum likelihood estimation. This approach allows for handling of data that are missing at random and takes into account the nonindependence of observations within the participant (McCulloch, Searle, & Neuhaus, 2008). Group (TD vs. ASD) and emotion type were tested as fixed factors, participant as a random factor, and fixation duration on AOI as dependent variable. This was completed independently for both the emotion recognition and free-choice response emotion expression conditions. To test the second hypothesis, that fixation duration to the eye region predicts accuracy in emotion recognition and expression within the ASD group, a linear-mixed model 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 analysis of variance (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 added to the analysis using ANOVA to explore interactions between the groups per different emotion stimuli. Last, to investigate possible differences in ability of adolescents with ASD to express the emotion between a free-choice response 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. 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, $t(38) = -1.69$, $p = .10$; sex composition, $\chi^2(1) = 2.56$, $p = .20$; or race, $\chi^2(2) = 1.33$, $p = .51$. There was group difference in IQ, $t(38) = 3.19$, $p < .01$. Given lack of prior research suggesting that IQ, aside from intellectual disability, might affect social gaze or facial emotion recognition, and our small sample size, the presented analyses do not include IQ as a covariate. Group descriptive statistics were also computed for all questionnaires. 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-2 received an ASD diagnosis from a comprehensive clinical evaluation completed by the study investigator prior to the present study, which included an Autism Diagnostic Interview–Revised (Lord, Rutter, & Le Couteur, 1994), in addition to parent and child questionnaires.

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 free-choice response task and $t(38) = -.60$, $p = .55$, for recognition task, indicating that the two groups did not differ on the amount of data collected. In addition, there did not appear to be any within group attrition, as the data lost were not related to participant actions (i.e., concentration or hyperactivity) but were instead tied to system failure. 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, Koldewyn, Jiang, & Kanwisher, 2014; Swanson, Serlin, & Siller, 2013), due to technical difficulties. For the recognition task, only seven TD participants and 10 ASD participants met the 50% cutoff. For the free-choice response task, eight of the 20 TD participants and nine of the 20 ASD participants met the cutoff. Given the variable on-task percentages across the entire task, 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. Twelve of 20 TD participants and 14 of 20 ASD participants showed on-task percentage scores above 50% for at least one stimulus during a recognition task. For the free-choice response task, 16 of 20 TD participants and 14 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 free-choice response task. Therefore, data loss was determined to be random and not systematic based on group.

TABLE 1
Demographic Characteristics

	ASD[a]		TD[a]	
	M (SD)	*Range*	*M* (SD)	*Range*
Age (in Years)	14.65 (1.79)	12–17	13.75 (1.59)	12–17
FSIQ-2[b,]*	94.90 (16.11)	70–120	109.65 (12.95)	84–129
SRS-2[b,]*	73.40 (11.41)	44–89	43.65 (4.61)	38–56
TAS-C[c] (Child)				
Total Score	16.10 (6.24)	7–27	14.60 (5.22)	7–26
Difficulty Identifying Feelings	4.45 (3.72)	0–12	2.60 (2.66)	0–9
Difficulty Describing Feelings	4.25 (1.83)	2–8	3.75 (2.29)	0–8
Externally-Oriented Thinking	7.40 (2.26)	4–11	8.25 (2.34)	4–13
SCARED[d] (Parent)				
Total Score*	23.40 (14.43)	2–52	9.40 (9.58)	0–29
Panic Disorder*	3.95 (4.58)	0–11	0.90 (1.07)	0–3
GAD*	8.10 (4.58)	2–17	3.20 (3.86)	0–11
Separation Anxiety*	3.20 (3.32)	0–10	0.50 (1.05)	0–4
Social Anxiety	6.40 (3.87)	0–14	4.55 (4.49)	0–14
School Avoidance*	1.75 (2.02)	0–7	0.25 (0.44)	0–1
SCARED[d] (Child)				
Total Score	22.15 (13.74)	0–49	21.20 (10.01)	7–47
Panic Disorder	3.95 (4.15)	0–15	4.30 (3.81)	0–17
GAD	6.65 (4.48)	0–15	6.45 (4.01)	0–16
Separation Anxiety	3.85 (3.53)	0–10	2.80 (1.91)	0–6
Social Anxiety	5.80 (3.82)	0–12	6.70 (3.28)	0–13
School Avoidance	1.90 (1.89)	0–5	0.95 (0.10)	0–4

	ASD n *(% of Total)*	*TD* n *(% of Total)*	χ^2(p)
Gender			2.56 (.20)
Male	14 (70.00)	9 (45.00)	
Female	6 (30.00)	11 (55.00)	
Race			1.33 (.51)
Caucasian	18 (90.00)	18 (90.00)	
Non-Caucasian	2 (10.00)	2 (10.00)	
Asian American	1 (5.00)	2 (10.00)	
African American	1 (5.00)	0 (0.00)	
Diagnoses[e]			
Asperger's	4 (20.00)		
Autism	16 (80.00)		
Anxiety	8 (40.00)		
OCD	3 (15.00)		
ADHD	12 (60.00)		
Depression	4 (20.00)		
ID/LD	5 (25.00)		

Note: Significant between-group differences are indicated (*$p < .01$). SRS-2 = Social Responsiveness Scale, Second Edition, parent version; ID = intellectual disability; LD = learning disability.

[a]*n* = 20.

[b]Full-Scale IQ–2 (FSIQ-2): IQ based on two subtests of the Wechsler Abbreviated Scale of Intelligence.

[c]Toronto Alexithymia Scale for Children (TAS-C): a self-report. Three factors—Difficulty Identifying Feelings, difficulty describing feeling, and Externally-Oriented Thinking—make up the total score.

[d]Screen for Child Anxiety Related Disorders (SCARED), child and parent version. Five scales make up the total anxiety: Panic/Somatic, Generalized Anxiety (GAD), Separation Anxiety, Social Anxiety, and School Avoidance.

[e]Based on parent report of adolescent's current diagnoses.

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, d = 1.02) and sadness (t = 3.54, p = .002, d = 1.13). As shown in Figure 3, there was no significant difference in accuracy of emotion recognition for any of the other emotions (all ts < 1.46, all ps > .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 faces' eye region compared to TD adolescents, there was not a significant between group difference, $F(1, 24.52) = 0.67$, $p = .42$, R^2 = 0.03. 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, $F(5, 472.54) = 1.66$, $p = .14$, $R^2 = 0.02$, on fixation duration to the eye region and no significant interaction effect between group and emotion type, $F(5, 472.54) = 1.59$, $p = .16$, $R^2 = 0.03$. There was also a nonsignificant effect for participants with ASD to spend less time looking at the eye region of stimuli expressing surprise compared to the TD participants, $F(1, 20.41) = 3.93$, $p = .06$, $R^2 = 0.09$. Table 2 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, $F(5, 411.95) = 2.25$, $p = .049$, $R^2 = 0.05$. Results from the linear mixed-model suggest no group difference in fixation duration to mouth region across emotions, $F(1, 22.47) = .87$, $p = .36$, $R^2 = 0.04$. However, there is a significant effect of emotion type on fixation to mouth region, $F(5, 411.95) = 4.02$, $p = .001$, $R^2 = 0.05$. 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, $F(1, 18) = 4.93$, $p = .04$, $R^2 = 0.12$.

An opposite pattern was observed for the free-choice response task, in which the participant was asked to respond to the video with a facial expression but not told the emotion. Although there was not a significant group difference across emotions, $F(1, 26.21) = 0.91$, $p = .35$, $R^2 = 0.03$, in gaze duration to the eye region, there was a significant effect of emotion, $F(5, 465.99) = 5.81$, $p < .01$, $R^2 = 0.04$, and a significant interaction effect between group and emotion type, $F(5, 465.99) = 2.74$, $p = .02$, $R^2 = 0.06$, for fixation duration to the eye region.[1] Figure 5 displays the gaze

TABLE 2
Group Difference in Eye Gaze Duration by Emotion Type for the Recognition Task

	ASD: M (SE)	*TD: M (SE)*	*Between-Group* t *Value (Sig.)*
Anger	852.20 ms (139.38)	1108.72 ms (148.89)	1.25 (.23)
Disgust	776.84 ms (143.62)	810.78 ms (153.63)	0.79 (.44)
Fear	785.16 ms (141.72)	935.14 ms (148.90)	1.78 (.07)
Happy	933.13 ms (142.37)	897.92 ms (150.27)	−0.04 (.97)
Sad	870.62 ms (142.56)	1035.38 ms (153.99)	0.85 (.40)
Surprise	730.01 ms (143.40)	1054.03 ms (151.34)	1.98 (.06)

Note: ASD = autism spectrum disorder; TD = typically developing.

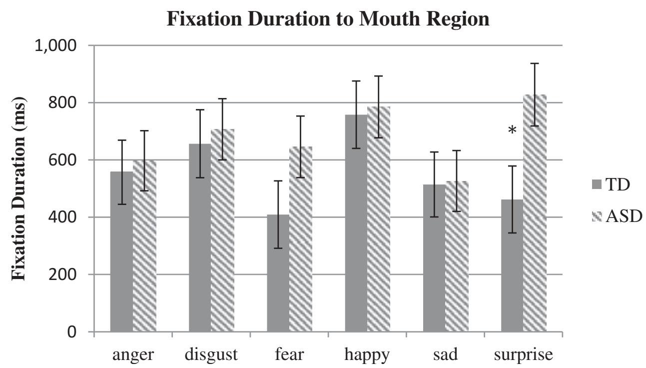

FIGURE 4 Fixation duration (ms) to the mouth region per emotion type for recognition task. *Note*: Standard errors are represented in the figure by the error bars attached to each column. An asterisk indicates significant between group difference (p < .05). TD = typically developing; ASD = autism spectrum disorder.

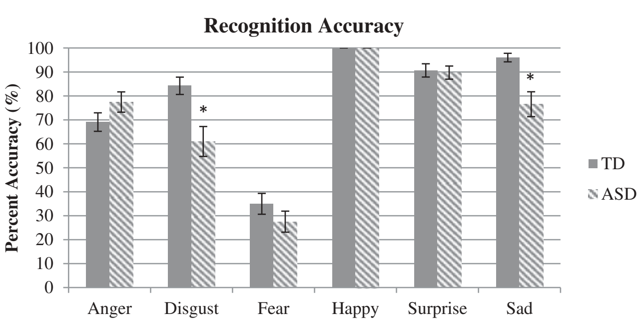

FIGURE 3 Accuracy (%) of emotion recognition per emotion type. *Note*: Standard errors are represented in the figure by the error bars attached to each column. An asterisk indicates significant between group difference (p < .05). TD = typically developing; ASD = autism spectrum disorder.

[1]All results comparing TD and ASD participants remain unchanged when IQ was added as a covariate, aside from the interaction effect between group and emotion type on fixation to eye region for free-choice response task. This interaction effect is no longer significant when IQ is added as a covariate.

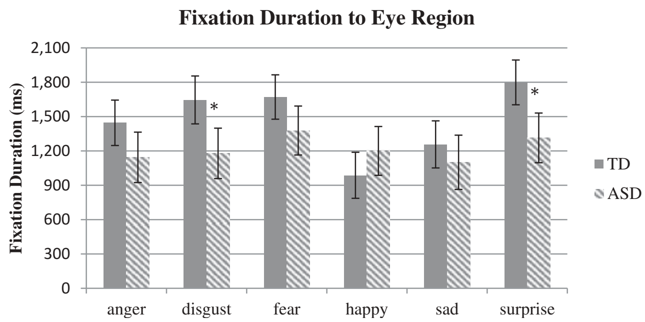

FIGURE 5 Fixation duration (ms) to the eye region per emotion type for free-choice response task. *Note*: Standard errors are represented in the figure by the error bars attached to each column. An asterisk indicates significant between group difference ($p < .05$). TD = typically developing; ASD = autism spectrum disorder.

TABLE 3
Group Difference in Gaze Duration to Mouth Region for the Free-Choice Response Task

	ASD: M (SE)	*TD: M (SE)*	*Between-Group* t *Value (Sig.)*
Anger	855.77 ms (138.22)	750.74 ms (125.28)	−0.36 (.72)
Disgust	616.77 ms (148.13)	589.25 ms (146.59)	0.07 (.94)
Fear	845.11 ms (137.47)	570.23 ms (128.45)	−1.80 (.09)
Happy	902.90 ms (134.36)	1026.02 ms (123.84)	0.54 (.60)
Sad	849.65 ms (155.23)	723.13 ms (127.97)	−0.88 (0.39)
Surprise	475.91 ms (131.74)	494.83 ms (136.87)	0.03 (.98)

Note: ASD = autism spectrum disorder; TD = typically developing.

duration to the eye region per emotion type for the free-choice response 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. There was not a significant effect of group on fixation duration to mouth region across emotions, $F(1, 26.32) = .20$, $p = .66$, $R^2 = 0.02$. There was also no significant interaction effect of group and emotion type, $F(5, 332.74) = 1.13$, $p = .34$, $R^2 = 0.08$. Table 3 displays the average gaze duration to the mouth region per emotion type.

Eye Gaze Predicting Accuracy (Hypothesis 2)

Inconsistent with what was hypothesized, greater fixation duration to the eye region did not predict accuracy of emotion recognition or expression for the teens with ASD. In the recognition task, there was no significant effect of fixation duration to the eye region for recognition accuracy, $F(1, 263.00) = .21$, $p = .65$, $R^2 = 0.02$, and taking into account emotion type, there was not a significant interaction effect of fixation duration and emotion type on accuracy, $F(5, 263.00) = 1.03$, $p = .40$, $R^2 = 0.29$. Similarly, fixation duration to the eye region did not predict degree to which emotion shown was mirrored by the participant during the free-choice response task, $F(1, 217.85) = .08$, $p = .77$, $R^2 = 0.02$, nor was there an interaction between fixation duration and emotion type, $F(5, 211.00) = 1.60$, $p = .16$, $R^2 = 0.07$.

However, there were significant effects of fixation duration to the mouth region on both recognition and expression accuracy. For the recognition task, there was a significant effect of fixation duration to mouth region on accuracy, $F(1, 233.00) = 3.98$, $p = .047$, $R^2 = 0.04$, and a significant direct effect of emotion on accuracy, $F(5, 233.00) = 6.56$, $p < .01$, $R^2 = 0.24$. 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 significantly higher accuracy for happy compared to disgust. Figure 6 displays the fixation duration for those stimuli that were correctly versus incorrectly identified by the participants with ASD.[2] As can be seen, for sadness, when correctly identified, individuals with ASD spent significantly more time fixating on the mouth region, compared to when sadness was misidentified. 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 free-choice response expression task, the effect of fixation duration to the mouth region on degree to which participants mirrored the emotion shown was not significant, $F(1, 149.24) = 1.89$, $p = .17$, $R^2 = 0.02$. However, there was a significant interaction effect of fixation duration and emotion

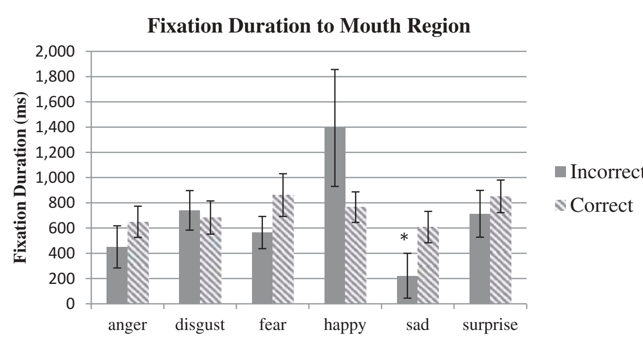

FIGURE 6 Fixation duration to the mouth region per accuracy for recognition task. *Note*: Standard errors are represented in the figure by the error bars attached to each column. An asterisk indicates significant difference between responses ($p < .05$).

[2] 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.

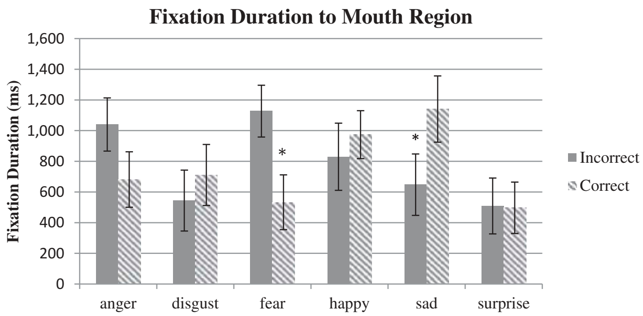

FIGURE 7 Fixation duration (ms) to the mouth region per accuracy for free-choice response task. *Note*: Standard errors are represented in the figure by the error bars attached to each column. An asterisk indicates significant between group difference ($p < .05$).

type on mirroring the target expression, $F(5, 142.03) = 6.21$, $p < .01$, $R^2 = 0.40$. As can be seen in Figure 7, a similar pattern emerges for the sad facial stimuli with more gaze toward the mouth region for correctly mirrored compared to incorrectly mirrored expressions. In addition, for the fear stimuli, individuals with ASD showed higher fixation to the mouth region when they did not mirror the emotion.

Group Comparisons of Emotion Expression (Hypothesis 3)

The third hypothesis, that the adolescents with ASD would be less accurate in emotion expression in scripted condition and show lesser degree to which they mirror the emotion shown in the free-choice response task compared to the TD adolescents, was partially supported. Participants with ASD were less likely to mirror the presented emotion compared to the TD group in the free-choice response expression task. A one-way ANOVA revealed a main effect of group, $F(1, 35) = 6.38$, $p = .02$, $d = 0.85$. However, there was no group difference in the ability to express the intended emotions during the scripted expression task, $F(1, 37) = 1.73$, $p = .20$, $d = 0.42$.

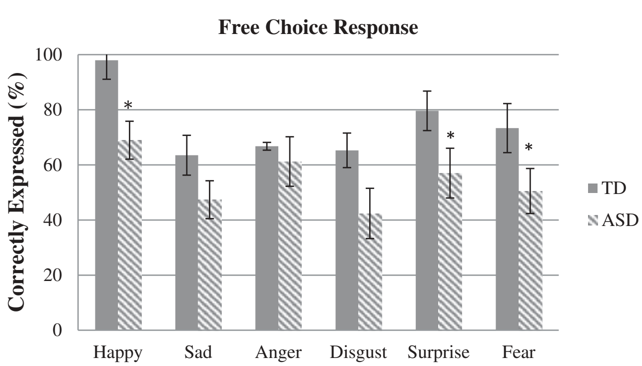

FIGURE 8 Accuracy (%) of emotion expression for free-choice response task. An asterisk indicates significant between group difference ($p < .05$). TD = typically developing; ASD = autism spectrum disorder.

Figure 8 displays the degree to which emotion shown was mirrored by emotion type for the free-choice response task. Exploratory analyses revealed a significant main effect of emotion, $F(5, 210) = 4.03$, $p = .002$, $d = 0.62$, but no Emotion × Group interaction effect, $F(5, 210) = .57$, $p = .72$, $d = 0.23$. Pairwise comparisons with Bonferroni correction (adjusted alpha level of 0.01) revealed that the degree to which participants mirrored the emotion shown 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 ($M = 83.06\%$, $SD = 31.61$), $p = .004$, $d = 0.28$ and $p = .002$, $d = –0.30$, 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, $F(5, 220) = 3.50$, $p = .005$, $d = 0.57$, but no main effect of group, $F(1, 220) = 2.24$, $p = .14$, $d = 0.42$, or interaction effect of group by emotion, $F(5, 220) = 1.28$, $p = .27$, $d = 0.34$. 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 ($M = 100\%$, $SD = 0.0$), $p = .001$, $d = –0.308$. Regarding group differences, participants with ASD were significantly less accurate in their expression of surprise only in the scripted expression ($t = 2.19$, $p = .04$, $d = .71$).

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 degree they mirrored the emotion

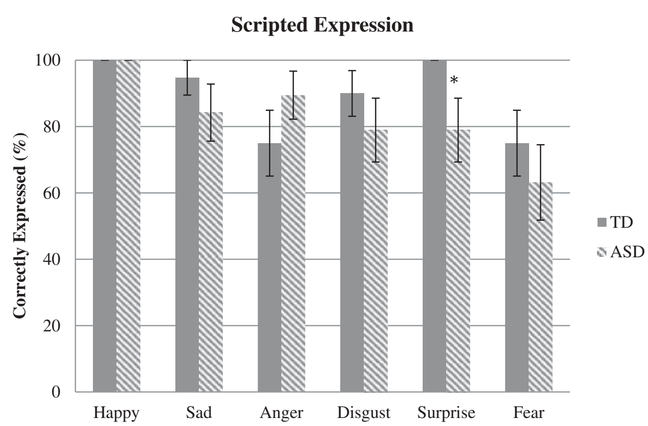

FIGURE 9 Accuracy (%) of emotion expression for scripted task. *Note*: Standard errors are represented in the figure by the error bars attached to each column. An asterisk indicates significant between group difference ($p < .05$). TD = typically developing; ASD = autism spectrum disorder.

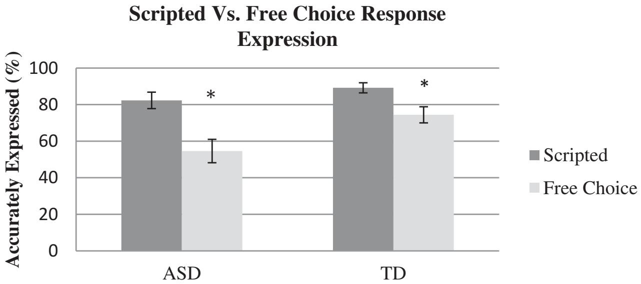

FIGURE 10 Accuracy for scripted and free-choice response expression for ASD and TD participants. *Note*: Standard errors are represented in the figure by the error bars attached to each column. An asterisk indicates significant difference between tasks. ASD = autism spectrum disorder; TD = typically developing.

shown in the free-choice response condition, "accuracy percentage" (i.e., mirroring the intended emotion expression) for the free-choice response 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 free-choice response presentations (M = 54.58%, SD = 27.94), $t(18) = 4.20$, $p < .01$, $dz = 0.96$, as was hypothesized.

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 free-choice response presentations (M = 74.41%, SD = 18.63), $t(17) = 3.72$, $p < .01$, $dz = 0.85$), similar to the pattern seen for adolescents with ASD.

DISCUSSION

This study sought to examine the possible role of visual attention (gaze) toward emotional stimuli on accuracy of facial emotion recognition and expression. In general, participants with ASD were significantly less accurate in identifying disgust and sadness as portrayed by others, a finding that is consistent with prior research suggesting deficits for recognition, especially of negative emotions (e.g., Ashwin, Chapman, Colle, & Baron-Cohen, 2006; Evers, Steyaert, Noens, & Wagemans, 2015; and see review: Harms, Martin, & Wallace, 2010).

Results 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, although 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, relative to TD adolescents. Although other studies have noted differences in results based on task stimuli, this study highlights the importance of task instructions, given that the stimuli (e.g., content, duration) and experimental setup were consistent across the two tasks. The results across the two tasks also 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.

Although 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 stimuli videos, adolescents with ASD more accurately identified and expressed the sad emotion when they spent more time looking at the mouth region, suggesting that the mouth region is especially important in distinguishing sadness from other emotions and in mirroring sadness back to others. These results appear to contradict prior work indicating greater importance of eyes compared to the mouth in identification of emotions (e.g., Baron-Cohen et al., 1997). However, it is possible that the mouth region has been undervalued in prior research due to use, primarily, of static stimuli. With the use of dynamic face stimuli, the mouth region, owing perhaps to the mouth's movement, might provide compensatory information to increase facial emotion recognition and expression. Of interest, the effect of fixation duration to mouth differed for fearful stimuli based on the task. Although 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 free-choice response task, more time looking at the mouth region actually resulted in less accurate emotion expression. This result once again suggests the importance of task instructions (e.g., identify vs. express emotion).

Results from the emotion expression tasks show a difference between TD and ASD participants in their ability to mirror the presented emotion during free-choice response but not when told which emotion to make, suggesting that youth with ASD do not express emotion in response to another person making an expression as well as youth without ASD. 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 although adolescents with ASD are capable of expressing emotions as well as their non-ASD peers, they do not do so when not explicitly prompted to. Given the nature of the free-choice paradigm we used, it is likely that participants did not genuinely feel the emotions the stimulus video was portraying; however, mirroring the emotion of one’s social partner during an interaction is an important aspect of interpersonal competence (Pfeifer, Iacoboni, Mazziotta, & Dapretto, 2008). These results indicate the need for training emotion expression and, perhaps, social mirroring, including identification of naturalistic prompting cues on when to express, in high-functioning adolescents with ASD in natural social 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 how individuals with ASD express the intended surprise emotion, compared to TD peers. However, adolescents with ASD did not differ from TD adolescents in 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, although adolescents 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 to fully understand the impairments that individuals with ASD display in everyday social situations. In social 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 study’s limitations, including the loss of eye-tracking data for many participants due to technical problems with Tobii and the setup 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. Notably, although the obtained power was .95 to detect a relationship between fixation duration and expression ability (Hypothesis 2), this was due to the per stimuli approach instead of the per subject approach, which was not feasible due to major data loss. Data loss is a common occurrence in eye-tracking work with adolescents (e.g., Louwerse et al., 2013). However, many studies do not report on rates of data loss. Future studies utilizing eye-tracking should consider the range of possible data loss in a priori power analyses as well as provide detail on how missing data was handled analytically, to aid replicability.

Similarly, given the number of different analyses both across and within emotions, as well as the varying patterns of results that emerged (e.g., differences only for certain emotions), the possibility of a Type II error must be considered. Although 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 free-choice response task) are less consistent. Future research may benefit from grouping the positive emotions and the negative emotions separately when exploring overall effects. Similarly, the study did not assess for motivation to respond to the stimuli, and therefore the differences between groups could potentially be due to social motivation or task understanding, which we did not assess for.

In terms of participant characteristics, the sample was predominately Caucasian, and these results may not generalize to individuals of other races and ethnicities. Similarly, although the TD 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. Although we found no difference in eye-tracking or expression results based on anxiety or alexithymia, other factors (i.e., depression) were not explored. In addition, many of the participants in the ASD group had a therapeutic history that might have involved training in emotion recognition or expression. The study did not allow for control of therapeutic history. Similarly, although 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 TD 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, as 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 reading others' emotion and with being able to show what they are feeling. This difficulty contributes to limited or negative social interactions. Findings from this study suggest that free-choice response facial emotional expression may be impaired in the context of an intact ability to show emotions (when told what to show) and that visually 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. Considering that facial emotion recognition and facial emotion expression are likely to be highly variable among individuals with ASD, as they are among TD youth, future studies should focus on process-driven, transdiagnostic approaches to studying impairments in 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 pattern to the eye region of the face does not, by itself, appear to be the mechanism by which individuals with ASD struggle with emotion expression. Instead, while viewing dynamic stimuli, eye gaze to mouth region appears to enhance accuracy of emotion recognition and expression, at least for some stimuli, such as sadness for youth with ASD. Further research is needed to fully understand the mechanisms behind the impaired emotion recognition and expression in individuals with ASD that contribute to the everyday social difficulties.

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